Culvert pipe materials and durability: Making the right selection for Minnesota

Presented by:

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Project objectives and goals

Project Goals:

Evaluate current practice and develop a research roadmap that will update design, construction, and monitoring practices for culvert installations in Minnesota.

- *Phase I Project*
  - *Develop recommendations for improving practice*
  - *Develop Research Needs*

Project Motivation

Three issues motivate this work:

1. The actual service life of infrastructure is less than expected
2. Advances in pipe materials & federal requirement to consider alternative materials
3. MnDOT seeks to improve/update guidelines - MnDOT Drainage Manual (Chapter 2)

What causes pipes to deteriorate?

- Acidity/alkalinity of water and soil (pH)
- Soil resistivity
- Chlorides & Sulfates
- Abrasion
- Loading (structural, freeze/thaw, bedding)

Overview of material types

- **Reinforced Concrete Pipe**
  - Most common in the state. Durable pipe
  - Service life can exceed 100 years

!Tie bars are structural elements!

Overview of material types

- **Galvanized Corrugated Metal Pipe**
  - Commonly used, inexpensive, lightweight, available
  - Design service life from 25-50 years.

Overview of material types

- **Aluminized Corrugated Metal Pipe**
  - Less-commonly used but positive feedback on use
  - Service life 3-8 times longer than galvanized

Overview of material types

- **Polymeric coated corrugated metal pipe**
  - Less common, lightweight
  - Optimum service life 100 years
  - Extremely Difficult to install!

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Image source (http://illowaculvert.com/Corrugated_Metal_Pipe.php)

Overview of material types

- **HDPE**
  - Lightweight
  - Good service life 50-100years

Image source: http://www.armtec.com/en-ca/products-and-services/drainage-solutions-and-water-treatment/hdpe-pipe/boss-2000.aspx

Databases Investigation

- NRCS Web Soil Survey (WSS)
  - Some Soil Chemistry
- District 3 pH map
  - Collected by MnDOT
- MNDOT HYDINFRA
  - Continual Culvert Inspection Effort

Databases Investigation

- USGS Database - (surface water, pH)
  - Larger Streams & Rivers
- Minnesota Pollution Control Agency (MPCA)
  - Shallow groundwater

Summary: Many databases were insufficient for this study.

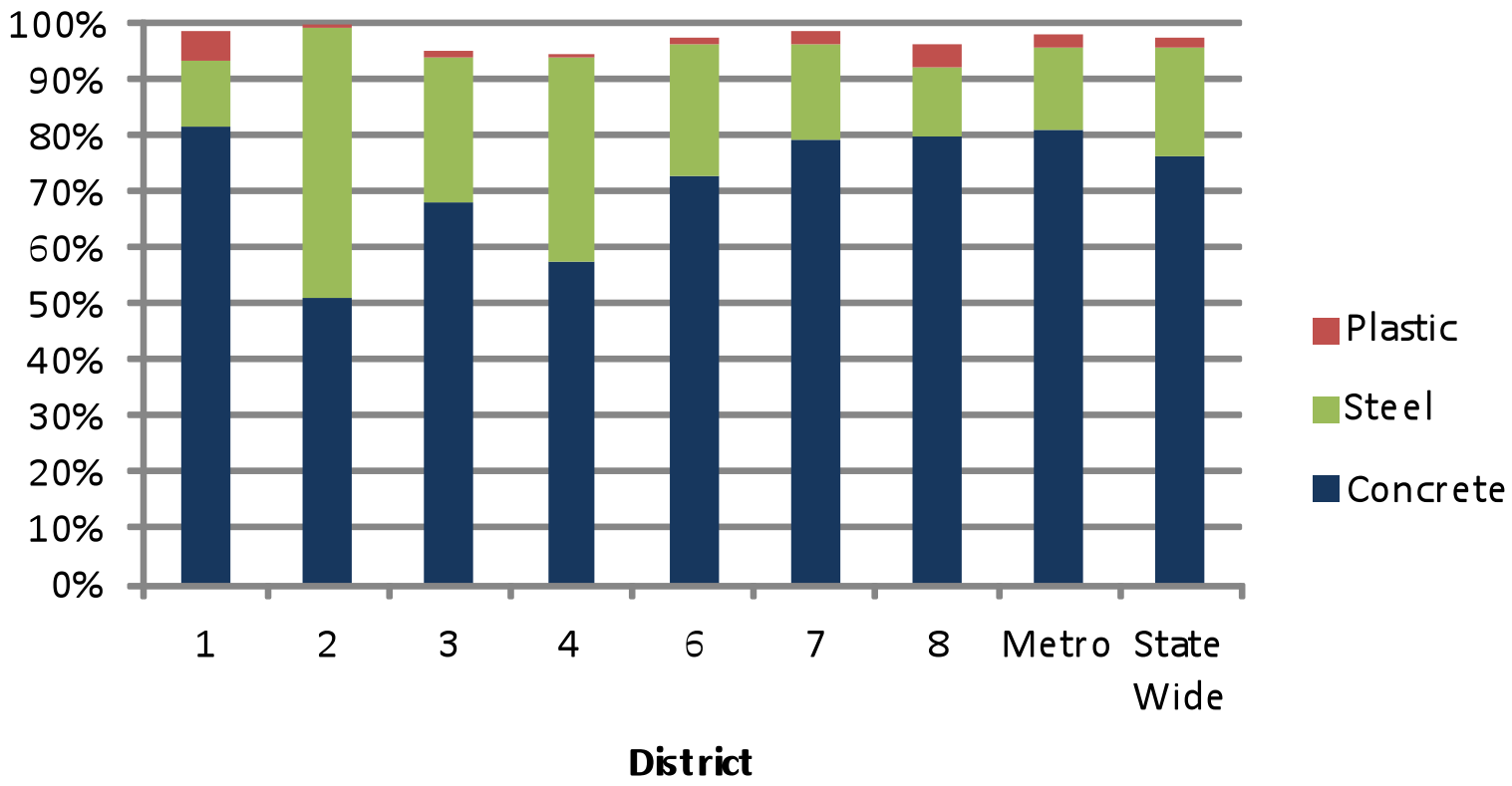
HYDINFRA database

- HYDraulic INFRAstructure inspection program
- Records
  - Location
  - Size
  - Condition
  - Other “Red Flags”

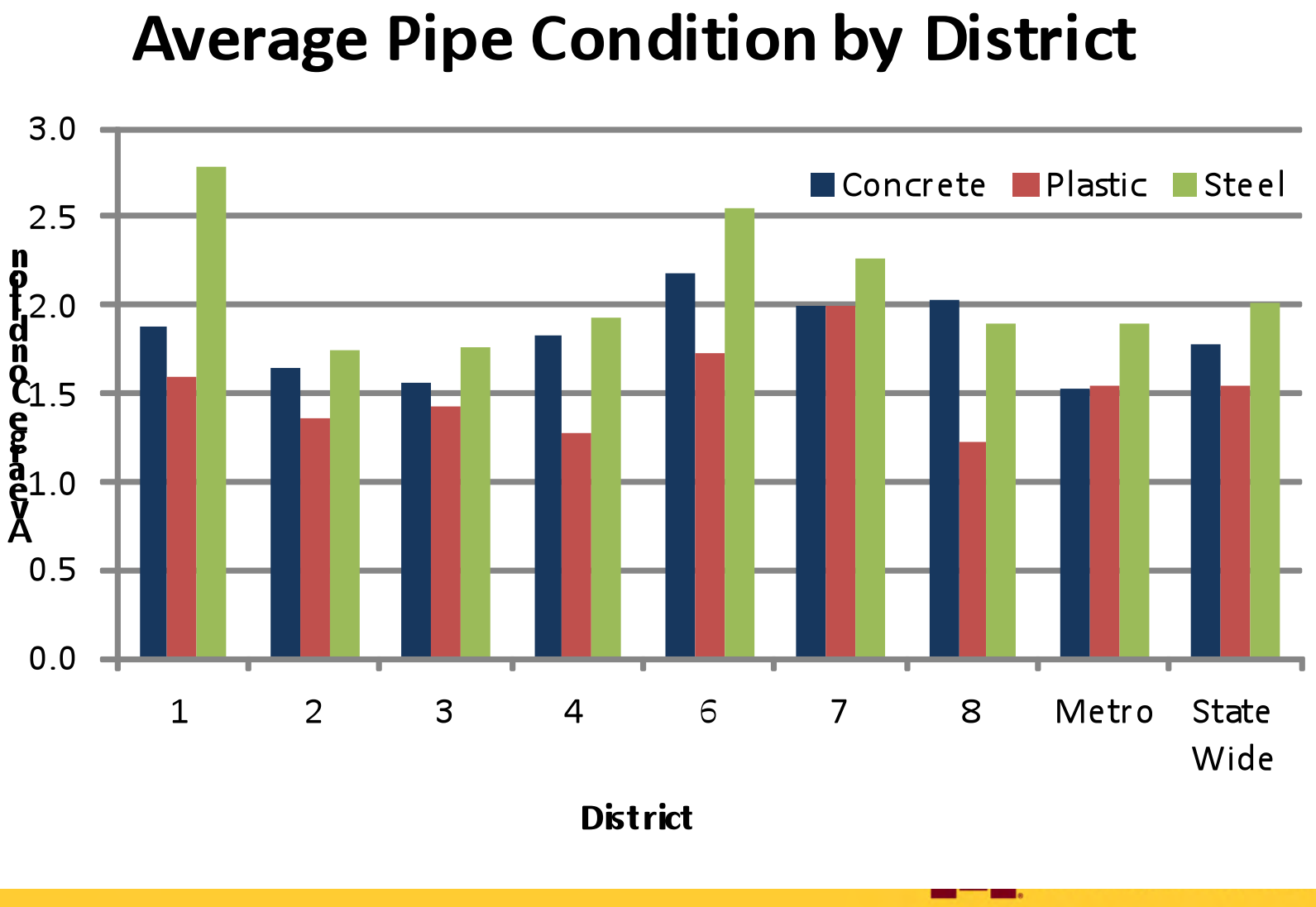
- **Over 95,000 pipes identified**

District 1 Pipe Conditions in HydInfra
Inspections January 1, 2004 till April 1, 2008

Major Findings



Major Findings



Major Findings

- **Concrete pipe is correlated with most of road damage – Is this perception or truth?**

- Joint separation is a major issue
  - ~18% of RCP have joint separation issues

- For joint separation pipes, ~14% results in road damage

		Road Condition for Joint Separated Concrete Pipes					
District	% RCP w/Joint Separation	No Damage	Distress Only	Void Only	Both	Any Damage	% Road Damage
1	15.5%	610	117	11	10	138	18.4%
2	19.6%	336	98	0	13	111	24.8%
3	18.8%	449	93	3	25	121	21.2%
4	29.7%	800	123	3	43	169	17.4%
6	19.6%	1340	111	23	20	154	10.3%
7	16.7%	444	17	80	37	134	23.2%
8	39.7%	957	49	0	9	58	5.7%
Metro	7.1%	629	41	3	8	52	7.6%
State Wide	17.7%	5565	649	123	165	937	14.4%

Recommendations

- MnDOT may or may not incorporate recommendations

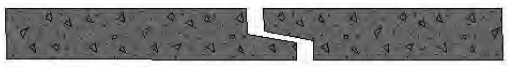
- Project did not consider all factors
  - Economics
  - Logistics
  - Safety

Recommendations

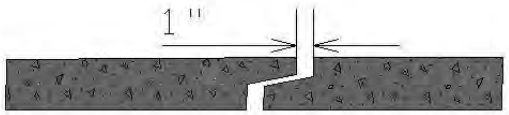
- 100 year design service life for centerline and mainline T.H. culverts
- 50-75 years design service life for entrance culverts
  - MnDOT District Interviews
  - Perrin & Jhaveri (2004) “The Economic Costs of Culvert Failures”

Recommendations

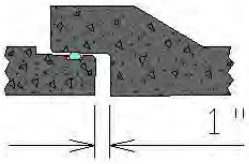
- Gasketed joints should become the default concrete pipe joint for all sizes of CP.
  - Joint separation most common failure (HydInfra)



JOINTS IN
NON-GASKETED PIPE
STD. PLATE 3000



JOINTS IN
GASKETED PIPE
STD. PLATE 3006



Recommendations

- Aluminized Corrugated 16g pipe should replace galvanized as the default steel pipe
  - ~Cost equivalent
  - Better service life

Recommendations

- Split HDPE pipe into two classes
  - Class I: 50-year material service life
  - Class II: 100-year material service life

- Adopt Florida DOT testing methods for determining HDPE material service life

Recommendations

- MnDOT should review the supplemental pipe inspection methodologies.
- Examples include:
  - 1) Consider video inspection for special or high risk pipe installations
  - 2) consider pressure/vacuum tests for critical pipes.
  - 3) Laser ring inspection for flexible pipe

Recommendations

- Adopt CalTrans abrasive conditions design methods
  - Abrasive conditions determined by previous installation
  - Found in NCHRP Project Report 20-07

Shady Creek (Highway 49 crossing) CA

Photo from: FHWA/CA/TL – CA01-0173

Research Needs

Research implementation priorities are as follows:

- Supplemental Inspection and Testing Methods
- Concrete Pipe Joint Separation Evaluation
  - Required joint strength
- Processed Based Abrasion Model
- Steel Pipe Service Life Map
  - Expected to start in July 2013

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Thank you!

Questions?

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