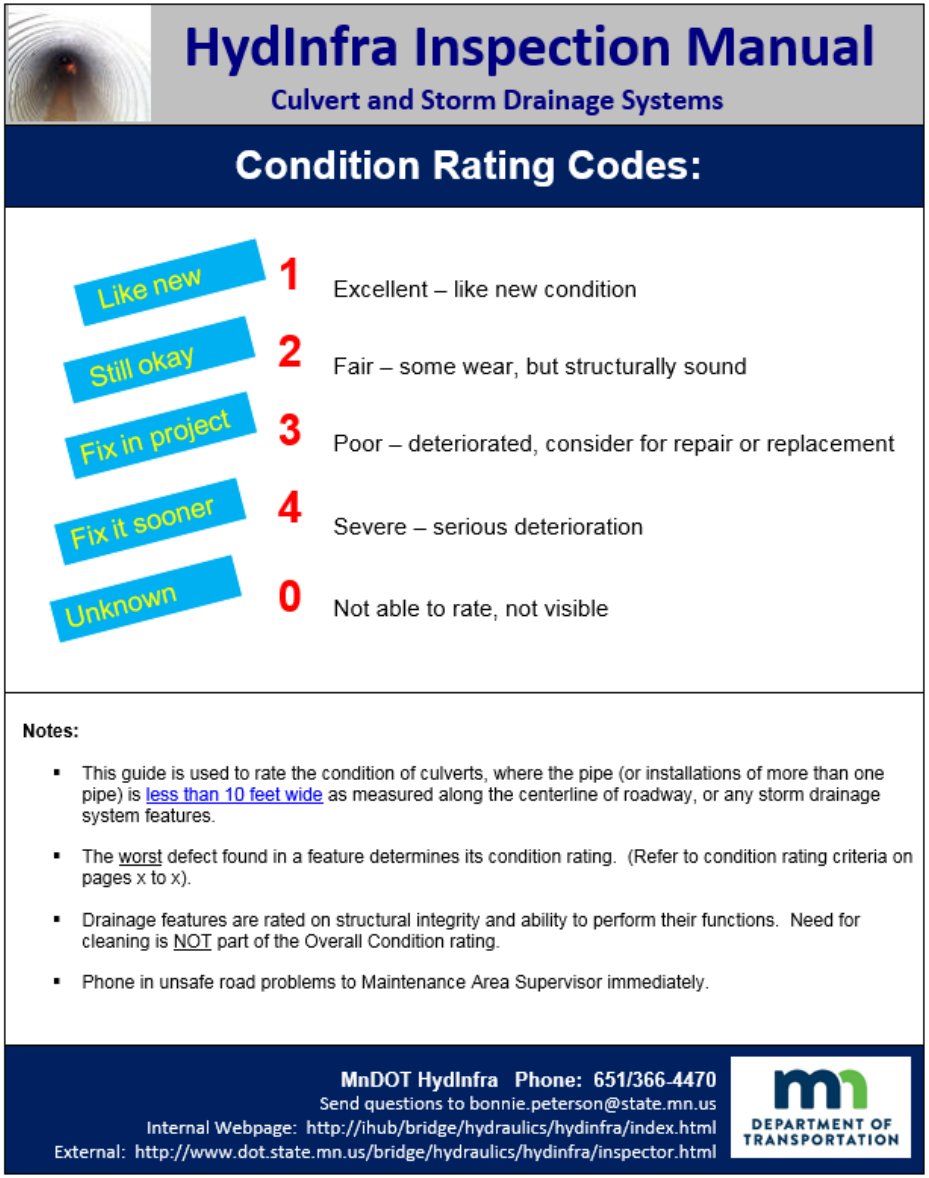
HydInfra Terms, Flags and Measures

Illustrated Guide to the HydInfra Manual

2020 June



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	Severe – serious deterioration
Unknown	0	Not able to rate, not visible

Notes:

- This guide is used to rate the condition of culverts, where the pipe (or installations of more than one pipe) is less than 10 feet wide as measured along the centerline of roadway, or any storm drainage system features.
- The worst defect found in a feature determines its condition rating. (Refer to condition rating criteria on pages x to x).
- Drainage features are rated on structural integrity and ability to perform their functions. Need for cleaning is NOT part of the Overall Condition rating.
- Phone in unsafe road problems to Maintenance Area Supervisor immediately.

MnDOT HydInfra Phone: 651/366-4470
Send questions to bonnie.peterson@state.mn.us
Internal Webpage: http://ihub/bridge/hydraulics/hydinfra/index.html
External: http://www.dot.state.mn.us/bridge/hydraulics/hydinfra/inspector.html

DEPARTMENT OF TRANSPORTATION

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Revised April 26, 2018

HYDINFRA

is Mn/DOT's

Hydraulic Infrastructure Inspection Program

HydInfra Culvert pipes are those less than 10-foot span that do not fit the definition of a Minnesota Bridge:

It is a bridge (and not a HydInfra culvert) if

Total Span of one or more pipes is 10 feet or greater, as measured along the highway centerline,

and the gap between pipes is less than half the smaller pipe's interior diameter.

HydInfra culverts are smaller than bridges (Not HydInfra if there's a Bridge No.)

HydInfra Culverts are less than 120 inch span

MN State Law defines Bridges as 10 foot span or greater. If it has no Bridge number, email Lisa.Hartfiel@state.mn.us

HydInfra Inspection Manual Stipulations:

- This guide is used to rate the condition of culverts less than 10 feet wide or any storm drainage system features.
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(Click links to pages on web manual index)

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TAMS HydInfra

Inventory Terms

Transportation Asset Management Terms

- TAMS – Transportation Asset Management System
- TAMS – the Agile Assets software used on a PC
- Collector – app used on a tablet in the field with GPS to inventory and inspect assets
- TAMS-HydInfra – MnDOT's small culvert and storm drain inspection program
- TAMS Work Order Management – Maintenance assigns work, and records costs, on asset repairs and more
- (Not in TAMS: NBI, BIRM and SIMS – 10 ft. span and larger culverts or bridge inventory asset management)

TAMS-HydInfra has 3 Asset Types:

- Line features – Pipes
  - Culverts
  - Storm Drain
  - Open Channels
  - Drain Tile
- Point features – Structures
  - Structures MH, CB and Drop Inlet
  - SPCDs (Water Quality Devices)
  - Special Features
- Polygon features – Ponds
  - Pond or
  - Basin

Asset have Inventory records

(Status, Class Code, Type, Size, Shape, Material, location, ownership
and other descriptive fields)

Status

Active Status: Inplace -- working, in the ground

Not Active:

- Abandoned: plugged and left in ground
- Removed: taken out of ground
- Duplicate: if 2 records for one pipe
- Review Status: check Status
- Turnback: road has been given to local gov't
- Proposed: blank asset ID created for plan

Status: Abandoned

is plugged and
left in the ground

Status: Removed

is taken out of the ground

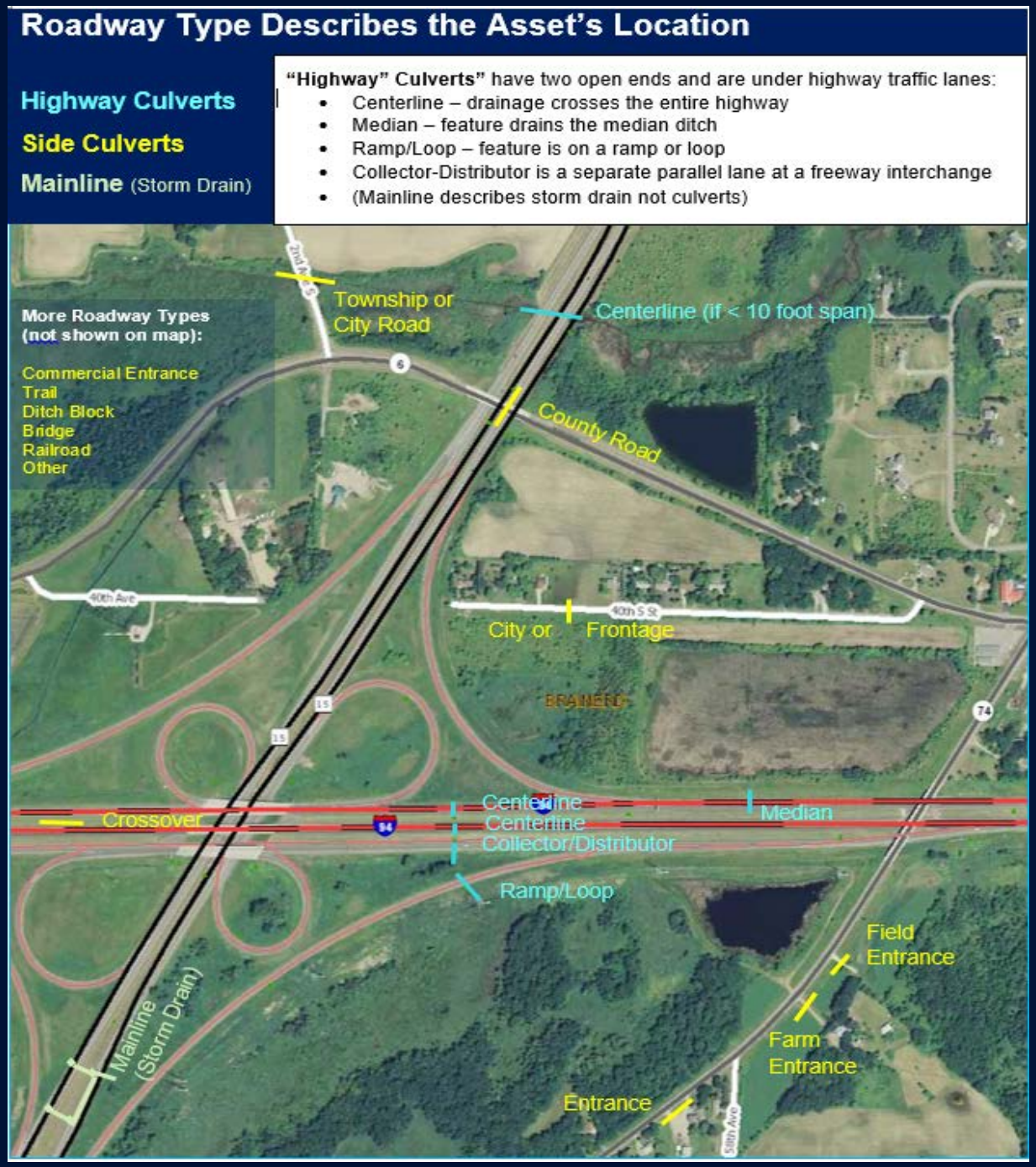
Materials in TAMS-HydInfra

Accurate identification of pipe material is essential to tracking material performance

- Concrete
- Brick/Masonry
- Aluminized Steel
- Corg. Steel (CSP)
- Structural Plate (Steel)
- Polymeric-Coated (Steel)
- Bituminous-Coated (Steel)
- Steel Casing
- Corg. Aluminum (CAP)
- Timber
- Vitrified Clay
- Other
- Corg. Plastic (HDPE)
- PVC
- PP - Polypropylene
- Perforated Plastic (pond drains)
- SRPE - Steel ribbed Polyethylene
- Liner HDPE
- Liner PVC
- Liner Cured in Place (CIPP)
- Liner Metal
- Liner Other

Roadway Type

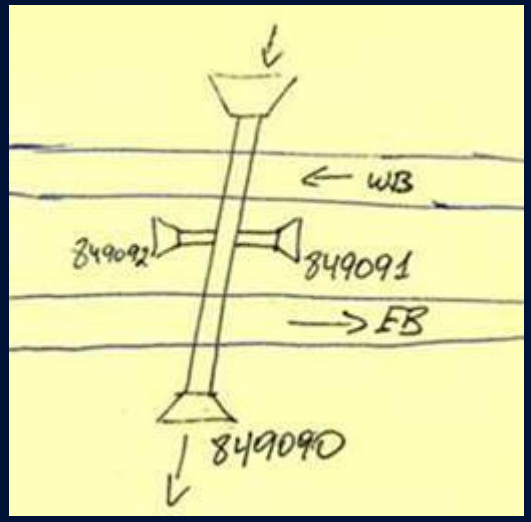
- Highway Culverts
- Side Culverts
- Not Culvert



Roadway Types:

Centerline and Ditch Block

(Ditch Block is not Median because it doesn't cross the lanes of traffic)



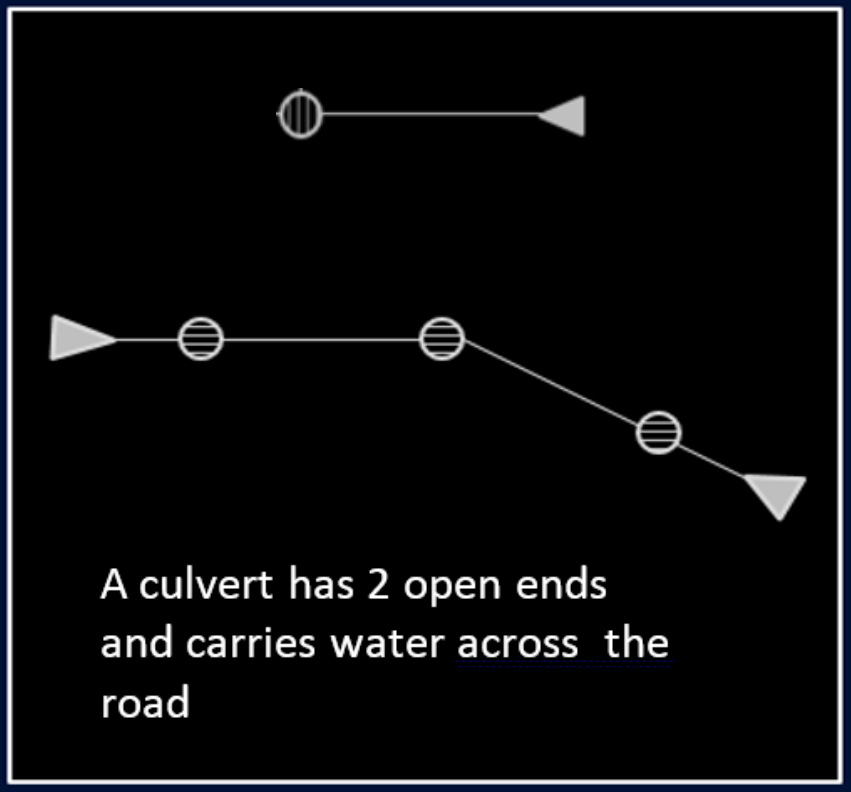
Clarification question and Sketch by Katie Westphal WSP_PB

Asset Type Pipe has 4 Class Codes:

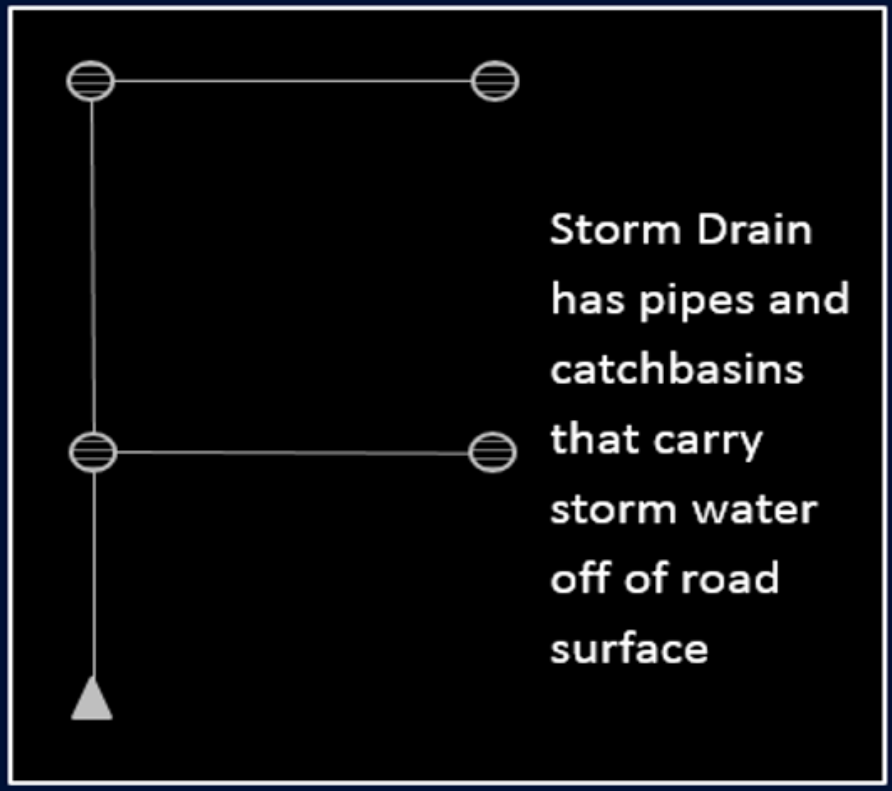
1. Culvert
2. Storm Drain
3. Drain Tile (ag. tile or perf. pipe
4. Waterway (ditch)

Choose Pipe Class Code

Is it a Culvert or Storm Drain Pipe?

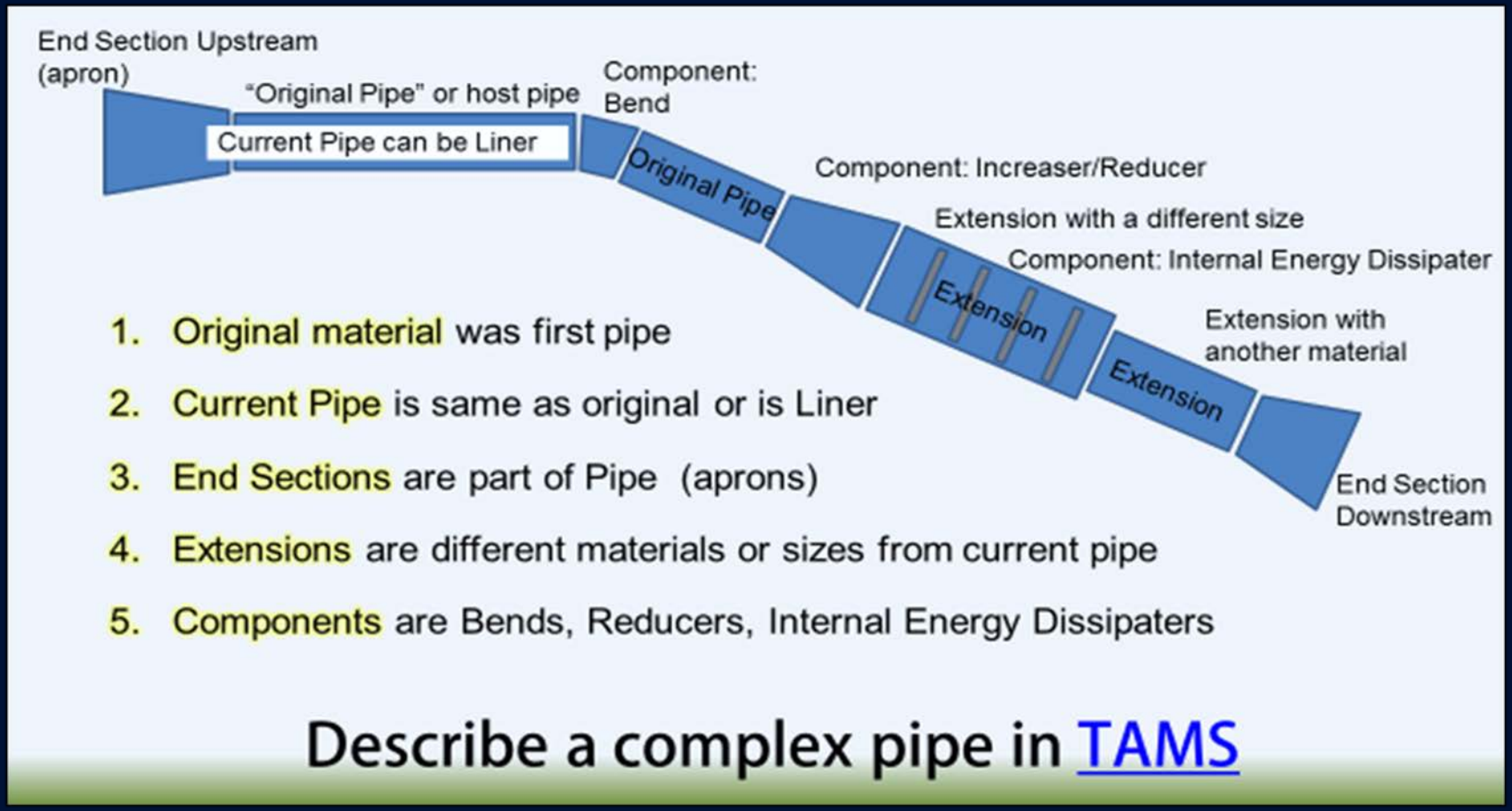


A culvert has 2 open ends and carries water across the road



Storm Drain has pipes and catchbasins that carry storm water off of road surface

Inventory describes the Pipe

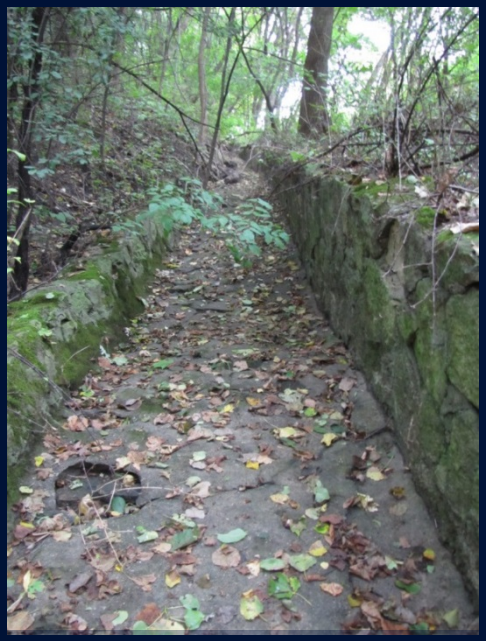


Submenus describe the Pipe's End Sections, Extensions and Components

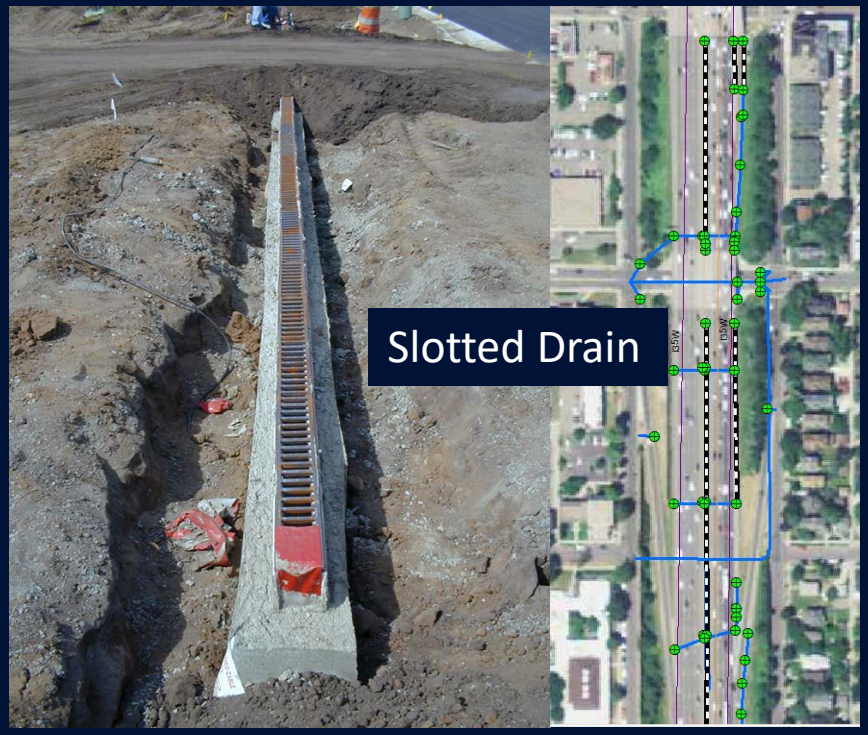
Pipe Type

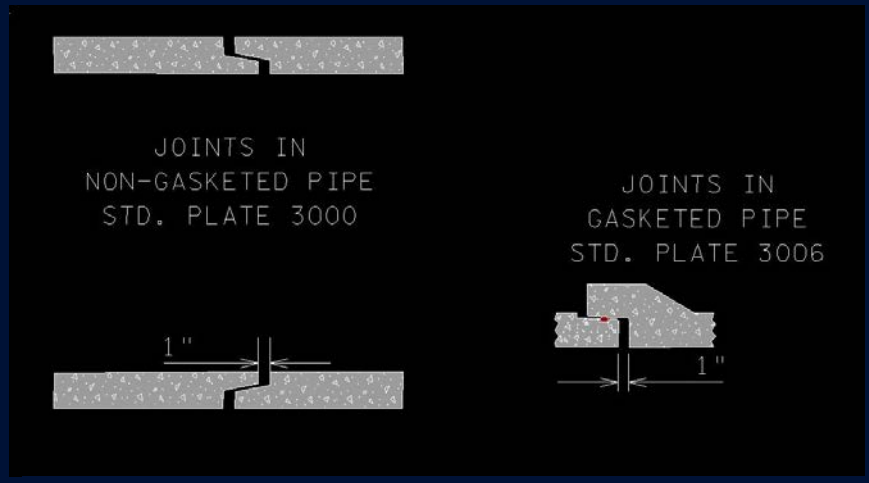
includes

- Slotted Drain
- Open Flume
- Gasketed
- Non-gasketed



Class Code: Open Channel and Pipe Type: Open Flume





Non-gasketed (joint)

Gasketed (joint)

Class Code: Open Channel and Pipe Type: Open Flume carries water down a slope in a special channel

Onlookers get a close-up view of construction

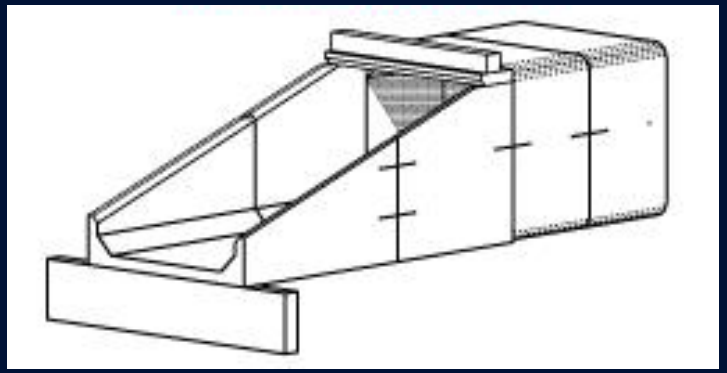
S:\Hydraulics\photos\Slide Scanning Photos\Scanned Hydraulics Slides\E7 390-20M 402 (Jackson Flume)

Pipes have sub-menus for

- End Sections (Flared Aprons, Safety Aprons, Flapgates, etc.)
- Components (Bends, Increaser Reducer, etc.)
- Extensions (different pipe shape, size or materials)
- Repair History (repair records from Culvert Cost app)

Pipe End Sections

- Box End Section
- Flared Apron
- Safety Apron
- Flap Gate
- Headwall
- Headwall/Wingwall



Flared Apron withTrash Grate

Flared Apron

Safety Apron 10:1

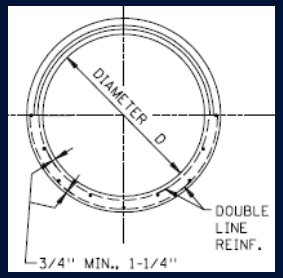
Pipe Components are captured in a submenu

Component describes other things inside the pipe including Increaser/Reducers, Energy Dissipater D-rings, Bend sections and Internal Band repairs.

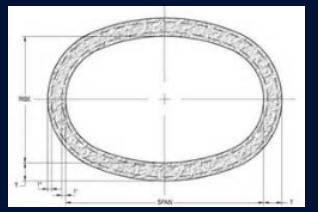
Pipe Shape

Most Common Pipe Shapes

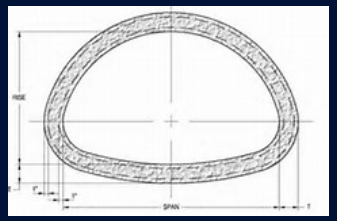
- Round



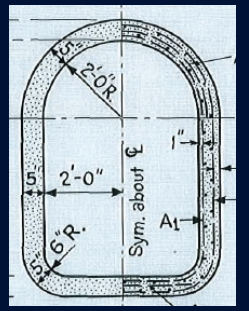
- Elliptical



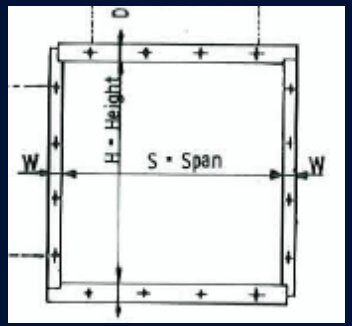
- Arch



- CattlePass

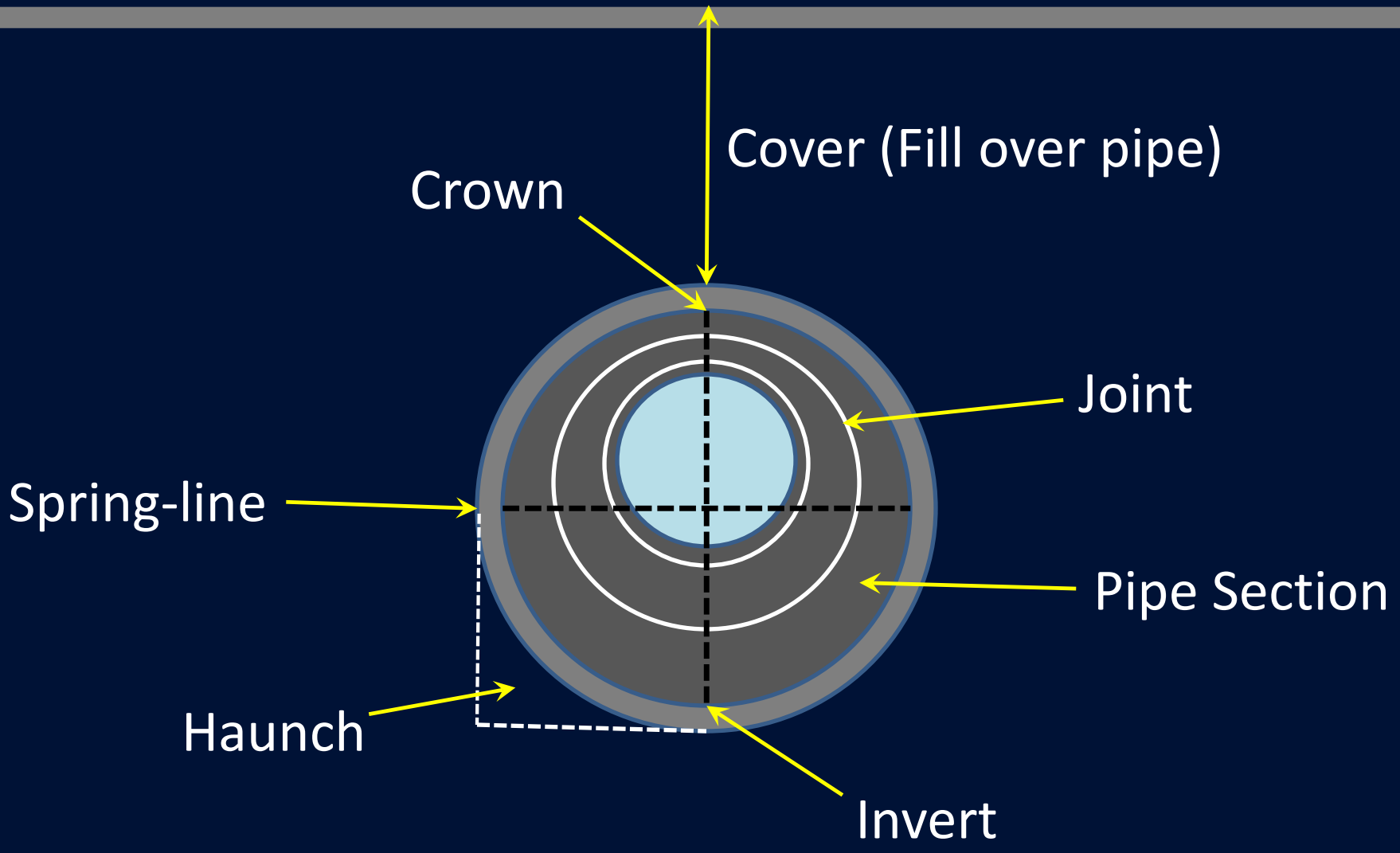


- Box



- Waterway (ditch or channel)
- Other
- Do not use Tunnel- shapes

Names for parts of a pipe



Clock time to describe defect locations

(as viewed from upstream end of pipe)

Hole or broken joint at 4 o'clock

Longitudinal crack at 6 o'clock

Asset Type Structure - Inventory

3 Structure Class Codes have 3 different Inspection forms:

1. Structure (CB, MH, DI)
2. SPCD (water quality)
3. Special Feature

HYD_STRUCTURE (point features)			
	Asset Class	HYD_STRUCTURE_TYPE_NAME	Description
HYD_STRUCTURE	Structure	Buried Manhole	Buried MH is hidden beneath surface
		Catch Basin	CB structure has grate with inflow from pavement
		Deck Drain	Deck Drain captures flow on a bridge
		Diverter	Diverter structure splits or changes flow
		Drop Inlet	DI captures drainage in ditch or swale
		Inspection Tee	Inspection Tee is opening to view or maintain structure
		Manhole	MH structure is a solid-top junction with no inflow
		Other	Other may be an odd type of storm drain structure
	SPCD	SPCD - Filter	Filter uses sand, gravel or screens to separate sediment
		SPCD - Grit Chamber	Grit Chamber has multiple cells to drop out sediment
		SPCD - Infiltration Device	Infiltration device distributes water to gravel area below
		SPCD - Separator	Separator swirls inflow to spin out cleaner outflow
		SPCD - Skimmer	Skimmer holds back floatable debris and oils
		SPCD - Sump MH	Sump manhole has pit in bottom to store some sediment
		SPCD - Sump MH with Baffle	Baffle in Sump MH is a plate with holes to prevent re-suspension of sediment
		Other	Other may be an odd type of water quality device
	Special Feature	SpecFeat - Ditch Block	Ditch Block is a tiny dam to divert water to a pipe
		SpecFeat - Energy Dissipater	Energy Dissipater, usually of concrete, tumbles flow
		SpecFeat - Floodgate	Floodgate caps downstream pipe end when it floods
		SpecFeat - Overflow	Overflow structure handles highwater outflows
		SpecFeat - Riprap	Riprap is broken rocks to dissipate flow velocity
		SpecFeat - Weir	Weir is a partition designed to overflow at specific level
		Other	Other is a strange structural asset not specifically listed

Class Code
Structure

- Catchbasin - CB

- Manhole - MH

- Drop Inlet - DI

And less common:

- Buried Manhole
- Control Structure
- Deck Drain
- Diverter
- Inspection Tee

Class Code: Structure
Structure Type: SPCD
(a water quality device)

Structural Pollution Control Device, Separator on MN 23 D8

Class Code: Structure
Structure Type: Special Feature

Structure Types for Special Feature:

- SpecFeat - Ditch Block
- SpecFeat - Energy Dissipater
- SpecFeat - Floodgate
- SpecFeat - Overflow
- SpecFeat - Riprap
- SpecFeat - Weir

What is the purpose? Special Features are odd structures with a purpose.

Historic photos from S:\Hydraulics\photos\Slide Scanning Photos\Scanned Hydraulics Slides\B22

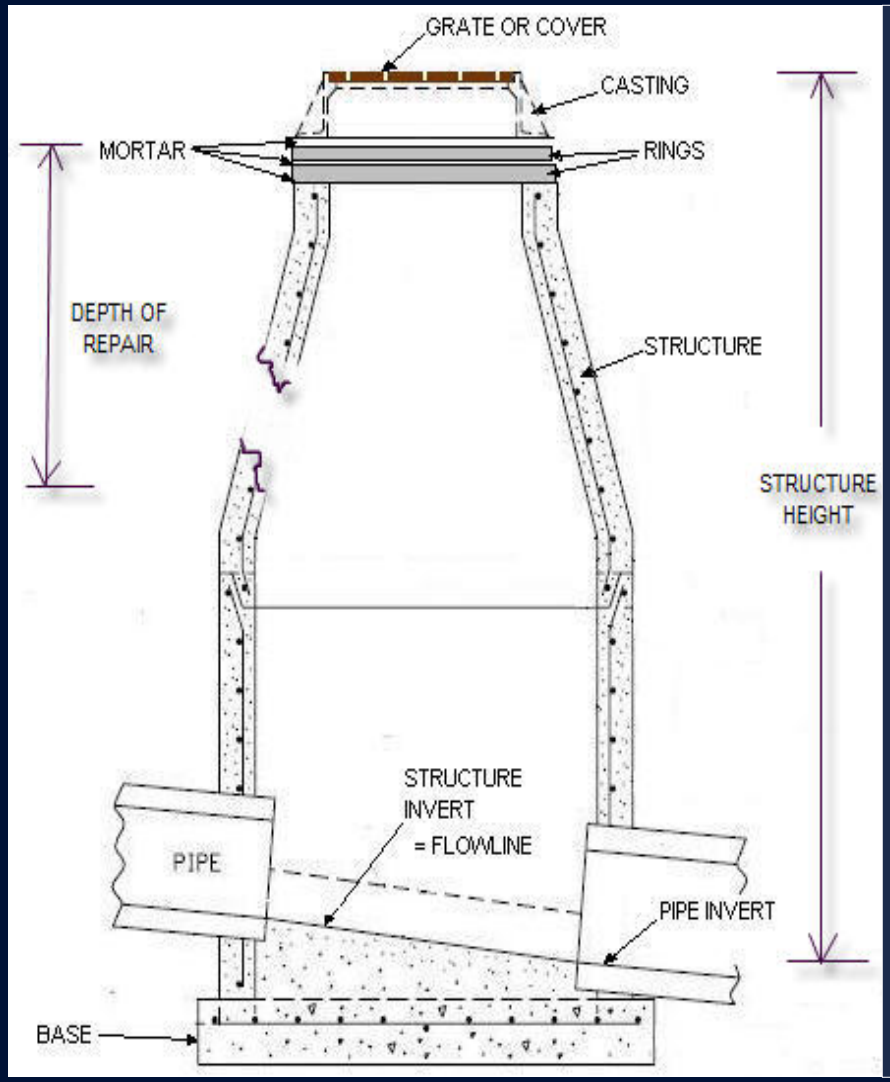
Most Structures are

Type: Structure

(catchbasins, manholes, drop inlets)

Structure Terms

For Class Code- Structure: Catchbasin, Manhole and Drop Inlet



Structure Height – Measure from top of grate to bottom of invert

Repair Depth – Measure from bottom of casting to bottom of the needed repair

Connected Pipes – number of pipes attached to the structure

Sump – a basin below the outgoing pipe that is deeper than 1 foot

Deteriorated Rings – (an inspection flag) The adjusting rings (= layers below the iron casting assembly) are broken or cracked. Rings may also have missing mortar.

Inside the structure, rings are below steel casting

Manhole (solid cover) with 3 rings

Drop Inlet
“ankle buster”

Asset Type Pond

Pond or Basin			
HYD_POND (polygon features)			
	Class Code	**Pond/Basin Type**	**Description**
HYD_POND	Pond	Dry Pond	Dry pond has outlet elevation at pond bottom and drains dry
		Mitigation Wetland	Mitigation Wetland was built to offset wetland loss on a construction project. Look for NWC (New Wetland Credit) or PVC (Public Value Credit) or other note on plans
		Natural Wetland	Natural Wetland identifies a pre-existing wetland protected by Minnesota or Federal law
		Unknown	Unknown type is used when the type is unidentified.
		Wet Pond	Wet pond normally has water up to the level of the outlet structure
	Basin	Filtration Basin	Filtration Basins might have draintile that allows drawdown between rainfalls.
		Infiltration Basin	Infiltration Basins are built to leak into the ground until dry. They normally have living plants on basin bottom

Class Code: Pond or Basin

Class Code
Pond or Basin

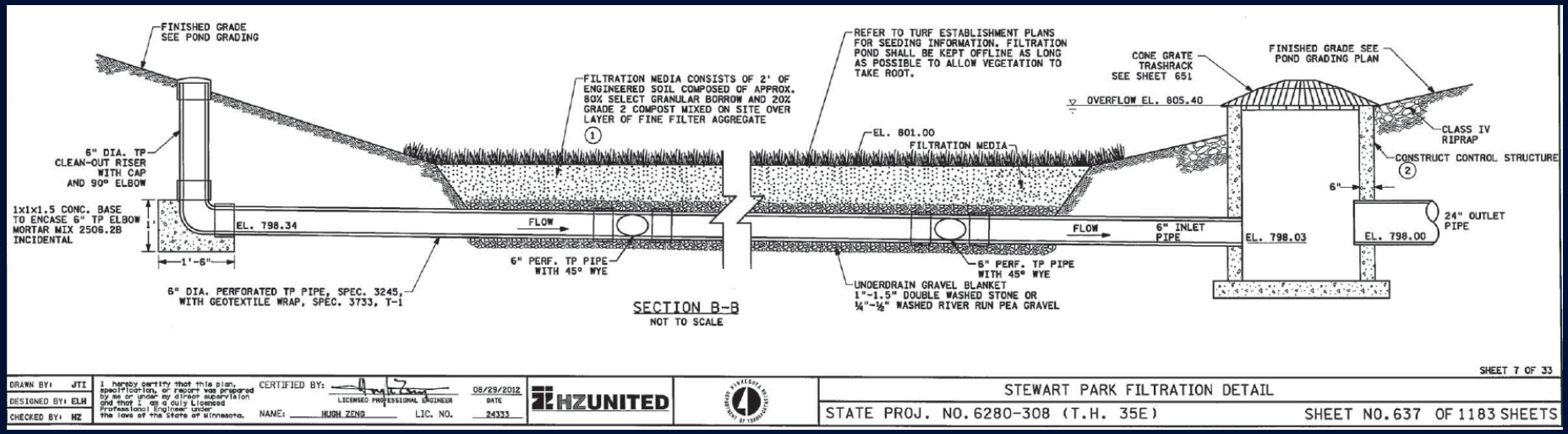
Ponds

are designed to detain or retain water and slow the outflow

Basins

are designed to filter or infiltrate stormwater, and maintain vegetation

Perforated pipe under Filtration Basin allows plants to live



Notice in profile view:

clean-out riser Perf. Pipe underdrain Outlet Control Structure

Inspection Terms

(Condition ratings, defects, repair needs, etc.)

Page 11-13

Capture Defects with Inspection

Flags and Measures

Flags and Measures

describe the condition

HydInfra Inspection Manual

Culvert and Storm Drainage Systems

Inspection Flags and Measures

		Images
Condition Indicators	• Needs Repair? • Repair under Road • Piping • Cracks • Holes • Deformation • Misalignment • Spalling/Flaking • Pitting/Rusting • Joints Separated* • Maximum Joint Separation • Number of Separated Joints • Separated Apron	Needs Repair Repair Under Road Piping Cracks Holes Deformation Misalignment Spalling/Flaking Pitting Rusting Joints Separated Max Joint Sep # Joints to Fix Apron Separated
Roadway Indicators	• Void in Road • Road Distress • Inslope Cavity • Erosion/Scour	Road Void Road Distress Inslope Cavity Erosion
Not in Condition Rating	• Needs Clean? • Plugged • **Sediment % Full** • **Water % Full** • Typical Water Flow	Needs Clean Plugged Silt Water Typical Water Flow

What's bad and how bad is it?

Choose the Flags that best describe the defects

Not all defects have flags to match.

Use Comments to describe the odd ones.

Inspection questions
start with the road condition

and end with your suggestions for needed repairs

Road Distress –

Pavement problem – Road Bump, Dip, Pavement Patch or Cracks (indicators of possible loss of roadbed through a poor condition pipe or structure).

Pavement problems can be visible when piping and road void are present.

Photo by HydInfra Inspector Brad Fredin
October 2018, MN55 project

Road Distress,
Road Void,
Piping

Void in Road – Evidence of a loss of soil from the road around or near the pipe or other feature.

D6 Jacked Pipe creates road void 27SEP2011 – Rob Coughlin

Void in the grout between slipliner and host pipe allows continued Piping and Road Void

Photos from Ohio DOT Office of Hydraulic Engineering, Jeffrey E. Syar, P.E., 11AUG17

Inslope Cavity –

A cavity or hole in the inslope of the roadway above an apron or pipe joint. Usually found in areas where joint separation has occurred.

Separated aprons affect the inslope, so are rated Condition 3. Condition 3 Highway Culverts only need inspections once every 4 years (that's not terribly often).

Separated aprons can be the first stage in major problems that can accelerate during a big rainstorm.

D7 MN30 Structural Plate, photo from Richard Vogelsang

Separated Apron –

Describe which end of pipe has a separated apron

- Inlet
- Outlet
- None
- Other
- Both
- No Aprons

Inslope cavities caused by apron and joint separations are hazardous for mowers. Most are not obvious like this one is.

Water Observed –

Describe the typical water situation in the pipe:

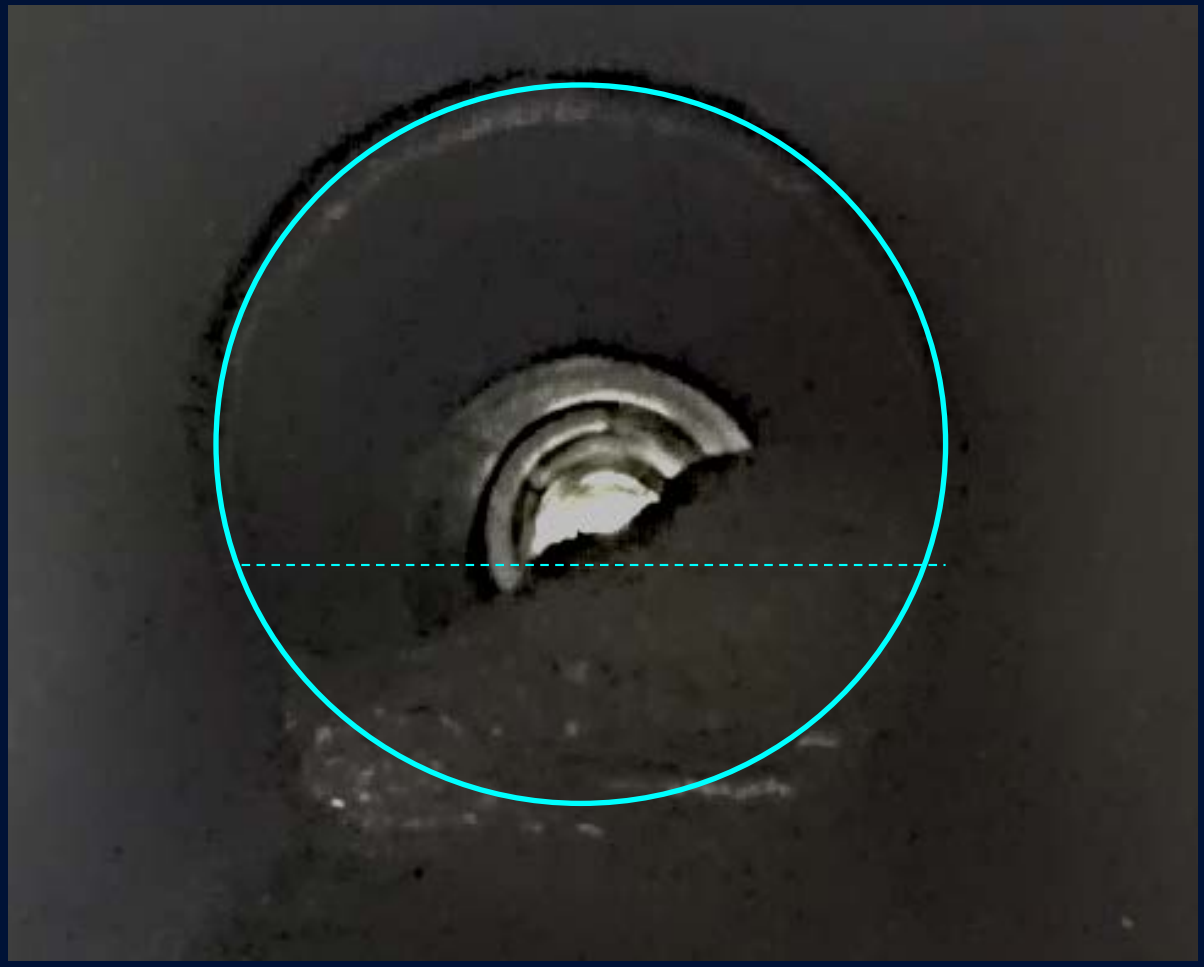
- Dry (usually has no water)
- Slow
- Fast
- Standing
- Full
- Saturated Soils

Water % Full – Today, how high is the water in the pipe, as a percentage of pipe height?

Erosion (or Scour) – Erosion or channel degradation has occurred as evidenced by a gully or loss of vegetation, caused by water flows.

Sediment Percent Full –

Estimate of sediment inside pipe compared to pipe height



Plugged –

Something is in pipe causing water to backup or restrict the water flow.

Needs Clean? –

Does this feature need to be cleaned?

- Yes, if Pipe is 30% or more full of sediment.
- Sediment or Debris will impede drainage.
- Or Plugged flag = Y

Looking inside the pipe

Pitting/Rusting –

Small pits are visible in the surface of the pipe, or if metal, rusted but still solid.

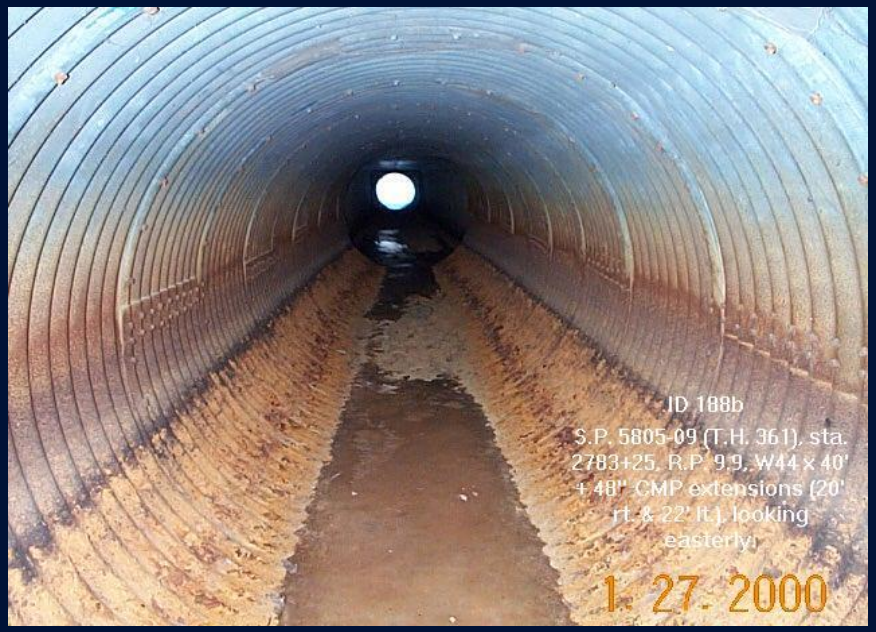
Aluminized-steel pipe may have rust at seams or joints.

Why are some DOTs are seeing early corrosion in aluminized pipes? This aluminized pipe in Ohio is about 12 years old. The material is flat-seam spiral rib aluminized steel – the ribs are folded seams visible on the outside of the pipe.

Photo from Ohio DOT.

Spalling/Flaking –

Flat chips of concrete are lost from feature's surface or if metal, flakes of rust are falling away.



Holes –

Hole goes completely through the asset's material.

Cracks –

- Not Visible
- Crack
- Fracture
- Displaced
- Unknown
- (don’t use Yes)

Deformation –

Feature's shape is distorted, flattened or oval-ed.

Deformed Concrete pipe also has cracks, spalling, slabbing.

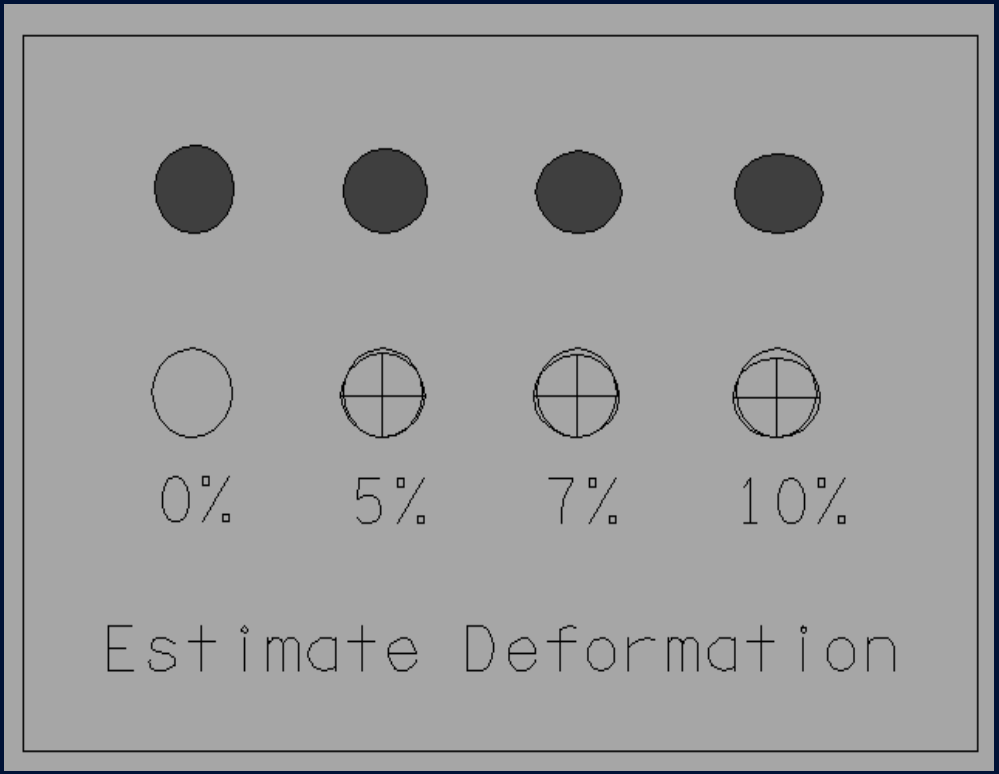
Fracture shows rust from reinforcing steel

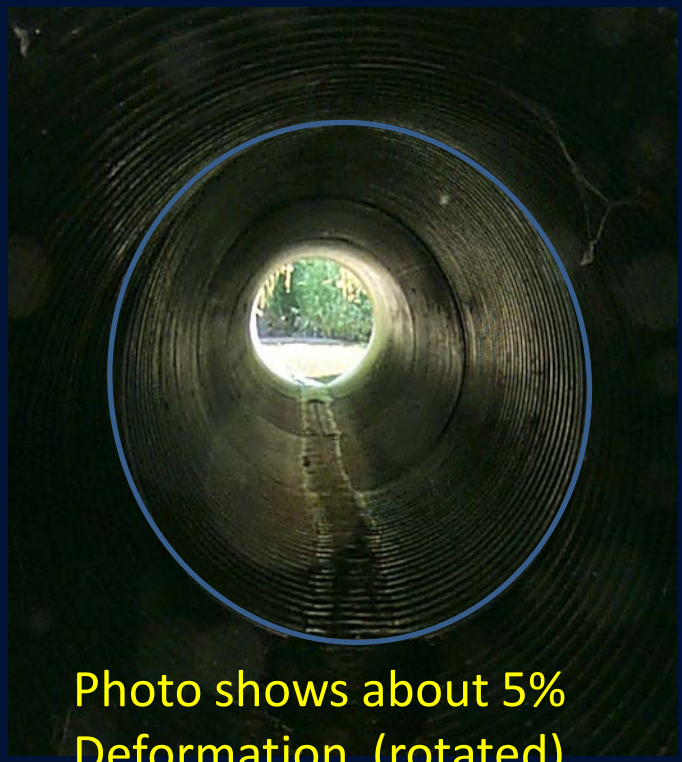
Concrete Fracture circumferential crack shown in video inspection.

Inspection criteria Condition 3:

*Water infiltration through cracks or rust staining or efflorescence.

Estimate Deformation in Pipe

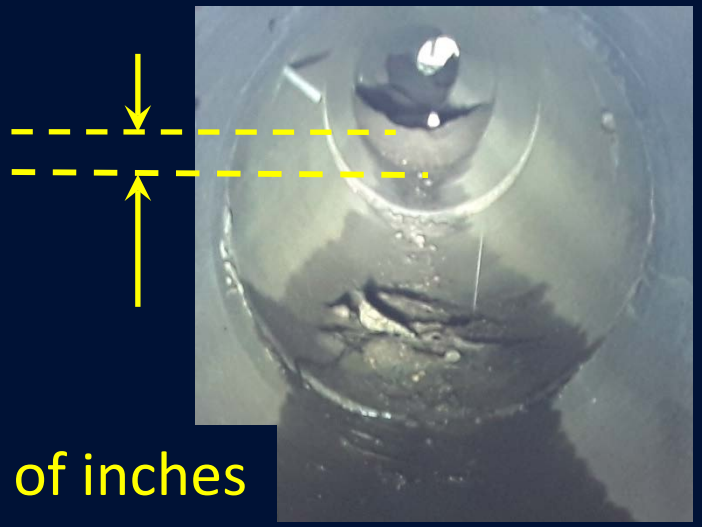




Then apply Plastic rating criteria (pg. 30 and 31) for Condition Rating.

Misalignment –

The pipe sections are offset and alignment is bad.



Estimate number of inches pipe is out of alignment

Photo from Metro WRE Bonnie Peterson

Photos from D3 Troy Gratke

Deteriorated Ties –

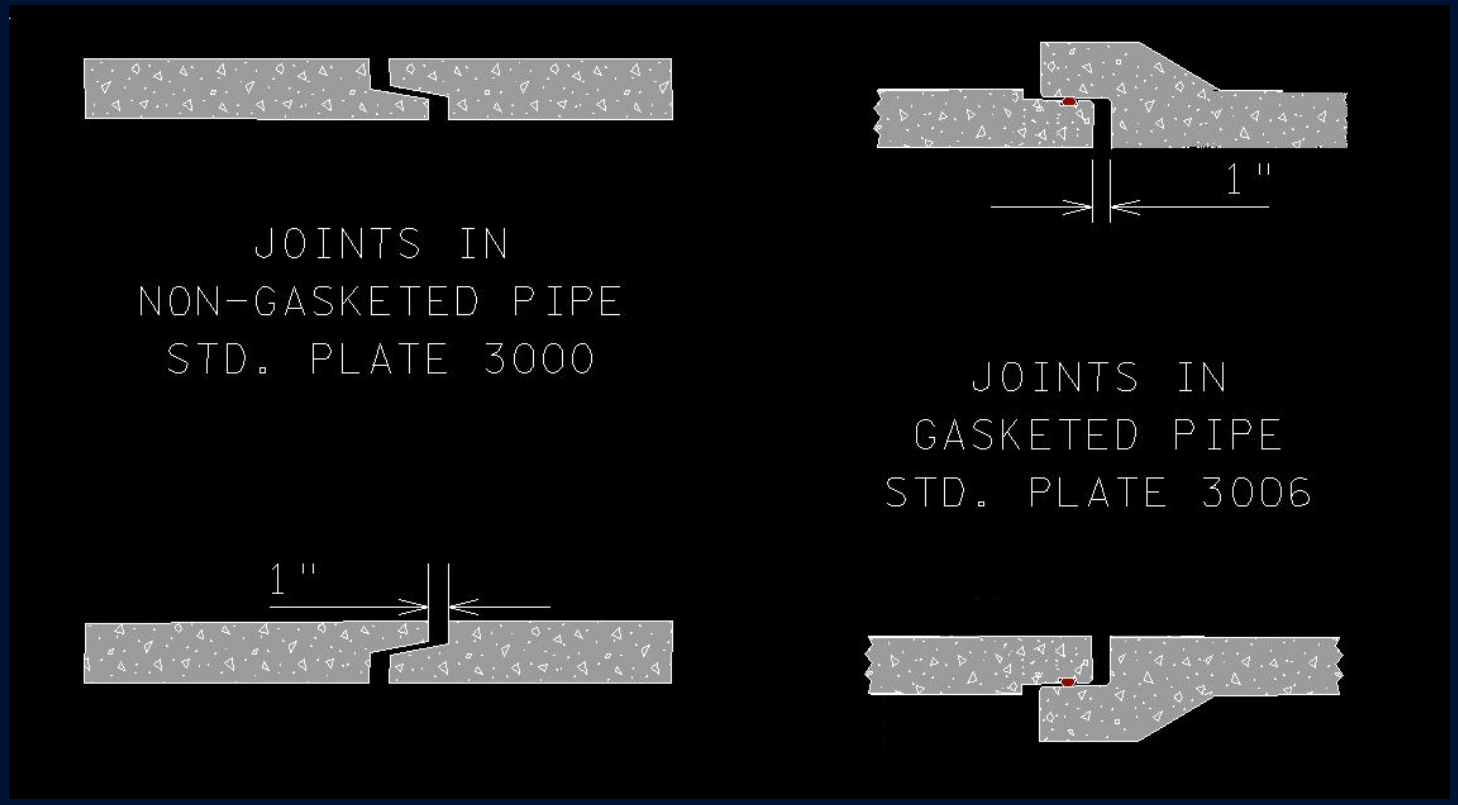
Pipe ties are rusted or broken, may not hold pipe joints together.

A good tie bolt looks like this:

Max Joint Separation –

Estimate or measure the largest separation between pipe sections

Max. Joint Separation in Concrete in non-gasketed or gasketed pipe



24” pipe examples with
Pipe Type 3000 and 3006

Estimate gap between pipe sections

Joints to Fix –

Count the number of joints that are separated by 1 inch or more, or have evidence of soil infiltrating the joints.

Infiltration –

Evidence that soil or water is seeping into pipe.

Piping –

Water is flowing along the outside of pipe (causes loss of soil in roadbed).

Gap outside of pipe allows water to carry road fill away.

Imagine water rising at the pipe inlet.

A **gap** between pipe and structure can cause **piping** and loss of road fill.

This is what piping looks like –

water leaves the pipe at holes or joint separations and flows along the outside

After the defect flags,
describe the repairs needed

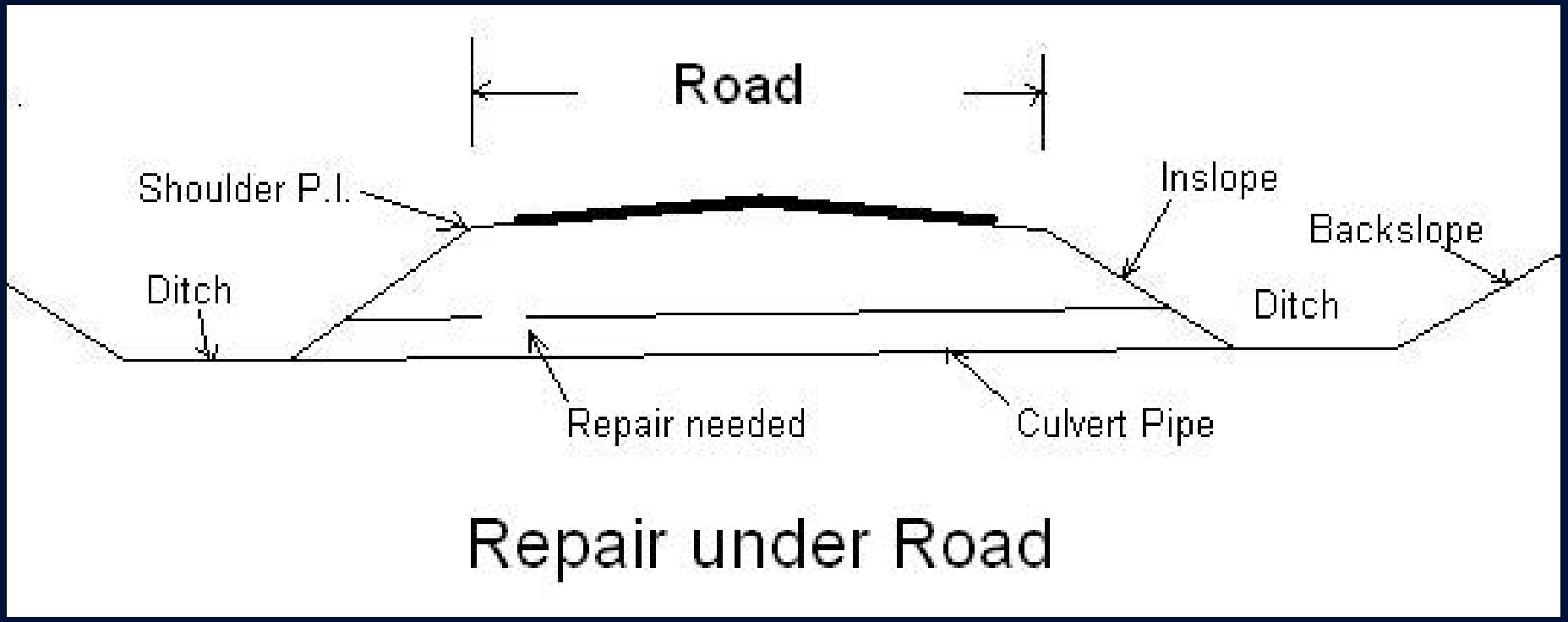
Needs Repair?

– Does this feature need to be repaired?

- Y or N (what we call a “Flag”)
- Condition 3 or 4 is always Yes
- Condition 1 or 2 pipes are good and don’t need repair

Repair under Road –

If a repair is needed, and the needed repair is located between the two shoulder PI's



Repair under Road

Shoulder P.I. is the point of intersection where the shoulder and inslope meet.

Repair under Road --

No

(not under road)

Yes

(is under road)

Shoulder P.I. is the dividing line.

Flags for Pipe repairs needed:

- Replace Apron
- Repair Invert
- Inspector Suggested Repair (menu)
  - Reset
  - Replace Apron
  - Joint Repair
  - Paved Invert
  - etc.
- Needs Marker

Flags for Structure repairs needed:

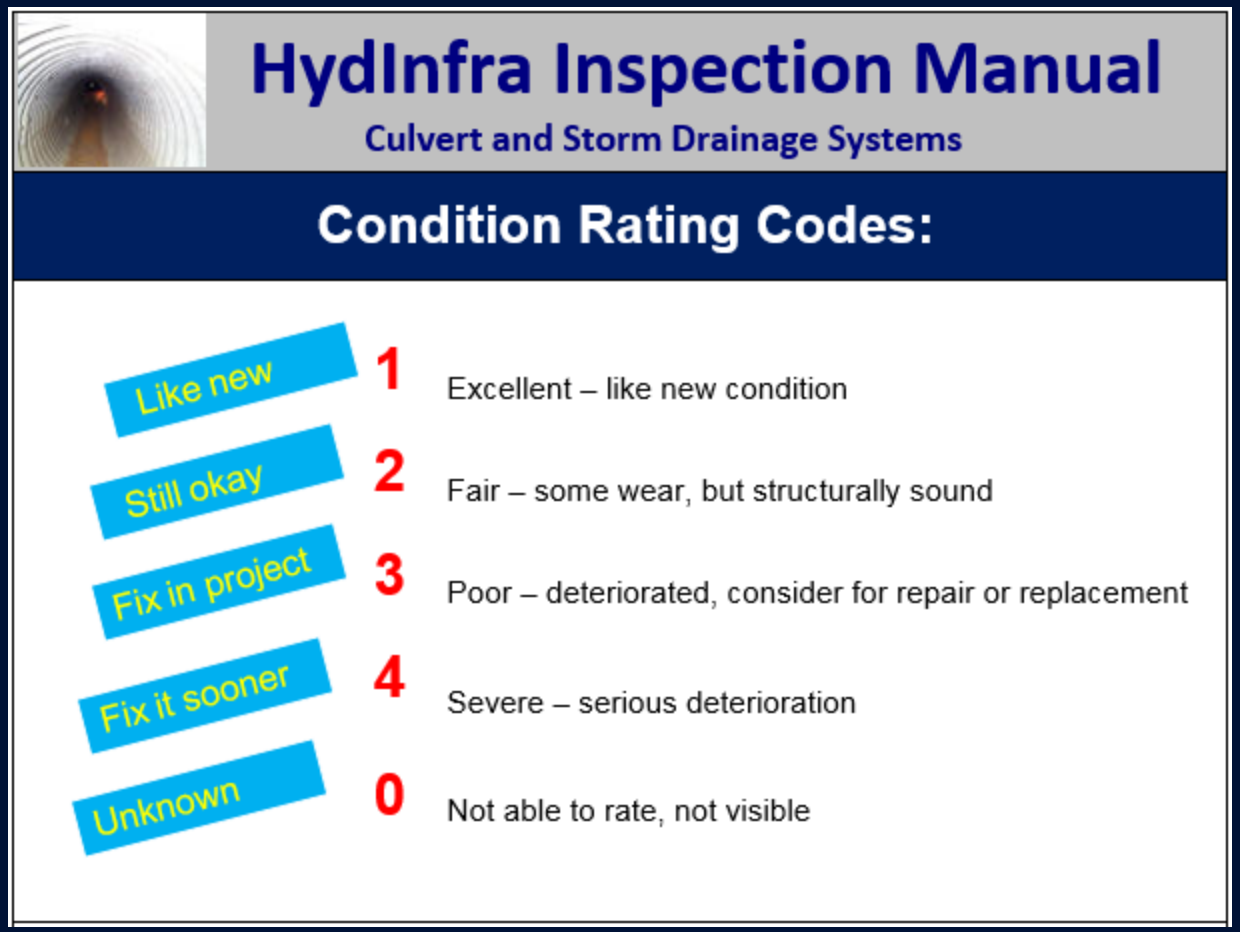
- Repair Invert
- Replace Grate
- Replace Casting
- Depth of Repair
- Inspector Suggested Repair

Finally,
apply all the defects to the
HydInfra Criteria
to determine the overall
Condition Rating

A QA/AC Report will determine if you followed HydInfra criteria

Condition Code defines the **Structural Integrity** of a feature

(is it broken? or not)



Condition Code does not include the need for cleaning

Need for cleaning is defined by:

- Clean = Yes
- Sediment % Full = “30%” or greater
- Plugged = Y indicates severe problem

What makes a pipe condition 4 ?

(See Inspection Criteria, page 27 – 36)

- Pipe condition is causing loss of fill beneath road surface
- Concrete - Joints separated and broken – gap more than 3”
- Metal – One hole greater than 1” or many small holes
- Plastic – Deformation > 10% of original inside diameter
- Repairs are needed sooner rather than later

Condition 0: Unknown

Not Accessible
or
Underwater
or
Under Dirt

- But, if you see serious defects from criteria, rate it 3 or 4.
- Don't overwrite condition 3 or 4 rating with a 0.
- Flags are mostly left blank, except Water, Sediment, etc.

Page 27 – 36

Condition Rating Criteria

Concrete
Structure and Pipe Inspection Criteria

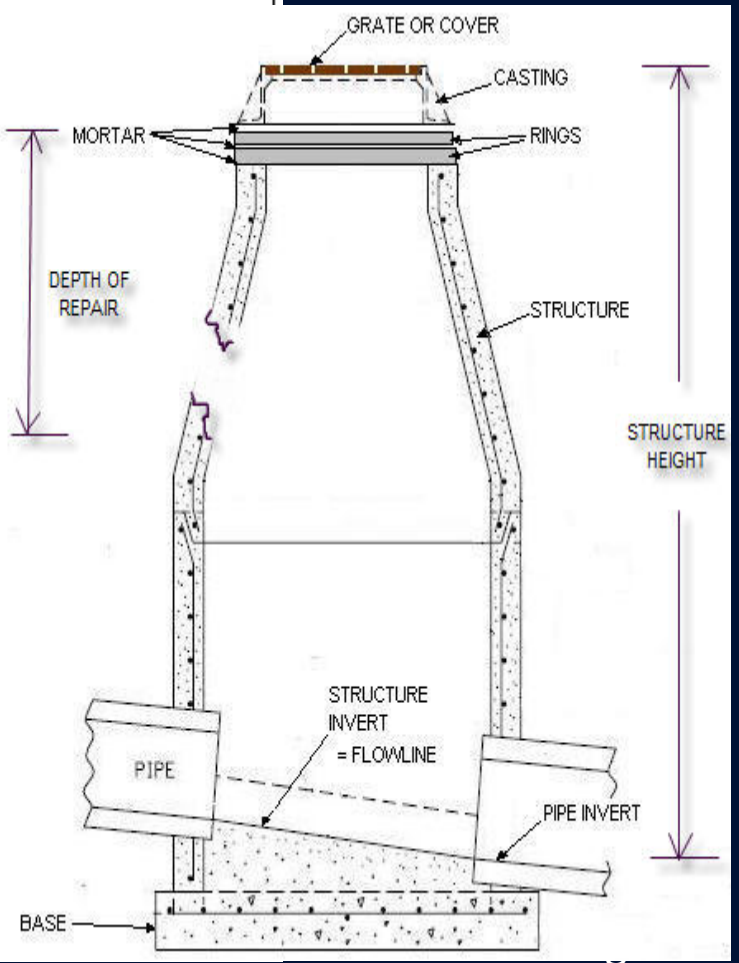
HydInfra Ratings Guide

Structure (MH, CB & DI)

Factors: Structural integrity, Integrity of surrounding material	Flags and Images
1 Excellent Condition ▪ Very minor defects in concrete rings ▪ None to hairline cracks evident ▪ None to slight spalling or scaling	
2 Fair Condition ▪ Some mortar missing at concrete rings ▪ Pitting of pre-cast concrete ▪ Aggregate is visible ▪ Spalling or scaling to 1/4 inch depth ▪ Cracks less than 1/8 inch ▪ Evidence of infiltration of water or soil	
3 Poor Condition ▪ Concrete rings broken, or mortar missing – gaps 1/2" to 1" ▪ Settlement of pavement or soil adjacent to structure ▪ Reinforcement shows ▪ Blocks/bricks flaking/crumbling ▪ Cracking evident with widths 1/8 - 1/4 inch ▪ Spalling or scaling > 1/4 inch depth	
4 Very Poor Condition ▪ Concrete rings broken or mortar missing – gaps >1" ▪ Voids in soil or depressed pavement adjacent to structure, caused by infiltration ▪ Structure settlement that affects structure stability or function ▪ Extensive exposure of reinforcement ▪ Cracks that show movement (misaligned pieces) ▪ Blocks/bricks missing ▪ Holes through the structure	

If the structure is not made of Concrete use rating criteria for Other Materials.

Concrete Structure Inspection Criteria



Structure Inspection:

Look **for gaps and cracks or weakening at rings**, structure walls, connected pipes and invert.

Deteriorated Rings

Concrete Pipe Inspection Criteria

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	Condition 1 Concrete Hairline cracks
2 Fair Condition ▪ Joints broken or pulled apart up to 1" (anywhere along joint) ▪ Aggregate exposed (pitting) ▪ Cracks evident with widths up to 1/8 inch ▪ Spalling or scaling to 1/4 inch depth	Joint Separation Pitting/Rusting Cracks Spalling/Flaking
3 Poor Condition ▪ Joints broken or pulled apart 1"-3" (anywhere along the joint) ▪ Cracking evident with widths 1/8 - 1/4 inch ▪ Spalling or scaling > 1/4 inch depth ▪ Reinforcement beginning to show ▪ Ends misaligned or shifted ▪ Infiltration of soil into pipe under inslope causing soil loss in road shoulder ▪ Pipe may be causing soil loss beneath road surface ▪ Erosion has undermined apron or pipe ▪ Apron is separated from pipe ▪ Repair is needed but is not under road	Joint Separation Cracks Spalling/Flaking Misaligned Infiltration Inslope Cavity Road Distress Erosion Separated Apron
4 Very Poor Condition ▪ Joints pulled apart or broken more than 3" at any point along joint (unless only at apron – see condition 3) ▪ Cracking evident with widths > 1/4 inch or cracks showing movement – pipe pieces have shifted ▪ Reinforcement fully exposed in places ▪ Holes through concrete or bottom gone ▪ Deformation – pipe is misshapen (look also for cracks and spalling) ▪ Piles of soil at joints, or any indication that soil infiltrates into pipe under roadway	Joint Separation Cracks Spalling/Flaking Holes Deformation Road Void Infiltration & Piping

Apron Separation→Joint Separation→Infiltration→Piping→Road Void→Road Distress

Common sequence for Condition Deterioration of Concrete Pipe

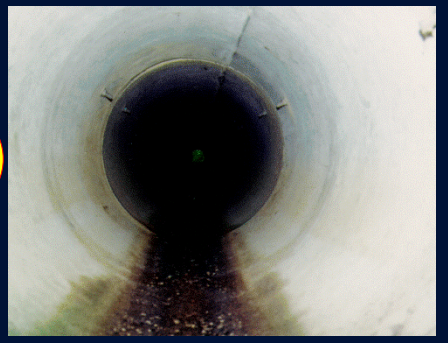
Concrete Pipe Joint Separation 1

Concrete Condition 1 Excellent

- Minor chipping at joints/openings
- No Joint Separation
- *Crack - Not Visible or hairline crack less than 1/100 inch
- Insignificant spalling or scaling

1

2



3

4

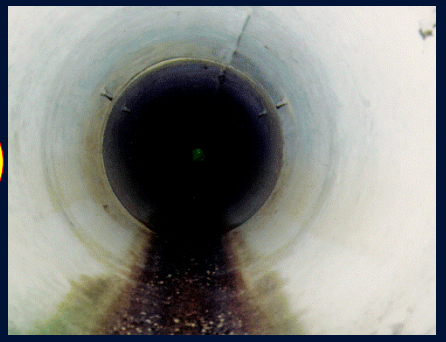
Concrete Pipe Joint Separation 2

Concrete Condition 2 Fair

- Joints broken or pulled apart up to 1”
- Exposed aggregate
- *Spalling or scaling to ½ inch depth less than 6 inch diameter patch
- Lengthwise Crack less than 1/20 inch wide (thickness of one dime) or around the pipe with no infiltration (not wet, stained or deposit)

1

2



3

4

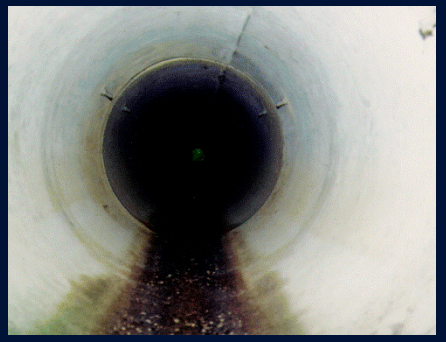
Concrete Pipe Joint Separation 3

Concrete Condition 3 Poor

- Joints broken or pulled apart 1”-3”
- Infiltration of water
- *Lengthwise crack with width 1/20 to 1/10 inch (thickness of 1 to 2 dimes)
- *Abrasion or Spalling ¼ to ½ inch with deeply exposed aggregate or reinforcement showing
- Apron is separated from pipe
- Pipe may be causing soil loss beneath road surface

1

2



3

4

Concrete Pipe Joint Separation 4

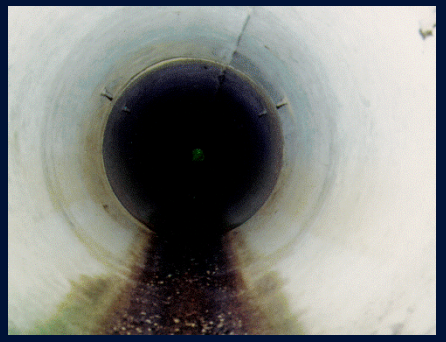
4 Fix it sooner

Concrete Condition 4 Very Poor

- Joints pulled apart or broken more than 3” at any point along joint
- *Lengthwise Fracture – crack greater than 1/10 inch wide (width of 2 dimes)
- *Fractured crack with displaced pipe pieces
- *Widespread spalling more than ¾ inch depth or invert deterioration
- Piles of soil at joints, or any indication that soil infiltrates into pipe under roadway

1

2



3

4

Criteria for Metal, Steel, Polymeric-Coated, Aluminized and Aluminum

Metal Pipe and Special Structure	
Factors: Structural integrity, Integrity of surrounding material	**Flags and Images**
1 Excellent Condition ▪ Discoloration of surface ▪ Galvanizing intact ▪ No rust or pitting	Condition 1 Steel
2 Fair Condition ▪ Galvanizing gone ▪ Pitting, superficial rust or tight rust flakes	Pitting/Rusting
3 Poor Condition ▪ Flaking rust evident, with some loss of wall thickness ▪ A hole, less than 1 inch in size ▪ Deformation, deflection or distortion visible, up to 10% of diameter ▪ Can poke a hole in pipe with a sharp point ▪ Inslope Cavity – Infiltration of soil into the pipe from road shoulder ▪ Infiltration of soil into pipe may be causing loss of fill beneath road surface ▪ Erosion has undermined apron or pipe ▪ Apron is separated from pipe ▪ Repair is needed but is not under road	Spalling/Flaking Holes Deformation Spalling/Flaking Inslope Cavity Road Distress Erosion Separated Apron
4 Very Poor Condition ▪ Hole 1 inch or greater, or many small holes, or bottom gone ▪ Cracks or tears ▪ Severe deformation greater than 10% of diameter ▪ Joints separated ▪ Misalignment ▪ Can poke a hole in pipe with a blunt rod ▪ Piping or Road Void – Pipe condition is causing soil loss beneath road surface	Holes Cracks Deformation Joint Separation Misaligned Spalling/Flaking Piping or Road Void

Rusting→Flaking→Holes→Infiltration→Piping→Road Void→Road Distress→Deformation

Common sequence for Condition Deterioration of Corrugated Metal Pipe

Steel Pipe will rust, flake and get holes

1 Excellent Condition

- Discoloration of surface
- Galvanizing intact
- No rust or pitting

1

2

3

4

Steel Pipe Rusts 2

1

2

3

4

2 Fair Condition

- Galvanizing gone
- Pitting, superficial rust or tight rust flakes

Steel Pipe rust flakes off, loses strength 3

1

2

3

4

3 Poor Condition

- Flaking rust evident, with some loss of wall thickness
- A hole, less than 1 inch in size
- Can poke a hole in pipe with a sharp point

Steel Pipe Rusts and gets Holes 4

1

2

3

4

4 Very Poor Condition

- Hole 1 inch or greater, or many small holes, or bottom gone
- Can poke a hole in pipe with a blunt rod
- Piping or Road Void -- Pipe condition is causing soil loss beneath road surface

Plastic Pipe is all different

HydInfra Criteria generalizes to 2 types:

- Dual wall
  - HDPE
  - HDPE Liners (like Snap-Tite)
  - Polypropylene
- Single Wall
  - PVC
  - CIPP

Plastic Dual-Wall Criteria

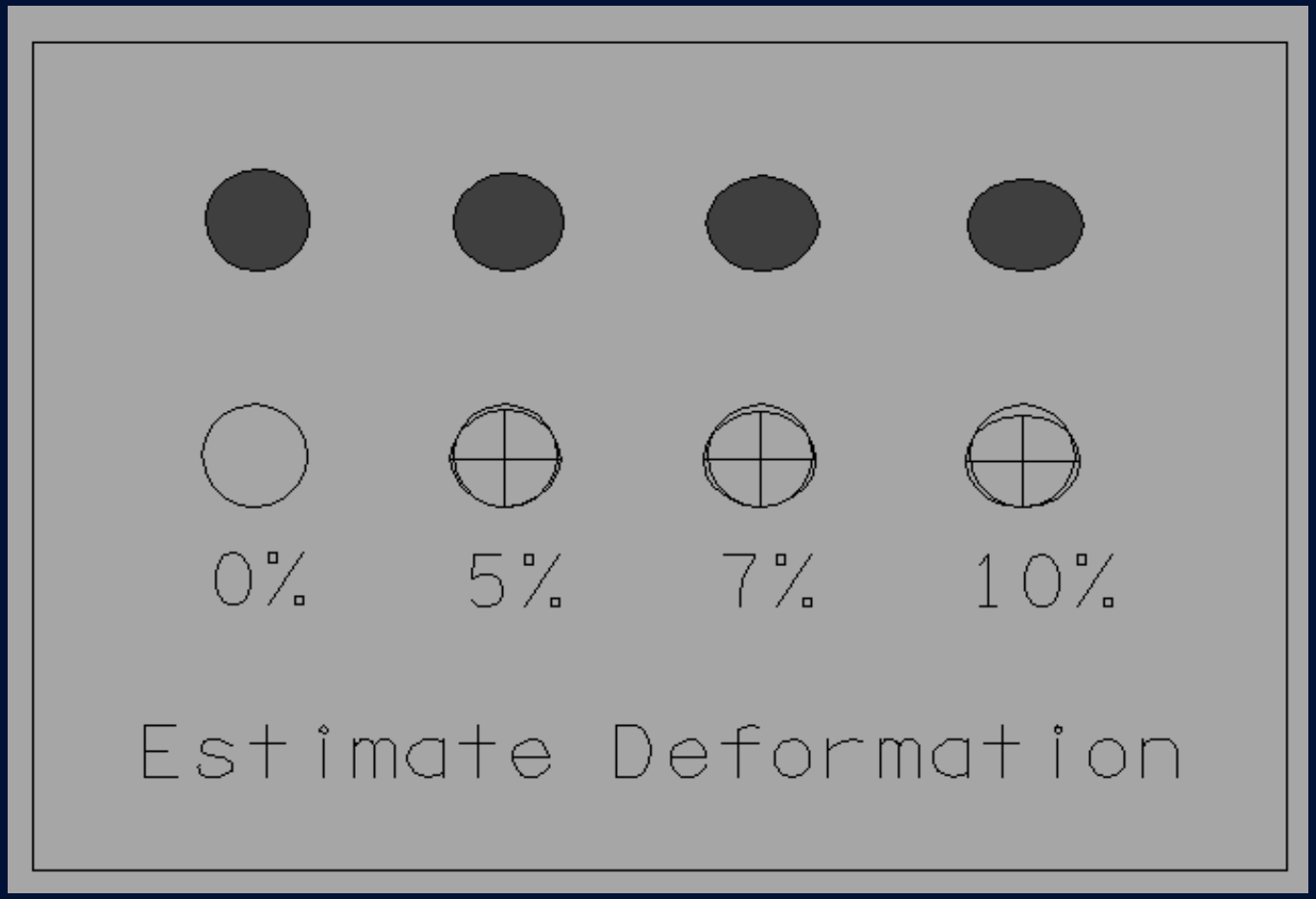
Factors: Structural integrity, Integrity of surrounding material	Flags
1 Excellent Condition	
• Pipe is straight	
• Joint separation less than 1”	
• *Deformation less than 5% of original inside diameter	
2 Fair Condition	
• *Deformation of pipe 5% to 7% of original inside diameter	
• *Local buckling or rippling in wall. For dual wall HDPE pipe, liner buckling in 2 or fewer areas	Deformation
• *Blistering less than 25% of pipe interior surface	
• Joint separation less than 3” with no soil infiltration through joints	Joint Separation
• For dual wall HDPE pipe, circumferential cracking in PE liner only, above flow line and less than 1/4 of circumference, (if crack is below flow line, freeze/thaw may increase damage, use Condition 3)	Cracks
• Minor misalignment and settlement throughout pipe	Misalignment
3 Poor Condition	
• Significant ponding of water due to sagging or vertical misalignment	Misalignment
• *Deformation of pipe 7% to 10% of original inside diameter	Deformation
• *Abrasion more than 10% of wall thickness	
• *Blistering over more than 25% of pipe interior surface	Joint Separation
• For dual wall HDPE pipe, liner buckling in more than 2 areas	Infiltration
• Joint separation more than 3 inches, but not detached	Inslope Cavity
• Evidence of soil infiltration in pipe under inslope	Crack-Fracture
• *For dual wall HDPE pipe, circumferential cracking in HDPE liner only, in upper or lower portion of pipe, less than 1/2 of pipe circumference, with no soil infiltration through joints	Cracks HDPE
• Erosion has undermined apron or pipe end	
• Apron is separated from pipe but not other pipe joints	CIPP delamination
• Repair is needed but is not under road	Separated Apron
4 Severe Condition	
• Floated – top of pipe is at or above ground surface	
• Joint separation allowing soil infiltration under road surface or shoulder	Misalignment –Float
• *Deformation greater than 10% of original inside diameter or kinked pipe wall	Joint Separation
• *For dual wall PE pipe, buckling of liner and exterior shell	Deformation
• Hole through pipe material	Holes
• *Abrasion more than 25% of wall thickness	Road Void, Piping
• *For dual wall PE pipe, circumferential cracking greater than 1/2 of pipe circumference, in the liner only or longitudinal cracks less than 12 inches	Cracks Cracks
• *Soil infiltration under road surface or shoulder (including Piping or Road Void)	
• Burnt (there is no inspection flag for burnt pipe, use spalling/flaking or holes)	Deformation

Plastic Single-Wall Criteria

Factors: Structural integrity, Integrity of surrounding material	Flags and Images
1 Excellent Condition	
• Pipe is straight	
• Joint separation less than 1”	
• *Deformation less than 5% of original inside diameter	
2 Fair Condition	
• *Deformation of pipe 5% to 7% of original inside diameter	Deformation
• Joint separation less than 3” with no soil infiltration through joints	Joint Separation
• Minor misalignment and settlement throughout pipe	Misalignment
• Default condition rating for lined pipe without serious defects is Condition 2	
3 Poor Condition	
• Significant ponding of water due to sagging or vertical misalignment	Misalignment
• *Deformation of pipe 7% to 10% of original inside diameter	Deformation
• *Abrasion more than 10% of wall thickness	
• Joint separation more than 3 inches, but not detached	Max Joint-Separation
• CIPP folds or flaps > 1” but not obstructing flow	CIPP Delamination
• CIPP localized delamination	Inslope Cavity or Infiltration
• Pipe condition is causing soil loss of inslope	Cracks
• Any crack in PVC pipe outside of road surface area	Erosion
• Erosion has undermined apron or pipe	Separated Apron
• Apron is separated from pipe	
• Repair is needed but is not under road	
4 Severe Condition	
• Floated – top of pipe is at or above ground surface	Misalignment –Float
• Joint separation allowing soil infiltration under road	Max Joint-Separation
• *Deformation greater than 10% of original inside diameter	Deformation
• *Abrasion more than 25% of wall thickness	Holes
• Hole through pipe material	Road Void, Piping
• CIPP delamination or gap that allows piping	
• Incomplete grouting of liner that allows piping	
• Uncured areas in CIPP walls	Cracks
• *Soil infiltration under road surface or shoulder (including Piping or Road Void)	
• Any crack in PVC pipe under road surface or shoulder	
• *Degradation from sunlight -- UV caused cracks or broken wall at exposed ends	
• Burnt (describe in comments. There is no inspection flag for burnt pipe, use spalling/flaking, holes or other flags that fit.)	

Plastic pipe may be deformed. 5% is visible.

Estimate Deformation – Round Pipe



Poor or Very Poor Plastic Criteria

use Comments to describe defects if no flag

3 Poor Condition • Significant ponding of water due to sagging or vertical misalignment • Deformation of pipe 7% to 10% of original inside diameter • For dual wall HDPE pipe, liner buckling in more than 2 areas • Joint separation more than 3 inches, but not detached • Evidence of soil infiltration in pipe • Pipe condition is causing soil loss in road shoulder • Any crack in PVC pipe outside of road surface area • For dual wall HDPE pipe, circumferential cracking in HDPE liner only, in upper or lower portion of pipe, less than 1/2 of pipe circumference, with no soil infiltration through joints • Erosion has undermined apron or pipe • Apron is separated from pipe • Repair is needed but is not under road	Misalignment Deformation Joint Separation Infiltration Inslope Cavity Cracks Cracks HDPE CIPP delamination Separated Apron
4 Very Poor Condition • Floated – top of pipe is at or above ground surface • Joint separation allowing major soil infiltration • Deformation greater than 10% of original inside diameter • Hole through pipe material • Pipe condition is causing soil loss beneath road surface • Any crack in PVC pipe under road surface area • For dual wall PE pipe, circumferential cracking greater than 1/2 of pipe circumference, in the liner only • For dual wall PE pipe, buckling of liner and exterior shell • Burnt (there is no inspection flag for burnt pipe, use spalling/flaking or holes)	Misalignment –Float Joint Separation Deformation Holes Road Void, Piping Cracks Cracks Deformation Burnt HDPE

Other Materials or SPCD Inspection use generalized criteria

SPCD (Structural Pollution Control Device) or Other Materials	
Factors: Structural integrity, Water Quality Functions, Clogging, Integrity of surrounding material	Flags and Images
1 Excellent Condition ▪ Materials are intact.	
2 Fair Condition ▪ Materials have minor defects but the feature is structurally sound. ▪ The feature is functioning properly.	
3 Poor Condition ▪ Materials have defects that may affect function or structural integrity of the feature ▪ Feature needs repair but can wait for construction project	
4 Very Poor Condition ▪ Components are broken or not working ▪ Outflow is non-functional ▪ Materials have severe defects and need repair soon.	

Criteria for
Assets built out of Dirt

Infiltration Areas or Ponds

Pond	
Factors: Water Quality Functions, Water containment functions – basin integrity/clogging/overtopping, Vegetation	**Flags and Images**
1 Excellent Condition ▪ Embankment is sound. ▪ Outflow structures are clear of debris and functional ▪ Vegetation is well established, without any noxious weeds (see county list of Noxious Weeds).	
2 Fair Condition ▪ Limited patches of missing vegetation. ▪ Sheet erosion occurring (look for exposed grass roots). ▪ "Healed" (vegetated) rills.	
3 Poor Condition ▪ Evidence of overtopping (flow marks over embankment for example). ▪ Noxious Weeds are present (see county list of Noxious Weeds). ▪ Vegetation missing over 500 sq. ft. or more total area. ▪ Pond or embankment liner material (geotextile, clay liner, etc.) is damaged. ▪ Infiltration pond has dead vegetation where water stands. ▪ Infiltration pond has standing water for more than 3 days in a row.	
4 Very Poor Condition ▪ Burrows, piping or alternate flow paths through embankment. ▪ Eroded gully or slope failure presents a hazard to vehicles leaving the roadway or threatens road or embankment integrity. ▪ Evidence of pond water backup onto upstream or adjacent properties or onto roadway. ▪ Normal outfall or emergency overflow or is non-functional or is bypassed.	

Ditch or Channel

Ditch	
Factors: Vegetation, Erosion (Physical integrity), Flow Capacity or Sediment Deposition	Flags and Images
1 Excellent Condition ▪ Vegetation is well established, without noxious weeds (see county list of Noxious Weeds). ▪ No eroded rills ▪ If it is an Infiltration ditch, ditch is infiltrating water.	
2 Fair Condition ▪ Sediment deposition is visible. ▪ Limited patches of missing vegetation. ▪ Sheet erosion occurring (look for exposed grass roots). ▪ "Healed" (vegetated) rills.	
3 Poor Condition ▪ Noxious Weeds are present (see county list of Noxious Weeds). ▪ Ditch liner material (geotextile, clay liner, etc.) is damaged. ▪ Ditch grade headcut (ditch bottom is de-grading from downhill to uphill) is occurring – pipe aprons suspended above eroded ditch bottom may be an indicator. ▪ "Infiltration Ditch" (ditch constructed specifically to infiltrate stormwater) has dead vegetation where water ponds. ▪ "Infiltration Ditch" (ditch constructed specifically to infiltrate stormwater) has standing water for more than 3 days in a row.	Erosion or Headcut
4 Very Poor Condition ▪ Eroded gully or slope failure presents a hazard to vehicles leaving the roadway or threatens road or embankment integrity. ▪ Sediment in ditch causing water to back up onto upstream or adjacent properties, or onto roadway. (Pipes are most likely the problem – check affected pipes first).	

Outfall Identification

An MS4 Outfall is a separate and identifiable drainage conveyance where stormwater leaves Mn/DOT right of way or merges with a natural water (lake, stream, wetland, county ditch, etc.) and is located within an MS4 boundary.

MS4 Outfall does NOT Include:

- Diffuse runoff (sheet flow)
- Natural waters passing through Mn/DOT Right of Way
- Municipal storm drains passing through Mn/DOT Right of Way without Mn/DOT inputs

MS4 Outfall does not include natural waters passing through MnDOT's Right of Way

Illicit Discharge and Phone #s

Illicit Discharge Identification

Illicit Discharge is a discharge or deposit of polluting materials, liquid or solid, that can be transported to natural waterways.

Look for:

- Unexpected pipes coming into the highway storm drain system.
- Pipes flowing when storm drains shouldn't be.
- Suspicious odors, floatables, colors or opaque water. (Don't sniff out an odor – your first impression is sufficient. Some substances are damaging to inhale.)

HYDINFRA can also be used to record deposits of dumped or otherwise deposited polluting materials.

Report suspected Illicit Discharge to your District Contact within 24 hours for follow up:

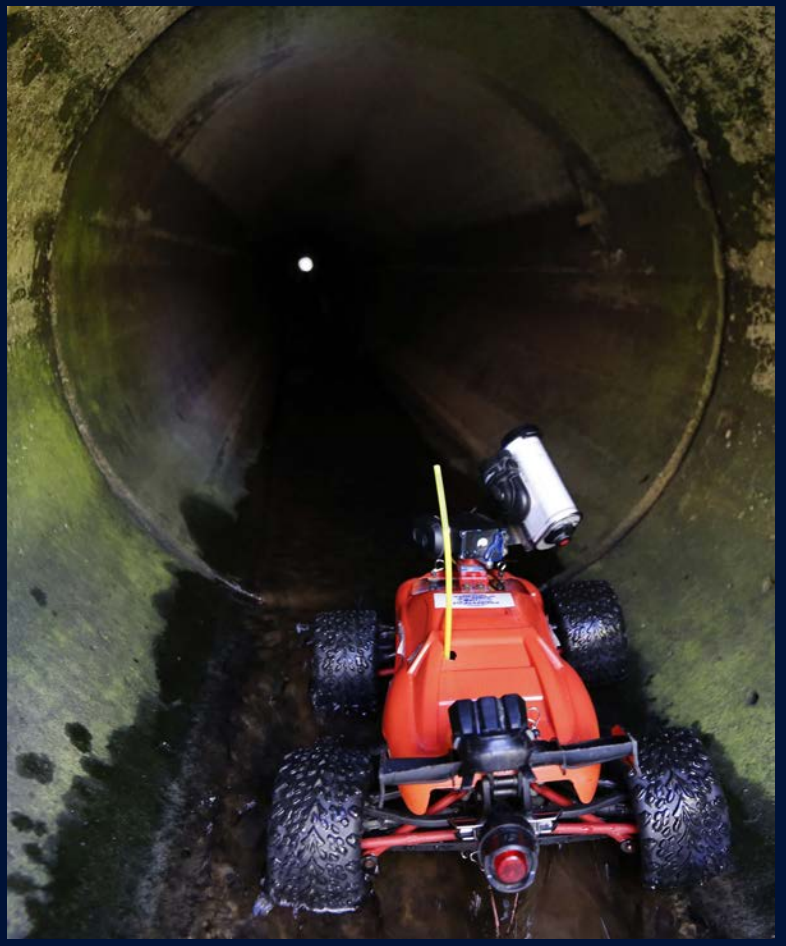
Accidental spills by trucks, that are reported to Dispatch, forwarded to MPCA Duty Officer and cleaned up by trucking company's contractor are not reported as Illicit Discharge, but are logged by Dispatch.

District	Contact	Phone
Metro District	Metro Dispatch	651-234-7500
District 1	Shelly Micke , Duluth	218-725-2758
District 2	District 2 Hydraulics Engineer, Bemidji	218-755-6500
District 3	Robert Nibbe, Hydraulics Engr, Baxter	218-828-5700
District 4	District 4 Hydraulics Engr, Detroit Lakes	1-800-657-3984
District 6	District 6 Hydraulics Engineer, Rochester	507-286-7692
District 7	Scott Morgan, Hydraulics, Mankato	507-304-6210
District 8	District 8 Hydraulics Engineer, Willmar	1-800-657-3792

(Not in the Manual)

Essential Tools

D6 HIVE unit with Pan and Tilt video



HIVE inspects inside pipes more than 55 feet long and climbs over obstacles.

D6 Rob Coughlin, photos and HIVE

Personal Equipment:

- Tick and Mosquito repellant
- Rubber boots
- Safety gear

D8 HydInfra Inspector – photo from Kurt Oellian

High-powered Flashlight and Shovel are essential tools

Photo from Metro, Lee Daleidan

Essential Inspection Tools

Shovel and flashlight in use by Inspector Metro WRE Photo from Lee Daleiden

Useful tools to bring for inspections

- Tablet with cellular data internet
- R1 GPS
- DMI
- Optional - Paper HydInfra reports for staying organized/taking notes
- Whiteboard/marker (label photos)
- Ruler/other measuring tools
- PPE – floatation vest
- Flashlight
- Bug Spray
- Hip boots/waders
- HIVE vehicle for smaller pipes
  - Spool/Cable
  - Tablet
  - Camera
  - Spare Batteries
  - Portable chargers if available and make sure all batteries are charged

(Tools list from D3 Nate Walton June 2017, rev. 2020)

LaMourea's Inspection Tools

- HydInfra Inspection Manual

- Mega Flashlight
- Shovel
- Measuring tape
- MH cover lifter
- Measuring wheel
- Rods to probe in sludge
- Sledge hammer??
- Weed Wacker

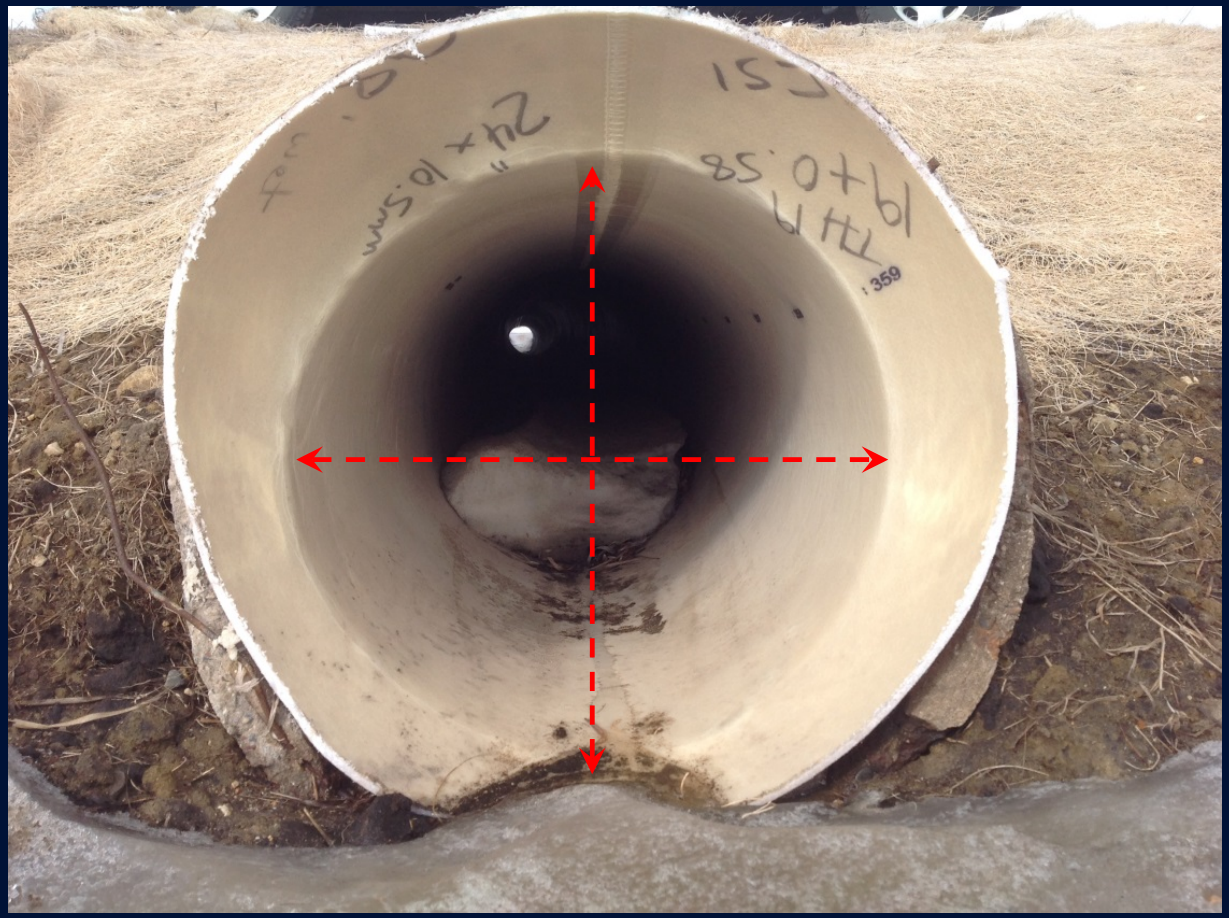
- Special tubular telescoping measuring tool that extends inside the pipe

Measure it.

Pipes sometimes are ordered for future Construction projects based on HydInfra dimensions

Measure lined pipes carefully

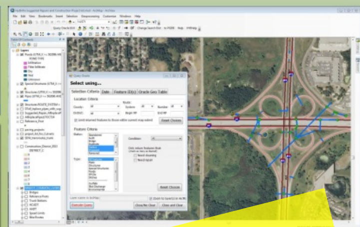
- Lined pipes will have odd dimensions
- Measure the interior dimensions



End Goal:

Lifecycle Cost Analysis
in Asset Management

Culvert Cost WIG
on the Road to Drainage Asset Management



HydInfra

HydInfra - MnDOT's Culvert and Storm Drain Inventory and Inspection System

It all began [illegible] when Hydraulics/WRE engineers created HydInfra to improve drainage design and maintenance work. HydInfra was built with GIS tools designed so that people new to ArcMap could query for drainage features, make a map and export the data to a spreadsheet. HydInfra's simple condition rating codes based on explicit criteria for different materials, and flags to record defects make it a versatile framework to build asset management on.

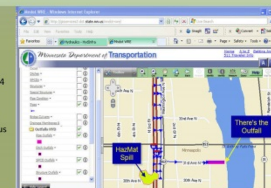
Extreme rainfall and floods cause damage to culverts. GIS and HydInfra help recovery.

HazMat Spills Response Utility Locations and MS4 Water Quality

Metro WRE and Maintenance partner on MS4 water quality requirements.

Storm drain networking and "Georilla" map service improve response times for hazardous spill capture.

Storm drain networks are also used for Gopher State One Call utility locations.



Recommended Inspection Frequency for Highway Pipes		
Overall Condition	Recommended Inspection Frequency Years	Comments
4 Very Poor	2	Pipes where problem is not under the road
	1	Pipes where problem requires a repair under the road
3 Poor	4	Most condition 3 pipes
	2	Pipes with Piping or Road Void
1 & 2 Like New and Fair	6	
0 Can't be Rated	2	
Pipes with no inspections		Goal to inspect within 6 years - 2019, many of these are storm drain pipe, so as districts identify pipes as storm drain, these should be reduced
Overall Target: 80% of Highway Pipes meet Recommended Inspection Frequency		

Drainage Performance Measure

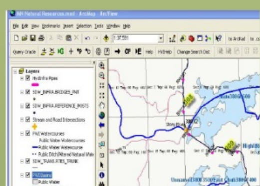
Drainage Performance Measure

In 2008, Maintenance Operations chose HydInfra to track their Drainage Performance Measure for highway culvert inventory and inspection. Soon after, the inventory was completed and highway culverts are now inspected on a regular schedule.

[illegible] inspect each culvert in District 8.

Big Storm + bad pipes = wrecked road

Culvert inspectors record defects that may cause road failure during extreme rainfall events. Pipe defects include road void, piping, and holes.

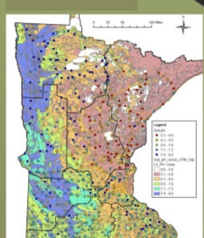


Project Scoping and Predesign

GIS layers from many sources give context to drainage design work. DNR layers for Public Waters illustrate areas that need environmental permits. HydInfra layers with drainage feature data help speed scoping and predesign tasks, especially in winter.

Research on Pipes and Materials

Research focusing on the projected lifespan of steel pipe is underway. The map below shows roadside pH overlaid on NRCS pH data. Acidity, or low pH, is a factor in steel pipe deterioration rates. The research is being done by Barbara Burkholder Heitkamp, U of M



HydInfra data is used in research to look at materials and their failure modes. In this chart, the depth of fill above the pipe is correlated to specific pipe defects.

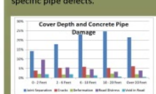


Figure 13 – Influence of cover depth on concrete pipe damage for all pipes

Culvert Repair Cost

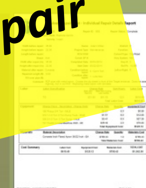
Culvert Cost WIG

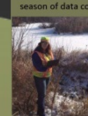
Maintenance crews repair or replace culverts and record the labor, equipment and materials in a mobile app based on ArcGIS Collector software.

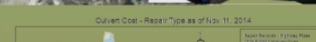
Repair data can be entered in the Culvert Cost app while in the field on an iPad, or in the office on a PC.

Repair data is available immediately in web-based reports that repair crews can access from the repair site . Others in MnDOT can find Culvert Cost Reports by searching IHUB for "Culvert Cost".

The map shows repairs, cleanings and new installations of culverts recorded in the first season of data collection.







The Road Ahead to Drainage Lifecycle Cost Analysis

1. Capture construction costs for drainage features from projects by contractors, along with as-built details about the drainage features.
2. Get an Enterprise Asset Management software solution that includes GIS, to merge HydInfra and Culvert Cost databases and to integrate data from MnDOT's many other parts, like Pavement, Traffic and Maintenance Operations' many responsibilities.
3. Inventory and inspect storm drain networks, ponds and other water quality devices and all those other features that are part of the drainage system.
4. Research pipe materials to improve service life predictions.
5. Project Lifecycle Performance to get the most bang for the buck.

End Goal: TAMS-HydInfra

Lifecycle Cost Analysis in Asset Management

2005 HydInfra

HYDINFRA Ratings Guide

Condition Codes:

1 Good as new condition

2 Some wear, but structurally sound

3 Schedule for repair or replacement

4 May require immediate fix – Inform Maintenance people

0 Not rate-able

Notes:

1) The worst condition found in a feature determines its condition rating (see lists).

2) The general conditions of the roadway and adjacent area should be used as clues to help determine the condition rating for each hydraulic feature that is inspected. These general conditions can be indicators of concealed structural problems.

3) Broken grates or plugged pipes should be reported to Maintenance within 24 hours.

2010 FLH

CHAPTER 2 – CULVERT ASSESSMENT TOOL

FEDERAL LANDS HIGHWAY

FHWA FLH CULVERT ASSESSMENT GUIDE

CONDITION ASSESSMENT RATING CODES

Good	Like new, with little or no deterioration, structurally sound and functionally adequate.
Fair	Some deterioration, but structurally sound and functionally adequate.
Poor	Significant deterioration and/or functional inadequacy, requiring repair action that should, if possible, be incorporated into the planned roadway project.
Critical	Very poor conditions that indicate possible imminent failure that could threaten public safety, requiring immediate repair action.
Unknown	All or part of the culvert is inaccessible to assessment or a rating cannot be assigned.

Notes:

2012 HydInfra

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	Severe – serious deterioration
Unknown	0	Not able to rate, not visible

Notes:

HydInfra influenced the 2016 NCHRP 14-26 Culvert and Storm Drain Inspection Manual

2016 Federal Manual

RATING SCALE AND ASSOCIATED ACTION

	1 GOOD	2 FAIR	3 POOR	4 CRITICAL	5 FAILED
CONDITION	Like new, with little or no deterioration, structurally sound and functionally adequate.	Some deterioration, but structurally sound and functionally adequate.	Significant deterioration and/or functional inadequacy, requiring maintenance or repair.	Very poor conditions that indicate possible imminent failure which could threaten public safety.	Failed or non-functional condition.
ACTION INDICATED	No action is recommended. Note in inspection report only.	No immediate action is recommended, but more frequent inspection may be warranted. Maintenance should be informed.	Team Leader (Inspector) evaluates need for corrective action and makes recommendation in inspection report.	Corrective action is required and urgent. Engineering evaluation is recommended to specify appropriate repair.	Emergency action is required to address public safety hazard. Roadway closure is typical.

HydInfra spawned the FLH Culvert Manual (2010) codes and later NCHRP 14-26 Culvert and Storm Drain Inspection Manual (2016)