



# Culvert Inspection and Repair

*We could have fixed it cheaper,  
sooner!*

Bonnie Peterson, HydInfra Coordinator  
Minnesota Department of Transportation  
APWX Mpls 2016

We all have a stake in **A**  **B**



# Big storm + bad pipe = wrecked road



*We could have fixed it cheaper, sooner.*

Identify failing culverts by learning  
the **common mechanisms** of  
~~culvert deterioration~~

*Road Failure*

in culverts less than 10 foot span  
and storm drain pipes.

# Pipe with Holes causes Piping and Road Void



Road fill washes away  
at each burst of rain

CMP Storm Drain on Hadley Avenue at  
MnDOT Oakdale Office in 2015



This is what **pipng** looks like –  
water leaves the pipe at holes or joint separations  
and **flows along the outside**



8/7/13, 2:09 PM

*FieldNotes* LT



# Typical Culvert Failure has a pavement patch

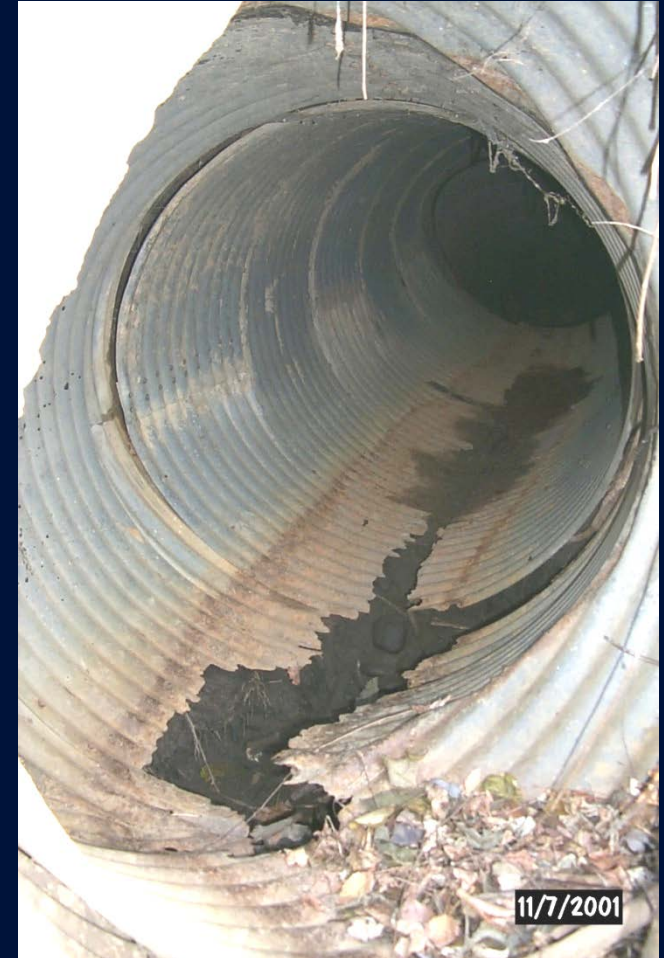


MN 95 2015 Eric Brenna

Water flows along the outside of pipe carrying road fill away.



MN 95 near MP 89, near Marine on the St. Croix



**Pipe Repair is too late**  
when the road surface  
reflects condition of pipe

While some steep slopes are prone to failure **leaking pipes lubricate the slide**





Pavement may span the void for awhile

until it doesn't.



Holes in 6' x6' box culvert allowed road fill to wash out but pipe did not collapse

**Inspect and Repair**  
to interrupt  
culvert deterioration

before the road is affected  
(cheaper)

A **good inspection system**  
tells you which culverts to fix  
before the paving project  
(not after)



HydInfra Project Design Report has inspection details for  
pipes, structures and special structures



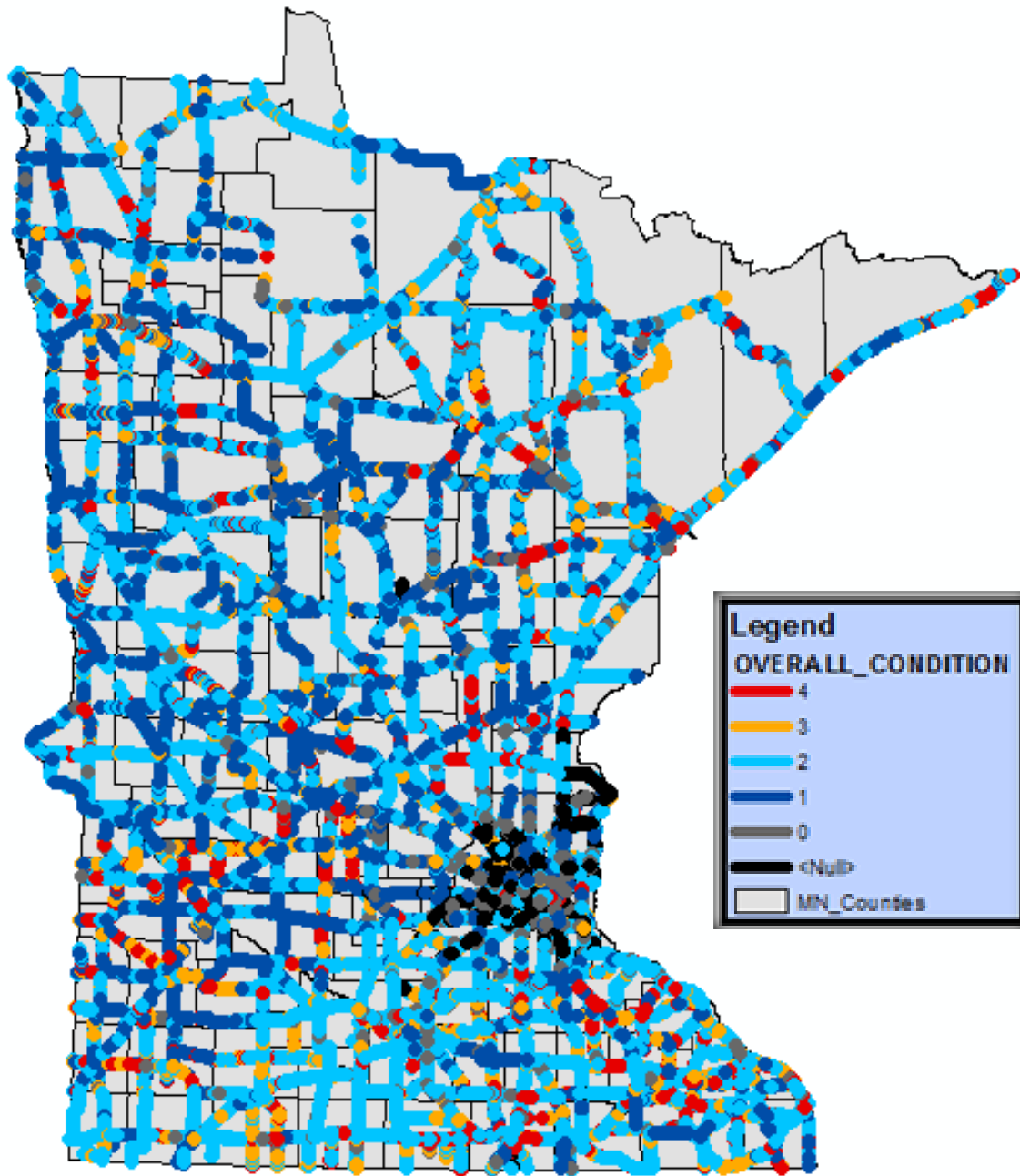
2 Decades of  
Culvert Inspection

HydInfra = Hydraulic Infrastructure

MnDOT's

Culvert and Storm Drainage System  
Inventory and Inspection Program

(Culverts less than 10 foot span and storm drain features)

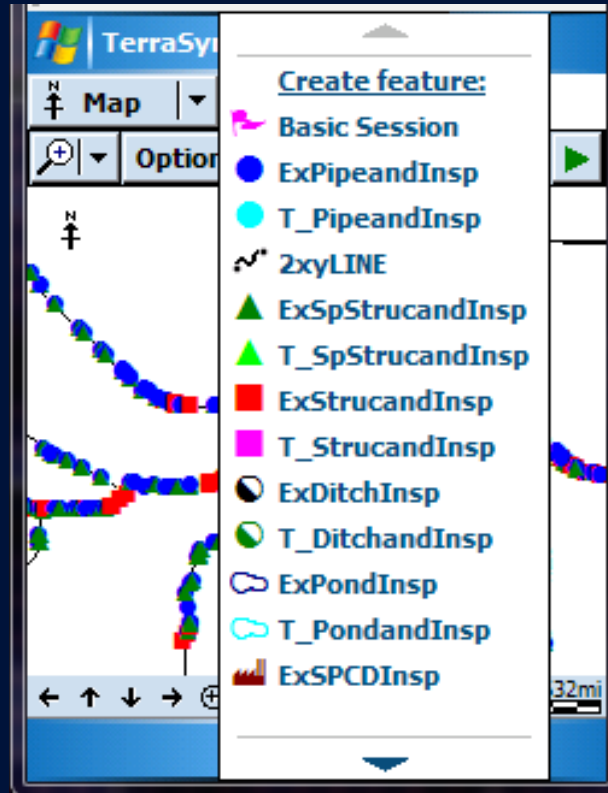


117,000  
HydInfra Pipes  
in MnDOT's  
inventory

Blue dots are  
pipes in  
good condition

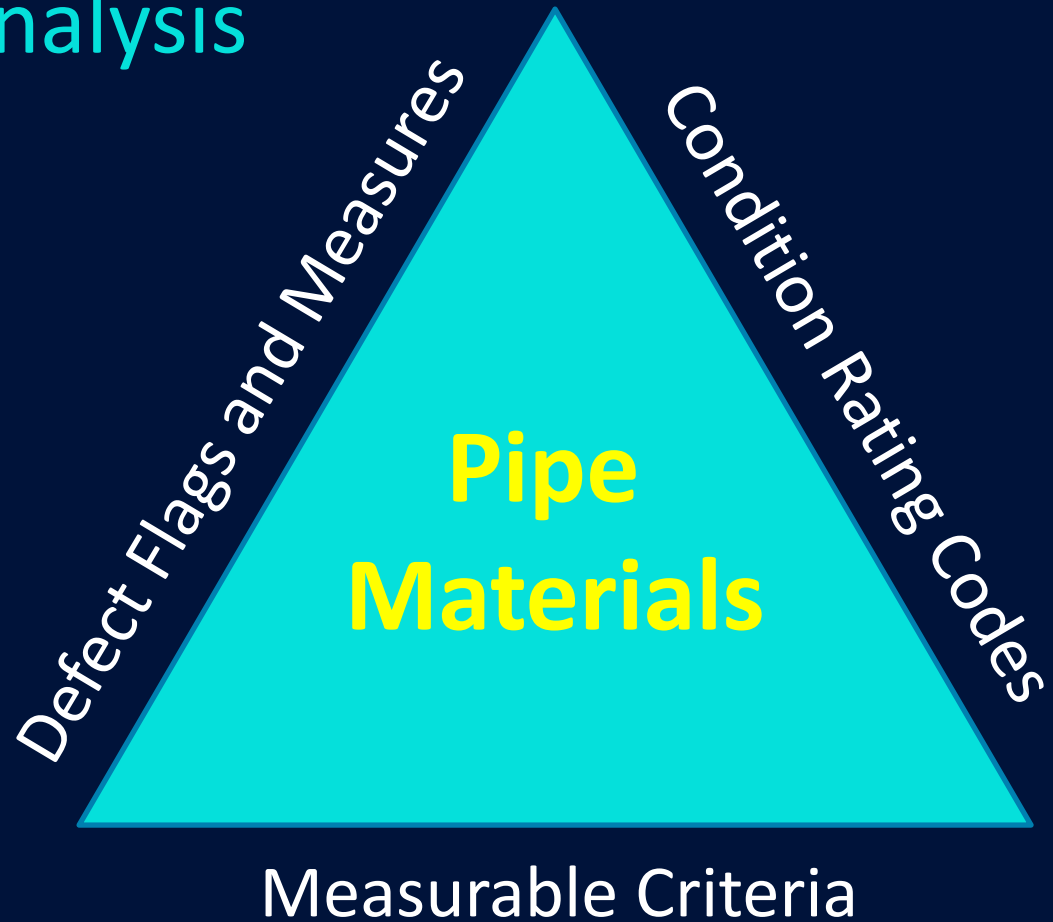
July 2016

# HydInfra Inspectors record drainage features with GPS devices



Inspectors use Trimble GPS with Terrasync or ArcPad. District Key Experts guide Inspectors and process field data with Pathfinder Office. Process will change in 2018 when Agile Assets software is implemented.

3-part rating system  
tracks **Materials** for  
Lifecycle Cost Analysis



# Track many **Materials** for Lifecycle costs

Pipe Materials &

**MATERIAL TYPE**

to track performance

- Concrete

**CONCRETE**

- Corg. Steel (CSP)
- Structural Plate
- Polymeric-Coated
- Bituminous-Coated
- Aluminized Steel

**STEEL**

- Corg. Aluminum (CAP)

**ALUMINUM**

- Timber
- Vitrified Clay
- Other

**OTHER**

- Corg. Plastic (HDPE)
- PVC
- Perforated Plastic
- Polypropylene
- SRPE (Steel Reinforced PolyEthylene)

**PLASTIC**

“Liner” materials describe a lined pipe:

- Liner HDPE
- Liner PVC
- Liner Cured in Place
- Liner Metal
- Liner Other

**LINER**





# Intuitive Condition Rating Codes suggest the need for repair



## HydInfra Inspection Manual

Culvert and Storm Drainage Systems

### Condition Rating Codes:

Like new

**1**

Excellent – like new condition

Still okay

**2**

Fair – some wear, but structurally sound

Fix in project

**3**

Poor – deteriorated, consider for repair or replacement

Fix it sooner

**4**

Very Poor – serious deterioration

Unknown

**0**

Not able to rate, not visible

# Flags and Measures describe the defects

## Condition Indicators

- Needs Repair?
- Piping
- Cracks
- Holes
- Deformation
- Misalignment
- Max Joint Separation
- # Separated Joints
- Separated Apron
- Spalling/Flaking
- Pitting/Rusting
- Infiltration

## Roadway Indicators

- Void in Road
- Road Distress
- Inslope Cavity
- Erosion/Scour

## Not in Condition Rating

- Needs Clean?
- Plugged
- Silt
- Sediment % Full
- Standing Water

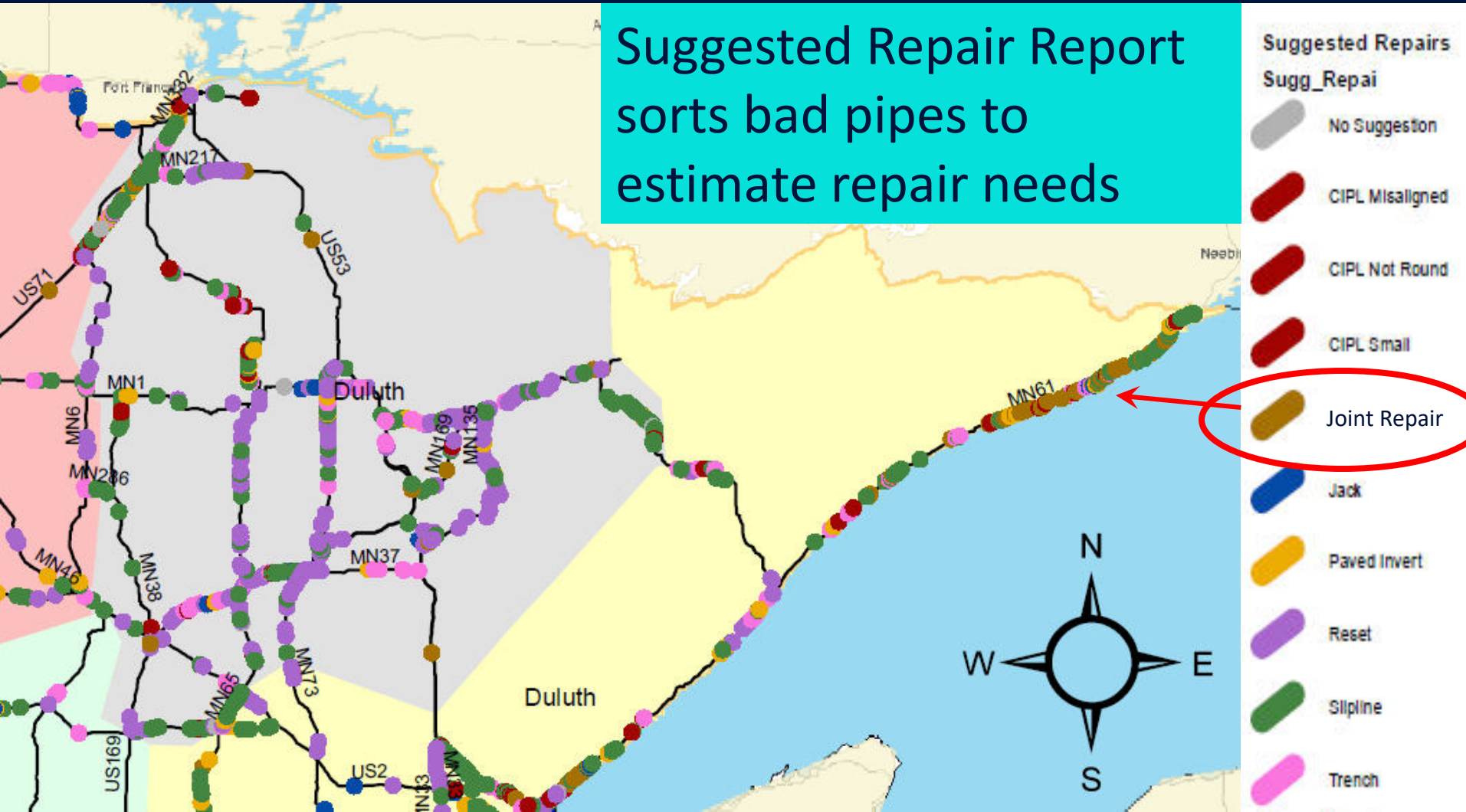
Each Material Type has **explicit rating criteria**

Road Void is always Condition 4

HydInfra Ratings Guide	
Concrete Pipe & Special Structure	
Factors: Structural integrity, Integrity of surrounding material	
1 Excellent Condition	<ul style="list-style-type: none"><li>Minor chipping at joints/openings</li><li>Hairline cracks</li><li>Insignificant spalling or scaling</li></ul>
2 Fair Condition	<ul style="list-style-type: none"><li>Joints broken or pulled apart up to 1" (anywhere along joint)</li><li>Aggregate exposed</li><li>Cracks evident with widths up to 1/8 inch</li><li>Spalling or scaling to 1/4 inch depth</li></ul>
3 Poor Condition	<ul style="list-style-type: none"><li>Joints broken or pulled apart 1-2" (anywhere along the joint)</li></ul>
4 Very Poor Condition	<ul style="list-style-type: none"><li>Joints pulled apart or broken (more than 3" at any point along joint)</li><li>Cracking evident with widths &gt; 1/4 inch</li><li>Reinforcement fully exposed in places</li><li>Eroded holes through concrete or bottom gone</li><li>Deformation</li><li>Cracks showing movement – pipe pieces have shifted</li><li>Pipe condition is causing soil loss beneath road surface</li></ul>
Notes: Special Structures include Aprons, Slotted Drain, Headwalls, Wingwalls, open Flumes, Weirs, Expander/Reducers, Floodgates, Energy Dissipaters and other items that are <u>not</u> Pipes, Structures, SPCDs (Structural Pollution Control Devices), Ponds or Ditches.  Attributes such as crack width and spalling depth won't be measured in most cases inspectors must estimate sizes based on what they see.	

# Pipe size, shape and material, plus defect flags point to **Repair Methods**

Suggested Repair Report sorts bad pipes to estimate repair needs



Cluster of suggested Joint Repairs indicates joint separations along Highway 61

# Statewide Pipe Repairs Cost Estimate from Suggested Repair Report

	A	B	C			H	I	L	R		
1			Repair me			Contract average bid			Contract		
2						Unit P			Contract		
3	District	1		<b>District</b>	<b>1</b>		<b>Cost</b>		<b>Total Cost</b>		
4			CIPL				<b>\$183,973</b>	973			
5			Grout				<b>\$77,387</b>	387			
6			Jack				<b>\$968,165</b>	165			
7			Paved Invert				<b>\$40,212</b>	212			
8			Reset			\$2,4	<b>\$323,374</b>	374			
9			Slipline				<b>\$1,552,383</b>	383			
10			Trench			\$26,3	<b>\$2,260,010</b>	010	\$5,405,504		
11	District	2									
12			CIPL				<b>\$323,374</b>	533			
13			Grout				<b>\$1,552,383</b>	978			
14			Jack				<b>\$2,260,010</b>	593			
15			Paved Invert					597			
16			Reset			\$2,4		980			
17			Slipline	45	3562	\$93.22	foot	\$365,255			
18			Trench	21	1633	\$65.37	foot	\$26,362.84	each	\$726,406	\$1,893,341
19	District	3									
20			CIPL	23	3637	\$129.65	foot	\$518,691			
21			Grout	5	644	\$32.48	foot	\$23,009			
22			Jack	8	1286	\$725.00	foot	\$1,025,585			
23			Paved Invert	2	152	\$16.24		\$2,715			
24			Reset	11	1029			\$2,449.80	each	\$29,643	
25			Slipline	44	3833	\$93.22	foot	\$393,043			
26			Trench	27	1848	\$65.37	foot	\$26,362.84	each	\$915,860	\$2,90



# Culvert Repair Methods

used by MnDOT Maintenance:



Trench  
New Pipe



Joint Repair



Paved  
Invert

- Trench New Pipe
- Slipline
- Replace Aprons
- Reset
- Extension
- Joint Repair
- Hole Repair
- Paved Invert
- Fill Voids

Culverts of different materials  
have different failure modes  
that progress through stages  
that end in road failure.

# Pipe Material and its Environment determine Lifespan



AARGH!

- **Avoidable defects** – Design or installation-caused problems, includes manufacture, construction or design
- **Random Events** – A culvert in the ground can be damaged by random events and forces – *huge rainfall, frost heave, etc.*
- **Gradual Deterioration** – A chunk of good pipe material in the ground may degrade gradually, influenced by its environment – manufacturer’s projected lifespan



Most Steel pipe **gradually** deteriorates through a **series of defects** shown by inspection flags:

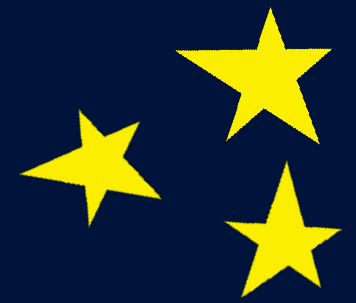


1. Pitting/Rusting
2. Spalling/Flaking
3. Holes
4. Piping
5. Road Void
6. Deformation

HydInfra data shows that about 10% of MnDOT's steel pipe has holes

Joint Separation and Misalignment  
is rare in **Steel** pipe  
and may indicate a slope failure





## *Repair Steel Pipe*

Pave the invert, install a liner or  
replace the culvert  
before piping and road voids occur

when inspection shows Flaking Rust or  
a **Hole less than 1 inch**



# Paved Invert Repair

for steel pipes 3 foot height or larger



1971 Paved Invert repair still looks good in 2015

– Bergstrand , Duluth



# Concrete pipe fails most often when **Joint Separation** and **Piping** causes **Road Void**



HydInfra data shows about 7% of MnDOT's  
concrete pipes have separated joints

# Void in Road may occur through Joint Separation 1 inch or greater



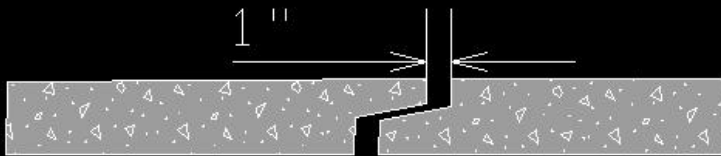
Concrete jacked pipe with 1 ½ in joint separation creates road void, shown by survey range pole in hole in the pavement. 27SEP2011 – Rob Coughlin

# Joint gaps are less likely with Gasketed Concrete Pipe



## Non-Gasketed joint

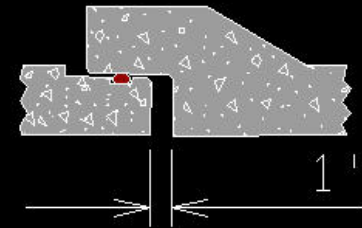
JOINTS IN  
NON-GASKETED PIPE  
STD. PLATE 3000



24" pipe example

## Gasketed joint

JOINTS IN  
GASKETED PIPE  
STD. PLATE 3006



# Pipe tie bolts are standard on new concrete culverts but won't hold under stresses



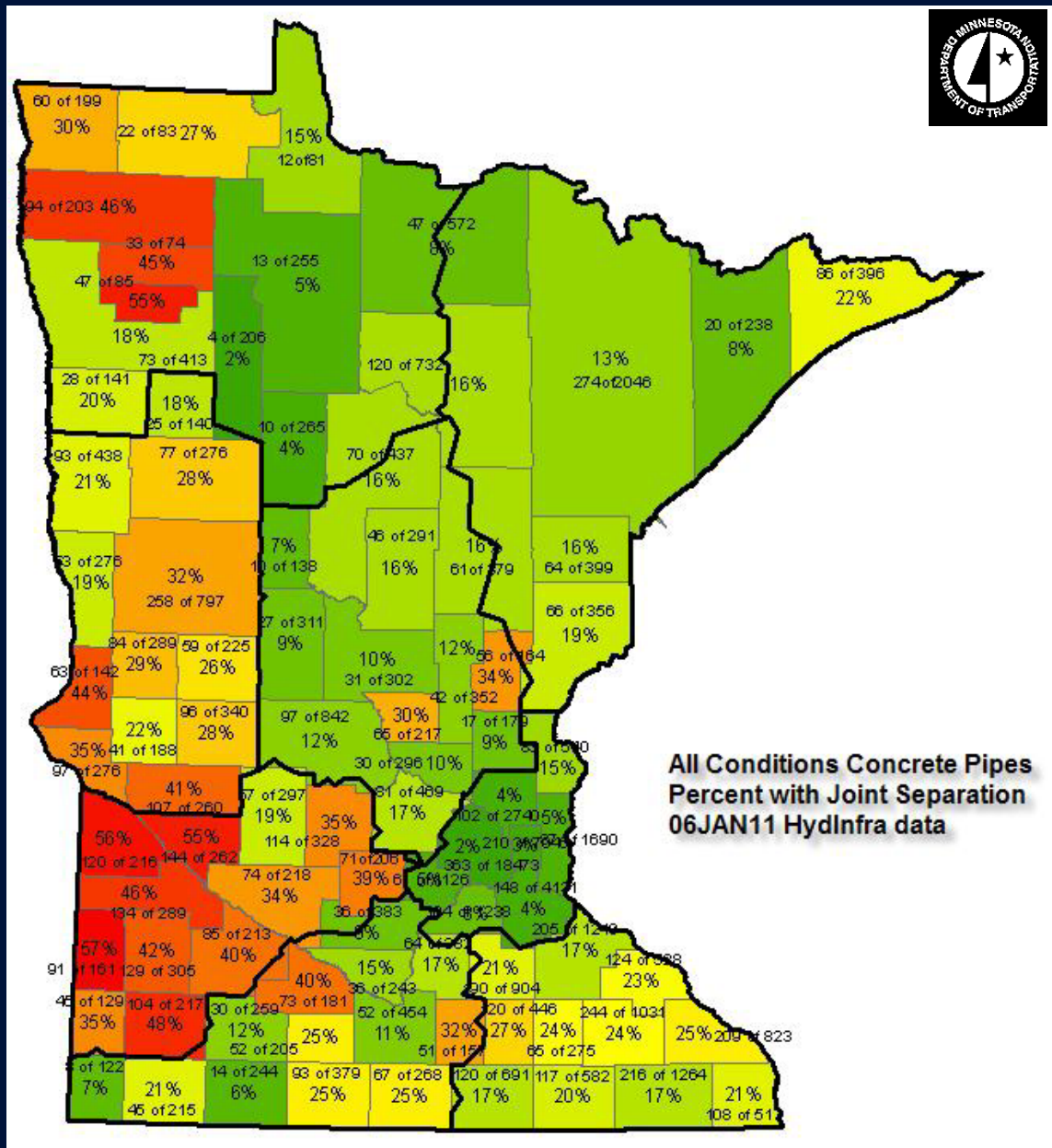
District 1 photo shows broken pipe tie pointing to joint separation in Concrete arch pipe





Concrete  
**Joint Separation**  
 may be worse in  
 western  
 Minnesota

Inspection flags  
 show **hotspots** for  
 Joint Separation



This 2011 map was created after Highway Culvert inventory was completed but before most Districts were focused on repairing pipes.

# Concrete abrasion, acid attack and bad manufacture are **far less common**



Abrasion from rocks  
District 1 Duluth



Acidic factory  
discharge,  
I-94 St. Paul  
Metro District



Bad concrete mix  
in alternating pipe  
sections, District 3  
Baxter

Acid attack looks similar to bad concrete mix  
but **alternating** good - bad pipe sections  
suggest bad material



MN Highway 36 culvert in Roseville alternated  
many good and a few bad pipe sections

# Porous weeping patches indicate bad concrete material



The pipe photo shows water trickling down the inside wall through perforations or honeycombing.

D7 MN Highway 22, 2014



## *Repair Concrete Pipe*



Repair joints or install liner  
or replace the culvert  
before piping and road voids occur

when inspection shows  
**Joint Separations 1 – 3 inches**

# Joint Repair in large Concrete culvert



There are many varieties of Plastic Pipe  
but we have information on **HDPE**

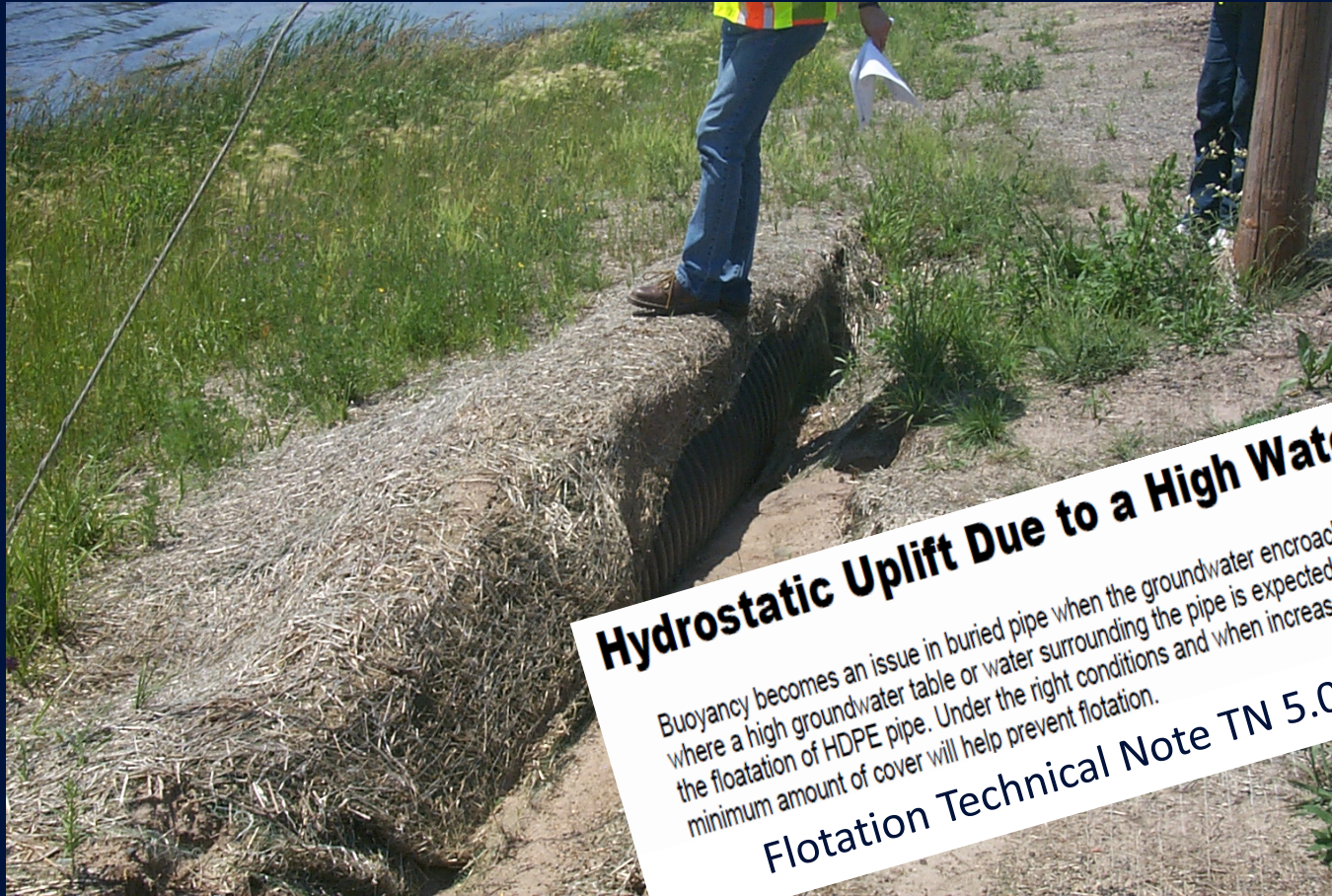
HydInfra data shows about 5% of  
HDPE pipes have visible deformation

# Random grass **fire** burned this HDPE It has Flaking, Holes and Deformation





# Too little cover – Construction change caused **Floated** HDPE



Pipe was re-routed across road inslope with too little cover (about 6 inches). High water or frost heave can cause the pipe to “float”.

# Bad Resin 1996 HDPE pipe shows Deformation and Misaligned and Separated Joints

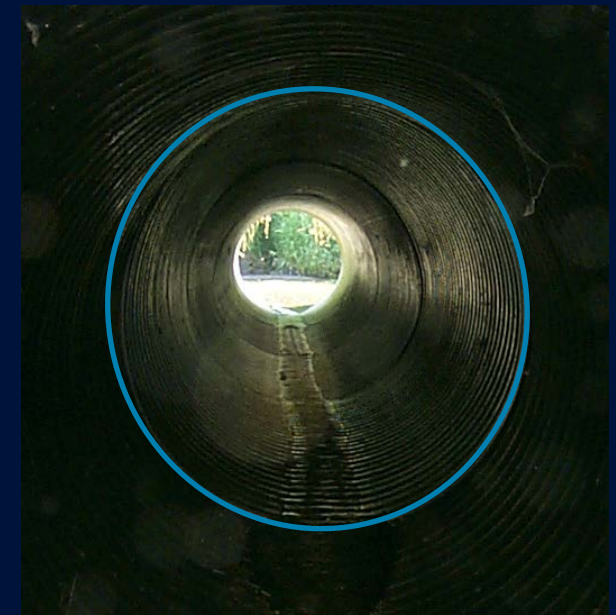
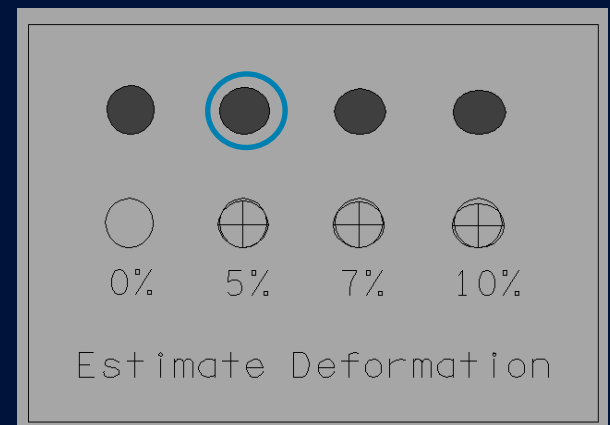


Photo above shows 5% Deformation (rotated)

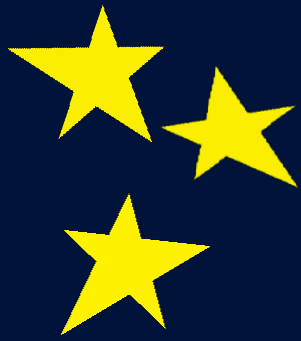


HydInfra ID 36918 has **manufacturing defect** in pipe material

# 1996 **bad resin** HDPE has patterned surface and cracks in 2006



Resin Specs have been changed since this pipe was manufactured



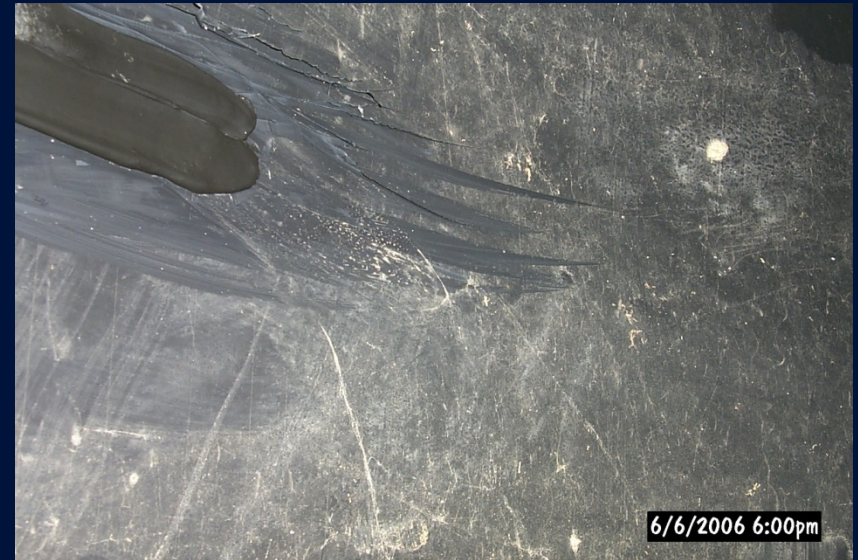
## *Repair Plastic Pipe*



Replace pipe or repair cracks  
before piping and road voids occur

or when inspection shows  
Cracks, Misalignment or  
**Deformed 10%**

# HDPE cracks were repaired by manufacturer



- 2006 repair on 1996 HDPE
- Drill hole to stop cracking
- Patched by manufacturer's crew with their material

Better inspections lead to  
better repair recommendations.

*Begin Part 2*  
*Kris Langlie and Rob Coughlin*