

# Put Your Drainage Asset Management System to Work

Adapted from Presentation at NHEC  
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# Big storm + bad pipe = wrecked road



We could have fixed it cheaper, sooner

In 2014  
MnDOT's Transportation Asset Management  
(TAMP) committee

ranked Culverts as  
**#1 priority**



HydInfra = Hydraulic Infrastructure

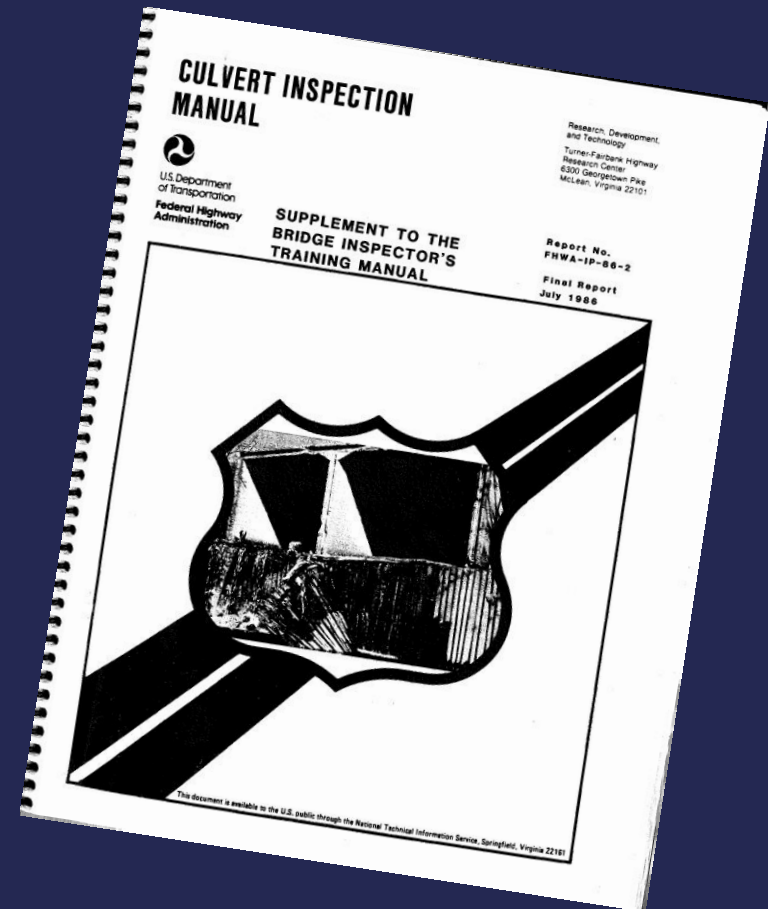
MnDOT's

Culvert and Storm Drainage System  
Inventory and Inspection Program



# HydInfra sprang from the 1986 Culvert Inspection Manual

with some  
important  
differences . . .



# MnDOT Hydraulic Engineers designed HydInfra in 1996

- Condition Ratings **1 – 4**
- **Flags and Measures** record defects
- Criteria for each **Material type**
- **Culverts less than 10 foot span**
- **Automated** from the get-go
  - Centralized database
  - GPS
  - GIS
  - Hired a specialist for development



# HydInfra Drainage Feature Types

- ★ Pipes – Culvert, Storm Drain, Drain Tile, Tunnels, etc.
- Structures – MH, CB, DI
- Special Structures – Aprons, Weirs, (catch all)
- Ponds – Infiltration, Wet, Dry, etc
- WQ devices – swirling separators, skimmers etc.
- Ditches
- Discharge Points – Outfalls (MS4) Infalls , etc.
- Illicit Discharges
- Environmental – pH, resistivity locations



# 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

Simple ratings codes suggest repair needs





HydInfra's **1 – 4 ratings system** came from  
bridge element condition ratings

## **Pontis Element Condition Ratings**

Bridges are divided into separate elements, which are rated based upon the severity and extent of deterioration. There are 7 culvert elements...

- #240: Steel Culvert (1-4, LF)
- #241: Concrete Culvert (1-4, LF)
- #242: Timber Culvert (1-4, LF)
- #243: Masonry/Other Culvert (1-4, LF)
- #388: Culvert End Treatment (1-4, Each)
- #421: Culvert Footing (1-4, LF)
- #987: Roadway over Culvert (1-3, Each)



# Pipe Materials &

**MATERIAL  
TYPE**

to track  
performance

■ Concrete

**CONCRETE**

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

**STEEL**

- Aluminized Steel
- Corg. Aluminum (CAP)

**ALUMINUM**

- Timber
- Other

**OTHER**

- Corg. Plastic (HDPE)
- PVC
- Perforated Plastic

**PLASTIC**

**“Liner” materials  
describe a lined pipe:**

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

**LINER**



# Materials differ

- Metal gets holes
- Concrete joints separate
- Plastic deforms or floats
- Odd materials require overarching criteria



Each Material type has explicit rating criteria

## HydInfra Ratings Guide

### Concrete Pipe & Special Structure

Factors: Structural integrity, Integrity of surrounding material

#### 1 Excellent Condition

- Minor chipping at joints/openings
- Hairline cracks
- Insignificant spalling or scaling

#### 2 Fair Condition

- Joints broken or pulled apart up to 1" (anywhere along joint)
- Aggregate exposed
- Cracks evident with widths up to 1/8 inch
- Spalling or scaling to 1/4 inch depth

#### 3 Poor Condition

- Joints broken or pulled apart 1" - 2" (anywhere along the joint)

#### 4 Very Poor Condition

- Joints pulled apart or broken (more than 3" at any point along joint)
- Cracking evident with widths > 1/4 inch
- Reinforcement fully exposed in places
- Eroded holes through concrete or bottom gone
- Deformation
- Cracks showing movement – pipe pieces have shifted
- Pipe condition is causing soil loss beneath road surface

- Pipe condition is causing soil loss beneath road surface

#### Notes:

Special Structures include Aprons, Slotted Drain, Headwalls, Wingwalls, open Flumes, Weirs, Expander/Reducers, Floodgates, Energy Dissipaters and other items that are not 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.



# HydInfra Condition Rating Criteria aim to **protect the roadway**

Holes or Joint Separations  
in pipes create  
**Piping and Road Voids**



# With “Flags” and “Measures” we can identify and correlate problems

## 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 Cavitation
- Erosion/Scour

## Not in Condition Rating

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



# Correlate sets of defects – “flags” with Material

Material/Flag combinations that we see in MnDOT photos:

	Concrete	Deformation	Cracks	Spalling
	Concrete	Joint Separation	Road Void	
	Concrete	Inslope Cavity	Joint Separation	
	Concrete	Joint Separation	Infiltration	
	Steel	Holes	Road Distress	
	Steel	Holes	Deformation	
	Steel	Holes	Piping	
	Steel	Holes	Road Void	
	HDPE	Cracks		
	HDPE	Misalignment (floating)		
	Liner HDPE	Deformation		



# GPS Inspections for mapping in GIS





# GIS provides context and tools

The screenshot displays the ArcMap interface with the 'Query Oracle' dialog box open. The dialog box is titled 'Select using...' and has three tabs: 'Selection Criteria', 'Date', and 'Oracle Geo Table'. The 'Selection Criteria' tab is active.

**Location Criteria:**

- County: All
- District: All
- Route: 62
- System: MN
- Begin RP: 0
- End RP: 24
- Limit returned features to those within current map extent
- Reset Choices

**Feature Criteria:**

- Status: Inplace (selected)
- Type: Pipes (selected)
- Condition: All
- Material Type: All
- Shape: All
- Span:
- Limiter: =
- Size: 0.00
- Unit: Feet
- Only return pipes that: (check as many as desired)
  - Need cleaning
  - Need repair
- Reset Choices

**Map Interface:**

- Map title: Hydinfra.mxd - ArcMap - ArcView
- Map content: Aerial view of Mankato, MN, showing streets (1st St, 3rd St, 4th St, 21st St, 412th St, 423rd St, 425th St, 312th Ave, 320th Ave, 440th St, Myrtle St, Wignam Ave) and pipes (628005, 628006, 628008).
- Scale: 1:39,420
- Coordinates: 300673.044 4859627.796 Meters

**Query Oracle Dialog Box:**

- Layer name in ArcMap: [ ]
- Zoom to layer(s) in ArcMap
- Execute Query
- Close/No Clear
- Close and Clear



Together  
condition, flags, material  
and GIS

create solutions



Put it to work

# HydInfra Capabilities:

1. Performance Measures
2. Prioritize Repairs
3. Estimate Costs – “Suggested Repair Method”
4. Maintenance Tasks
5. Project Pre-design
6. Respond to flood damage
7. MS4 Water Quality record keeping
8. Utilities locations – “Call before you dig”
9. Research
10. Lifecycle Cost



# 1. Performance Measures with worthwhile goals

(If you measure it, it will happen)

Inspection Cycle for Drainage		
Recommended Inspection Frequency		
Overall Condition	Recommended Inspection Frequency Years	Comments
4 Very Poor	2	Pipes where
	1	Pipes where
3 Poor	4	Most condi
	2	Pipes with
1 & 2 Like New and Fair	6	
0 Can't be Rated	2	
Pipes with no inspections		Goal to in pipe, so reduced

Overall Target: 80% of Highway Pipes meet Recommended Inspection Frequency

Inspection Cycle:  
Condition 4: 1 or 2 years  
Condition 3: 4 years  
Condition 2: 6 years  
Condition 1: 6 years  
Condition 0: 2 years

- Start with inventory and inspection cycle
- Later target to reduce numbers of bad pipes



## 2. **Prioritize** based on today's requirement

Choose your  
biggest, worst culverts  
that have piping and road voids  
with shallow cover,  
and highest ADT  
(and highest price tag)



**Or Prioritize** based on today's funds

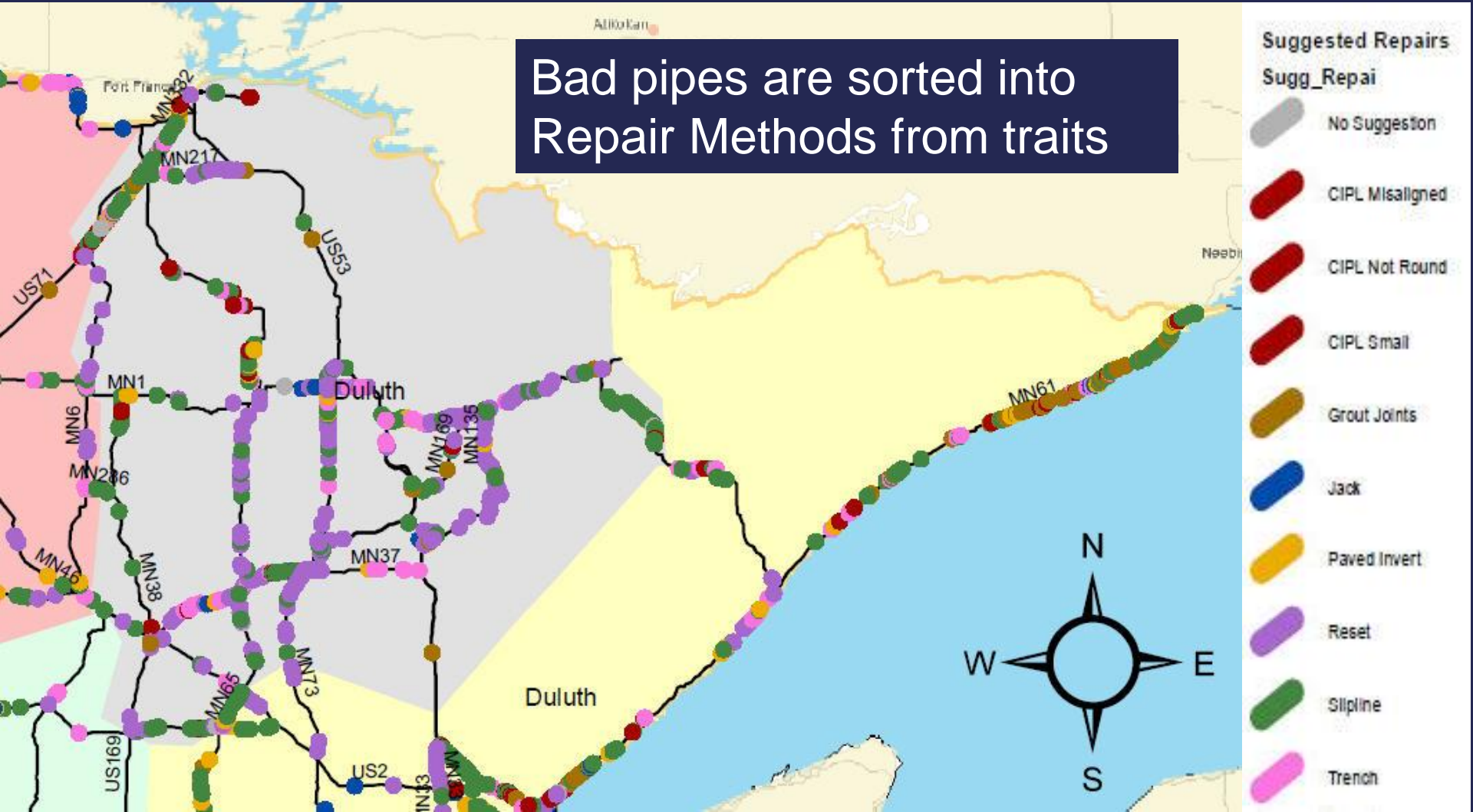
Choose the pipes that  
Maintenance can repair now  
with little cash:

Resets, Paved Inverts, Joint Repair



# 3. Automate State-wide Repair Estimates with Pipe Suggested Repair Method

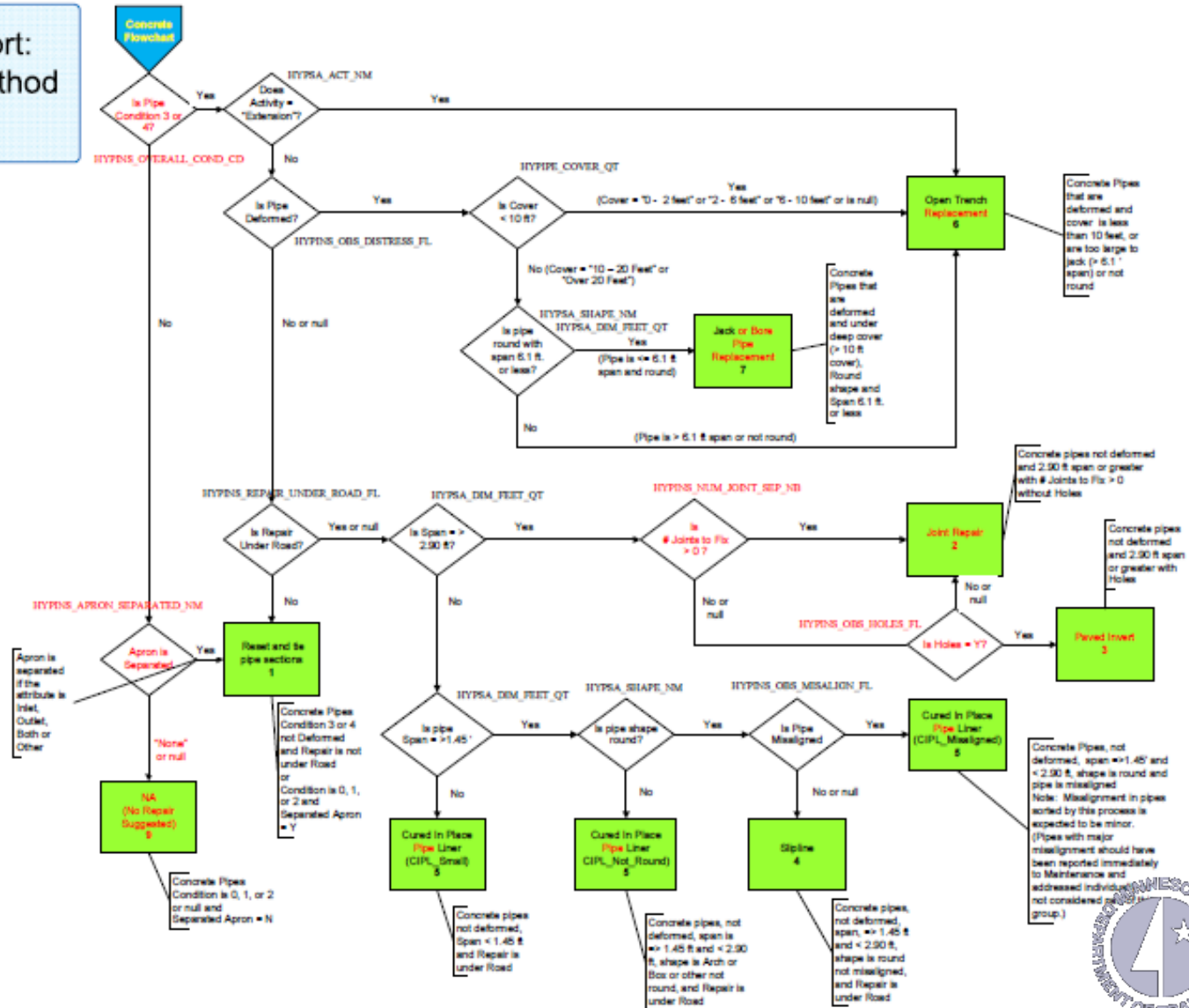
Bad pipes are sorted into Repair Methods from traits





# Suggested Repair sorting process covers the most common problems

Flowchart of HydInfra Report: Pipe Suggested Repair Method Concrete Pipes



# Web-based HydInfra Report selects bad pipes for 7 potential repairs



## Suggested Repair Method Condition 3 and 4 Concrete or Steel Pipes District 6, May 30, 2012

Pipe ID	Hwy	Ref Pt.	Material	RoadType	Shape	Span	Rise	Units	Length	Units	Cover	SpanFt	Condition Rating			D	H	Pi	M	J
													Cond	R	RU					
732154	14	161.625	Concrete	Centerline	Round	24	24	Inches	70	Feet	2 - 6 Feet	2.00	4	Y	Y	N	N	N	Y	Y
732156	14	161.751	Concrete	Centerline	Box	36	36	Inches	24	Feet	2 - 6 Feet	3.00	4	Y	Y	Y	N	N	N	Y
732157	14	161.751	Org. Steel (CSP)	Centerline	Round	30	30	Inches	31	Feet	2 - 6 Feet	2.50	3	Y	N	N	N	N	N	N
732155	14	161.752	Org. Steel (CSP)	Centerline	Round	30	30	Inches	31	Feet	2 - 6 Feet	2.50	3	Y	N	N	N	N	N	N
482227	14	161.839	Concrete	Mainline	Round	24	24	Inches	56	Feet	2 - 6 Feet	2.00	4	Y	Y	N	N	N	N	Y
482229	14	162.061	Concrete	Mainline	Round	24	24	Inches	60	Feet	0 - 2 Feet	2.00	3	Y	Y	N	N	N	N	Y
482231	14	162.424	Concrete	Mainline	Round	24	24	Inches	68	Feet	2 - 6 Feet	2.00	4	Y	Y	N	N	N	N	Y
482207	14	163.501	Concrete	Mainline	Round	24	24	Inches	70	Feet	2 - 6 Feet	2.00	4	Y	Y	N	N	N	Y	Y
482215	14	165.033	Concrete	Mainline	Round	36	36	Inches	60	Feet	2 - 6 Feet	3.00	4	Y	Y	N	N	N	N	Y

# 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	Total Cost
3	District	1		<b>District</b>	<b>1</b>		<b>Cost</b>		
4			CIPL				<b>\$183,973</b>	.973	
5			Grout				<b>\$77,387</b>	.165	
6			Jack				<b>\$968,165</b>	.374	
7			Paved Invert				<b>\$40,212</b>	.010	\$5,405,504
8			Reset			\$2,4	<b>\$323,374</b>	.533	
9			Slipline				<b>\$1,552,383</b>	.593	
10			Trench			\$26,3	<b>\$2,260,010</b>	.980	
11	District	2							
12			CIPL						
13			Grout						
14			Jack						
15			Paved Invert						
16			Reset			\$2,4			
17			Slipline	45	3562	\$93.22	foot	\$365,255	
18			Trench	21	1633	\$65.37	foot	\$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			\$29,643	
25			Slipline	44	3833	\$93.22	foot	\$393,043	
26			Trench	27	1848	\$65.37	foot	\$915,860	\$2,909,546



# 4. Improve response time on day-to-day Maintenance issues with HydInfra + Mobile Mapping

Inspector calls in  
HydInfra ID  
Highway  
Milepost location



## 5. Predesign for Construction Projects

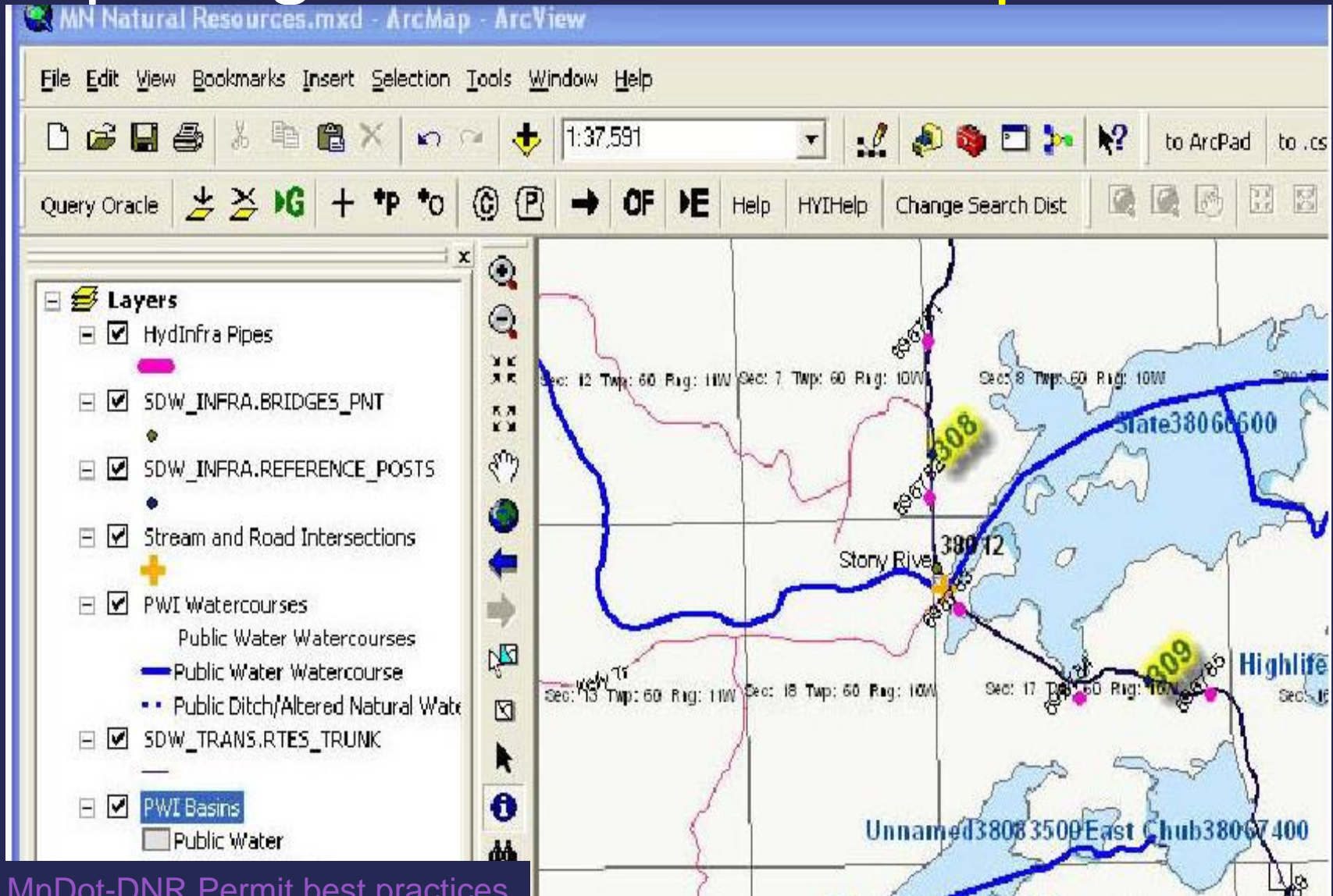


Stimulus projects and construction scoping  
get a head start with  
HydInfra inventory and inspection data

# Know which pipes to fix before the paving project (not after)



# Use GIS to identify culverts for fish passage or environmental permits



## 6. Respond to flood damage when heavy rains wash out culvert

- Roadway is out
- Culvert data is known
- FEMA disaster declared  
= special forms and records
- Asset Management to  
find spare parts

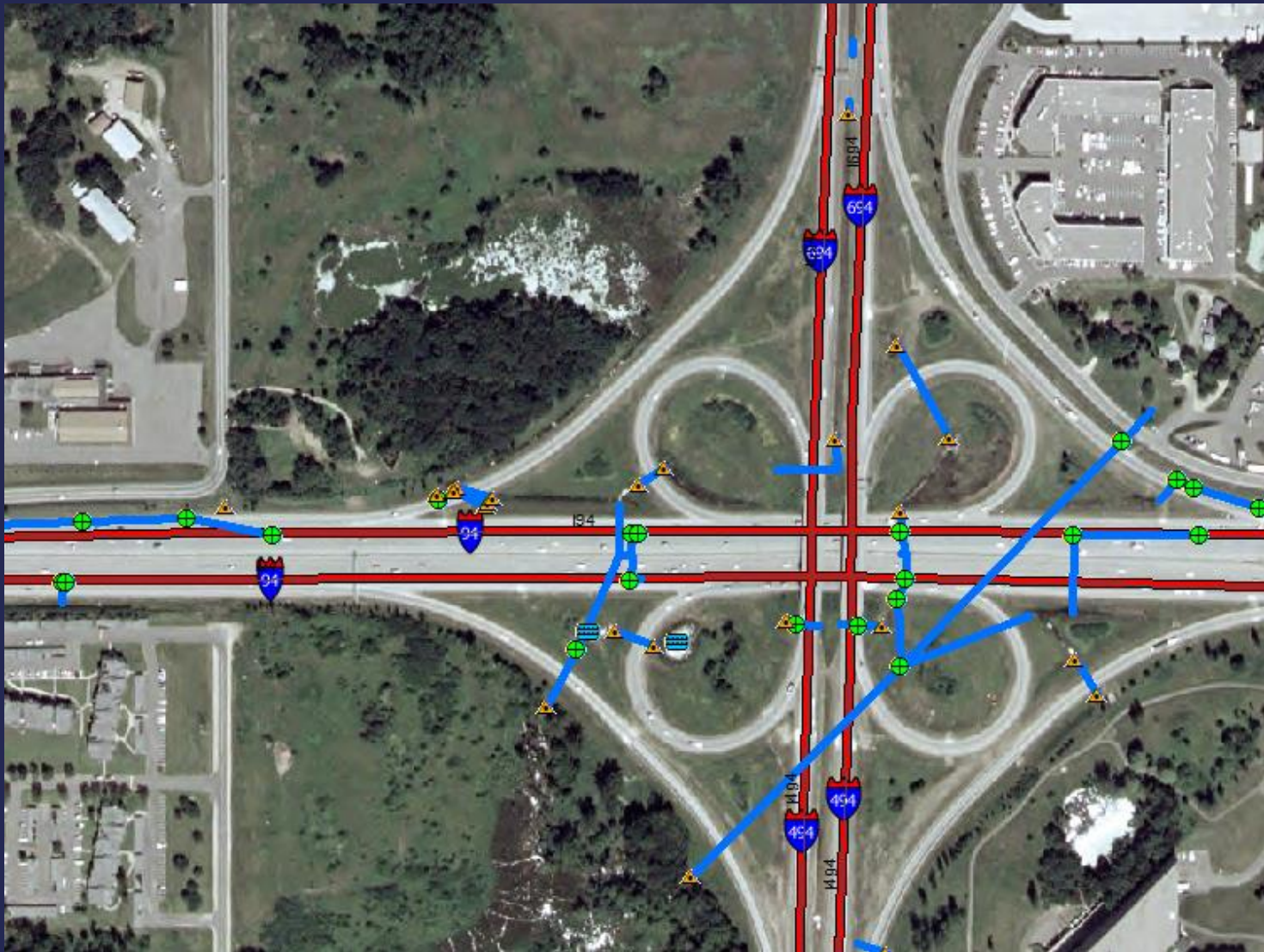




# 7. Map storm drain networks for MS4 Water Quality and Hazardous Spills

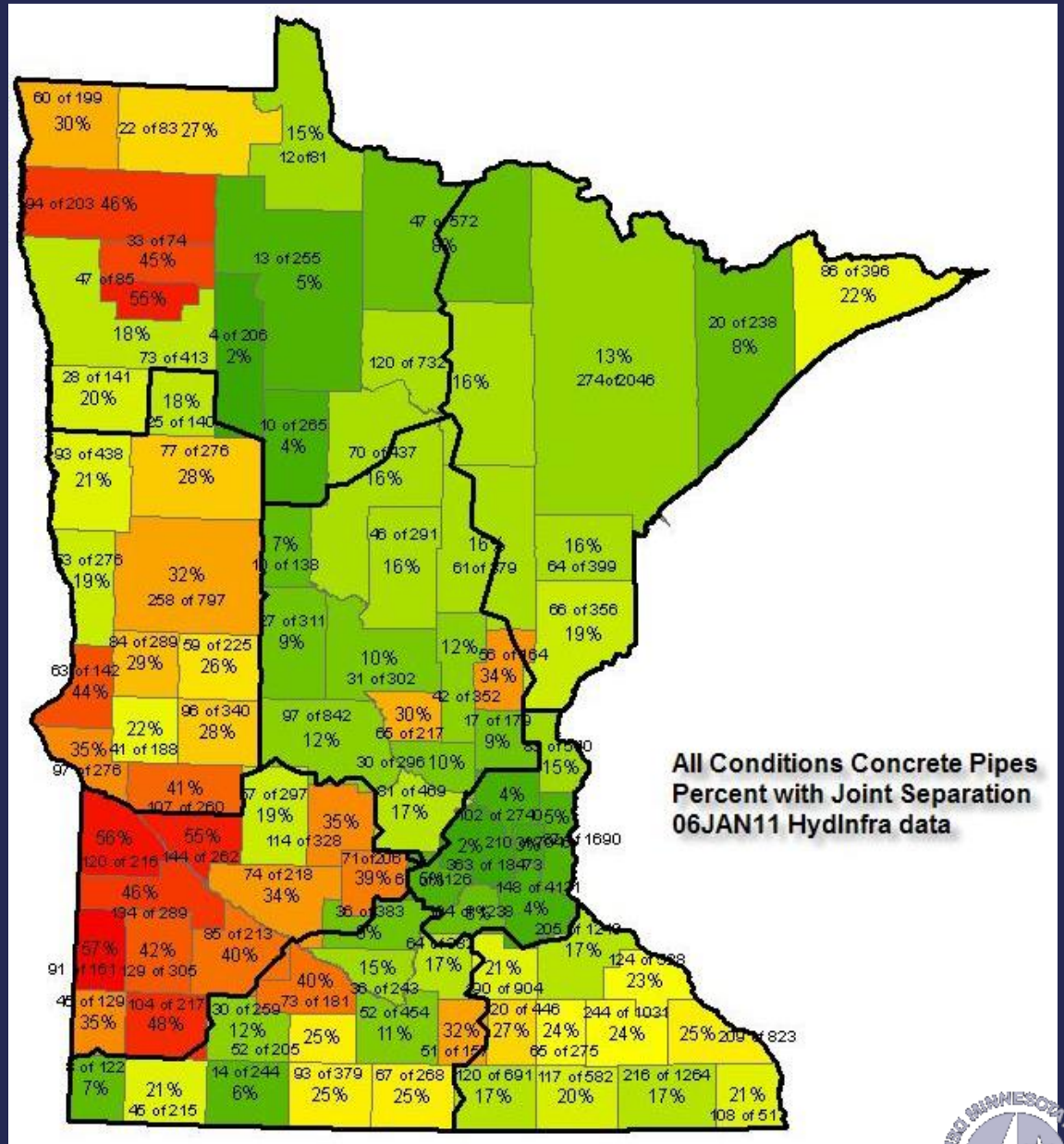
The image shows a screenshot of a web-based GIS application running in a Windows Internet Explorer browser. The browser address bar shows the URL: <http://gisservices2.dot.state.mn.us/mndot-wre/>. The page header identifies the user as 'Hydraulics - HydInfra' and the application as 'Mndot WRE'. The main content area displays the Minnesota Department of Transportation logo and navigation links: Home, A to Z, Getting Around, and 511 Traveler Info. A left-hand sidebar contains a legend with categories such as Ditches, SPCDs, Structures, Pipe Condition, Pipes, Bridge Culverts, Drainage Membranes &, Outfalls HYD, Ditch Outfalls, SPCD Outfalls, and Structure Outfalls. The 'Pipes' category is checked. The map area shows a street grid with labels for 6th St N, 4th St N, N 3rd St, Washington Ave N, 2nd St N, 33rd Ave N, 31st Ave N, and 30th Ave N. A yellow highlighted area on N 3rd St is labeled 'HazMat Spill'. A pink highlighted pipe segment on 31st Ave N is labeled 'There's the Outfall' with a yellow arrow pointing to it. The map also shows St. Anthony Falls Pond and major roads 153 and 23. A 'Toolbox' at the top of the map area includes icons for Out, Pan, Full, Back, Forward, Identity, Measure, Query, and Help.

# 8. Storm utility locations for “Call before you dig”

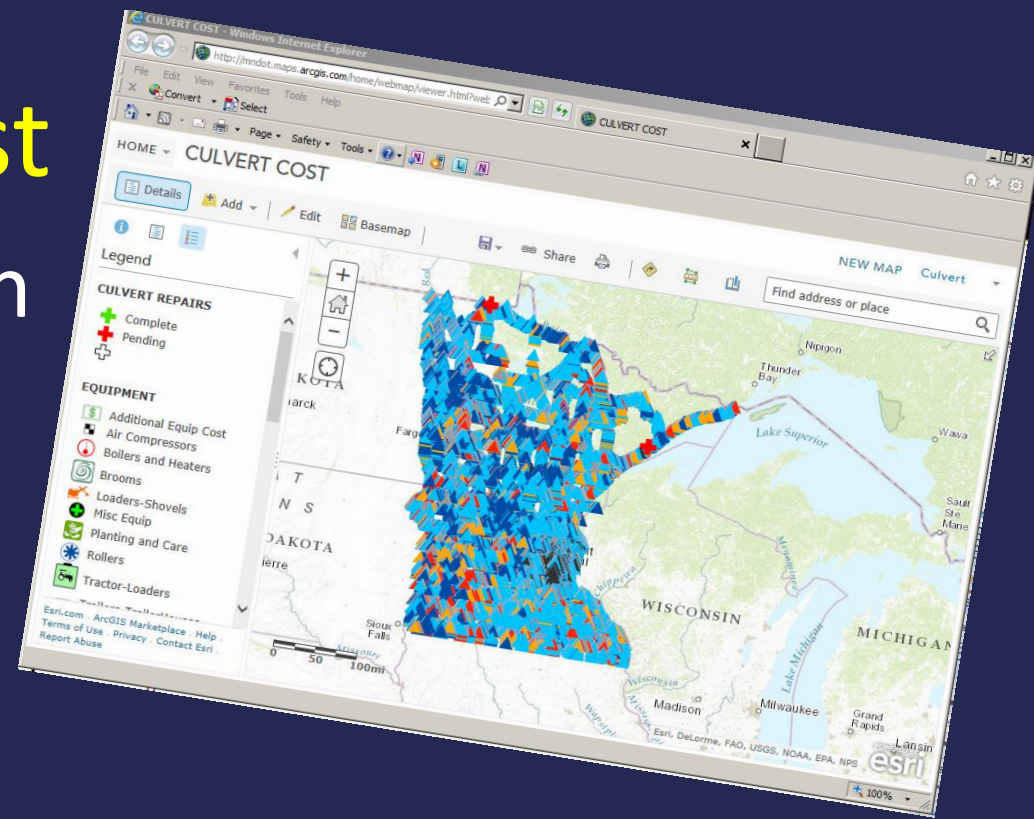


# 9. Research Pipe Materials

Inspection flags  
show **hotspots**  
for  
Joint Separation  
in Concrete Pipe



# 10. Lifecycle Cost capture started with “Wildly Important Goal”



- Maintenance captures culvert repair costs with Mobile App
- Construction costs are being estimated

# Mobile App captures Culvert Repair Cost

The screenshot shows a mobile application interface for managing culvert costs. The main title is 'CULVERT COST'. The interface includes a top navigation bar with 'HOME' and 'NEW' options, and a toolbar with various utility icons like 'Details', 'Add', 'Edit', 'Basemap', 'Share', 'Directions', 'Measure', and 'Bookmarks'. A sidebar on the left, titled 'Add Features', lists various equipment categories under 'CULVERT\_REPAIRS' and 'EQUIPMENT'. The 'Loaders-Shovels' category is highlighted with a red circle. The main area displays a map with a grey line representing a culvert and a blue triangle labeled 'PIPE ID: 607519'. A red crosshair icon is placed on the culvert line, and a red arrow points from the 'Loaders-Shovels' icon in the sidebar to this icon. An 'EQUIPMENT' data entry form is open, showing the following details:

Field	Value
REPAIR ID	977
EQUIPMENT CATEGORY	Loaders-Shovels
EQUIPMENT DESCRIPTION	Excavator, Hydraulic, Truck Mounted - HR
UNIT COST	760 4 Wheel Drive Loader-Hough, Pettibone - HR
QUANTITY	770 Shovels 1/2 C.Y.. or 3/4 C.Y. - HR
	772 Excavator, Hydraulic, Truck Mounted - HR

A 'DELETE' button is visible at the bottom of the form.



# Preliminary Repair Costs for Trench New Pipe are coming in

Repair Made	Total Cost	Culvert Type (Roadway)	Highway/ Not Highway	Material	Width (inches)
Trench New Pipe	\$2,924	Entrance	Not Highway	Corg. Plastic (HDPE)	24.00
Trench New Pipe	\$19,163	Centerline	Highway	Corg. Plastic (HDPE)	24.00
Trench New Pipe	\$10,058	Field Entrance	Not Highway	Corg. Steel (CSP)	36.00
Trench New Pipe	\$0	Centerline	Highway	Corg. Plastic (HDPE)	24.00
Trench New Pipe	\$3,258	Entrance	Not Highway	Corg. Steel (CSP)	8.00
Trench New Pipe	\$8,197	Field Entrance	Not Highway	Corg. Plastic (HDPE)	36.00
Trench New Pipe	\$4,423	Field Entrance	Not Highway	Corg. Steel (CSP)	18.00
Trench New Pipe	\$7,228	Farm Entrance	Not Highway	Corg. Steel (CSP)	18.00
Trench New Pipe	\$6,311	Other	Not Highway	Corg. Steel (CSP)	24.00



MnDOT will choose Asset  
Management Software this Fall.

HydInfra will be perfected!



Sad Reality:

**Competing needs** edge out culvert repairs

Legislature granted \$\$ for Maintenance to repair pavement.

Money has to be used this year, or it's gone.

So, culvert repairs waited because Maintenance forces were fixing pavement instead.





# HEAVEN ON EARTH

States **sharing** databases  
to improve  
Lifecycle performance

END?



# Repair is too late when road voids have occurred

**Cause: Bad Pipe**

**Effect: Bad Road**



Piping: water runs outside the pipe causing void in road



The road had collapsed.  
The culvert was still standing



Concrete pavement  
will span a road  
void for awhile,  
before it collapses.

# Use it – HydInfra Tasks:

- Provide condition rating codes everyone can understand and use
- Record drainage feature inventory data
- Track multiple inspections over time
- Track repairs or maintenance tasks and other activities
- Track tasks to comply with water quality, required by MS4
- Track performance measures for inspection cycle or condition targets
- Assist with project scoping and pre-design
- Speed response to capture hazardous spills
- Prioritize repairs based on feature attributes, roadway type and location
- Automate estimating for statewide repair needs and costs (costs in development)
- Track and research pipe materials' failure modes and performance over time (Correlations -- map materials' attributes to find patterns)
- Assist in flood/storm recovery
- Track and sum lifecycle costs over time (in development)



# Set up Drainage Asset Management System:

- 1. Condition ratings** that everybody can understand
  - 1 -4 rating is self-clear,
  - Ratings suggest maintenance action needed, or not
- 2. Explicit criteria** describe failure modes
  - Avoid words like “Moderate” or “Excessive”
    - (no one knows what those words mean)
  - Include measureable, or estimate-able criteria
    - Like Holes, or maximum joint separation
  - Odd materials require an overarching criteria
- 3. Pipe Materials** differ and defects need to be described
  - Metal gets holes
  - Concrete joints separate
  - Plastic deforms or floats
- 4. Drainage feature types**
  - Pipes, Structures, Ponds, Water Quality devices, Ditches, Special Structures, Discharge Points, etc
  - Rate all features with similar criteria, based on materials
- 5. Use GPS and GIS** to identify features
  - Map it and you understand the context
- 6. Hydraulics and Maintenance** people are in this together
  - Flow of ideas helps us ask the right questions
  - Maintenance Performance Measures for Culverts caused it to happen
- 7. User support** people get continuous feedback from Users and develop improvements



# Use it – HydInfra Tools:

## –Web-based data access

- Reports
- Data upload (internal and external access)
- Map service for information in the field
- GIS data access tools simplify access in the office
- Mobile App for Maintenance' Repairs



# HydInfra Credentials:

- 2005 Federal Highway Administration Transportation Asset Management Case Studies “Culvert Management Systems Alabama, Maryland, Minnesota, and Shelby County”
- 2014 MnDOT Map21 TAMP Federal study with MN, Louisiana and NY.
- 2010 Federal Lands Highways’ [Chapter 2 - Culvert Assessment Tool](#) of the “[FHWA FLH CULVERT ASSESSMENT GUIDE](#)” borrowed elements from [HydInfra condition rating criteria](#)
- Currently NCHRP 14-26 Culvert Inspection Manual panel member

