

## Culvert Inspection and Ratings

## Culvert Inspection and Rating



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## Culvert Inspection and Ratings

## Introduction

- Bridge sized culverts have an equivalent diameter of 1500mm or greater
- Bridge site that requires a 1500 mm pipe due to hydraulic discharge
- Will routinely inspect smaller culverts if there are several ( low level crossing)
- May also inspect if multiple small culverts are equivalent in hydraulic capacity to bridge-sized (2-1200mm)
- May inspect certain other non-bridge sized culverts (3 - 900mm)



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## Culvert Inspection and Ratings

## Introduction

- Many different types of culverts – refer to Table 1.1 in Manual
- Vast majority are CSP or SPCSP in various shapes - round, arch pipe, horizontal ellipse
- Three culvert forms (Cul1, CulE, CulM)
- Same forms used for all types of culverts
- Timber pipe (TP) culverts exception
  - Use TT form



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## Culvert Inspection and Ratings

## Form Types

- CUL1
  - Single culvert or single culvert extended with same material and size
- CULM
  - Two or more culverts (MP, SP or BP etc.)
  - Includes 1 Upstream & 1 Downstream End section for each Barrel section
  - Exception is Concrete Boxes (BP) where single U/S and single D/S sections for all barrel sections
  - Includes 2 cell box extended with single steel
- CULE
  - Single culvert extended with different material and/or size
  - One Upstream & Downstream section, Barrel sections for all cells and/or pipes



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## Culvert Inspection and Ratings


# Inventory Information

Bridge Culvert Information								
Pipe #	Barrel	Span	Rise (or Dia.)	Type	Length	Corr. Profile	PI/Slab Thickness	Shape
1	MAIN	1800		MP	33	125X26	2.8	ROUND
Special Features Comment								

- Extracted from BIS
- Span/rise is original design shape
- If round then only rise is recorded
- Span types – refer to Table 1.1 and Sec. 13.2.3
- Corrugation Profile and Plate Thickness selected from Table 13.1 and 13.2 (p.13.5 in manual)
- Specific information is provided for all pipes
  - a culvert extended with same material and size is considered to be one culvert (Cul1)

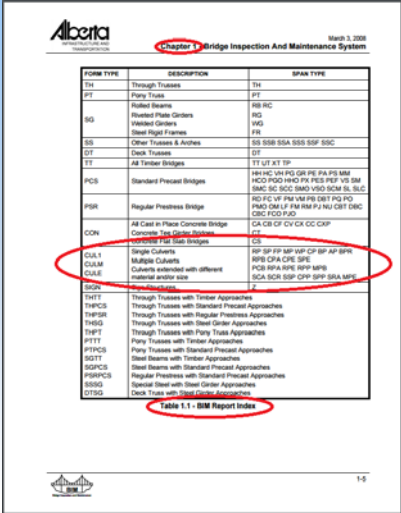



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## Culvert Inspection and Ratings

# Culvert Span Types






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## Culvert Inspection and Ratings

# Numbering and Identification

- Where the culvert does not carry flow determine “upstream” and “downstream”
  - Look in direction of increasing chainage
    - (to north or east)
  - Left is “upstream” (end 1)
  - Right is “downstream” (end 2)
  - Keep same choice for each subsequent inspection

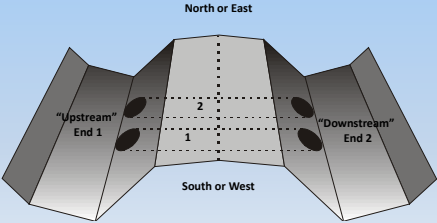



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## Culvert Inspection and Ratings

# Numbering and Identification






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## Numbering and Identification

- Primary span is the largest span at the site
- Secondary span is the smaller span
- Multiple culverts of same dimension are numbered in order of increasing chainage (from south to north or west to east)
- Multiple culverts also have same Ring numbering system (R1, R2, R3, etc.)




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## Ends - General

- Individual rating sections for the Upstream and Downstream ends
- Single upstream and downstream end sections for the CUL1, CULE forms
- Separate Upstream and Downstream ends for each Barrel section on CULM forms - except Concrete Boxes
- Upstream and Downstream sections are identical
- Items are inspected and rated the same way for both ends




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## Ends - General

Culvert Component	Downstream End		Explanation of Condition
	Last	Now	
Direction	S		
End Treatment (Concrete, Steel, Others, None)	STEEL		
Headwall	X	X	
Collar	X	X	
Wingwalls	X	X	
(Shape : )			
Cutoff Wall	X	X	
Bevel End	8	8	
Heaving (mm)	0		
Invert Above/Below Stream Bed	BELOW		
Above/Below (mm)	200		
Scour Protection	8	8	
(Type : RIP R&P)			
(Avg. Rock Size(mm) : 300)			
Scour/Erosion	8	8	
Beavers (Y/N)	No		
<b>Downstream End General Rating</b>	<b>8</b>	<b>8</b>	




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## Ends - End Treatment

- Purpose:
  - Improve aesthetics
  - Improve hydraulic performance
  - Prevent undermining due to scour
  - Prevent scour of the embankment
  - Reduce piping along or under the culvert
  - Resist uplift due to buoyancy forces
  - Shorten the culvert
  - Stiffen the ends



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### End Treatment -Types

- Steel:
  - Most common
  - Bevel end with no concrete treatment
- Concrete
  - Presence of any or all of: Headwall, Collar, Wingwall, Cutoff Wall
- Other
  - Timber Culvert with Timber End Treatment
- None
  - Square end – no Bevel present

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### Bevel Ends – End Treatment Type is “Steel”



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### Bevel Ends with Full Concrete End Treatment - Type is “Concrete”



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### Bevel End with Full Concrete End Treatment - Type is “Concrete”




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## End Treatment - Headwall

Culvert Component	Downstream End		
	Last	Now	Explanation of Condition
Headwall			

- Located over the crown
- Usually attached to the barrel
- Purpose:
  - Aesthetics
  - Strengthen end
  - Resist buoyancy force
  - Retaining walls




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## End Treatment - Headwall

- Look for:
  - Signs of movement or tilting
  - Loose connections
- Rate according to condition of material and functionality of component
- Condition affecting functionality rate 4 or less



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## End Treatment - Collar / Slope Protection

Culvert Component	Downstream End		
	Last	Now	Explanation of Condition
Collar/Concrete Slope Protection			

- Located along the beveled slopes of flexible culverts between headwall and cutoff wall
- Usually constructed from concrete
- Usually used with and connected to headwall and cutoff walls
  - May be used alone




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## End Treatment - Collar / Slope Protection

- Purpose:
  - Aesthetics
  - Stiffen the bevel
  - Resist buoyancy force
  - Improve hydraulic efficiency of end
    - protect against scour / erosion
    - reduces piping potential
  - Concrete slope protection




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## End Treatment - Collar / Slope Protection

- Look for:
  - Evidence of piping or scour / erosion
  - Loose connections
  - Voids underneath or settlement
- Rate according to condition of material and functionality of component
- If piping, rate 4 or less:
  - Also rated under bevel end and barrel



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## End Treatment - Wingwalls

Wingwalls	5	5	Both wings pushing towards streambed. North wall is 100 mm at top and 65 mm away from barrel worst of all four corners. (Shape: FLARE)
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- Generally found at culverts that do not have bevels
- Shape is either Parallel or Flared to culvert axis
- Main difference from Bevel is Wingwall is not attached to the barrel
- Usually constructed from concrete or steel
- Purpose
  - Improve hydraulic efficiency
  - Retain embankment fill




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## End Treatment - Wingwalls

- Record Shape as “Parallel”, “Flare”, or “Perpendicular” ( to culvert axis)
  - Parallel wingwall
    - Req’ less scour protection between walls
  - Flared wingwalls
    - more hydraulic efficient
- May have a reinforced concrete slab between
  - Prevents undermining of wingwalls due to scour
  - Act as struts for greater stability
  - If present rate with wingwalls




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## End Treatment - Wingwalls

- Look for:
  - Evidence of movement
  - Loose connections (gap at barrel)
  - Scour / erosion at toe or behind wingwall
- If wingwall is unstable rate 4 or less
- Separation losing fill rate 4 or less
- Includes rating of wingwall floor slab





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## End Treatment – Flared Wingwalls





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## End Treatment - Cutoff Wall

Culvert Component	Downstream End		
	Last	Now	Explanation of Condition
Cutoff Wall			

- Located at the end of the culvert
- Vertical wall extending down below the bottom of the culvert
- Depth exceeds the depth of the riprap or concrete apron
- Usually constructed from concrete or steel
- Purpose:
  - Reduce potential for undermining of end of culvert
  - Minimize possibility of piping
  - Resist buoyancy force




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## End Treatment - Cutoff Wall

- Look for evidence of:
  - Undermining
  - Piping
  - Uplift
  - Loose connections
- Usually not possible to inspect since they are submerged or covered with ice or debris
  - If not visible rate “N”
  - If certain not present rate “X”
- If piping, rate 4 or less
  - May also affect Bevel End and Barrel Rating



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## Ends - Bevel End

Culvert Component	Downstream End		Explanation of Condition
	Last	Now	
Bevel End			
Heaving (mm)			
Invert Above/Below Stream Bed			
Above/Below (mm)			

- Sloped section at the end of the culvert
- Permanently attached to the barrel
- Generally parallel to the culvert axis
- Bevel types
  - Full bevel
  - Step bevel



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## Ends - Bevel End

- Compared to projecting ends, bevel ends are more:
  - Aesthetic
  - Economical
  - Hydraulically efficient
- Compared to projecting ends, bevel ends on corrugated steel culverts are more flexible and susceptible to:
  - Deform due to lateral earth pressure
  - Uplift due to buoyancy
  - Heave due to frost action



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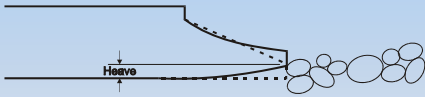


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## Ends - Bevel End


- Measure or estimate heaving of bevel and record amount



- Often best place to estimate is from inside barrel looking back to Bevel
- Use waterline as level
- Some heave is tolerable as long as water is entering Bevel



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## Ends - Bevel End

- If possible, measure or estimate height above or depth below streambed and record amount in mm. (may not be able to measure or confirm measurements in high water or winter).
- Normally "Below" as designed to be buried ¼ diameter below streambed.
- If invert is "at streambed" record Above/Below as 0mm.
- Find a representative natural streambed location
  - Discount presence of localized scour hole or deposits (aggrading) at end of culvert



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## Ends - Bevel End

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## Ends - Bevel End

- Look for:
  - Piping
  - Deformation
  - Impact damage
  - Corrosion that affect strength
  - Abrasion
- If piping, rate 4 or less
  - Also rated under End Treatment if present
- Defects/deformations not affecting function rate 6 or less (un-supported bevel - no heave)
- Severe corrosion affecting strength (perforations) rate 4 or less – otherwise corrosions should not affect rating
- If no bevel, rate “X”
  - Underpasses often have square ends

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## Ends - Bevel End

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## Ends - Scour Protection

Scour Protection	8	
(Type : RIP RAP)		
(Avg. Rock Size(mm) : 600)		

- Usually heavy rock riprap
- The current version of Std. Drawing S-1418-03 shows the minimum requirements for riprap
  - Coverage
  - Size
  - Minimum thickness
  - Gradation

<http://www.transportation.alberta.ca/4860.htm>


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## Ends - Scour Protection

- Purpose is to prevent scour and erosion at culvert ends which may:
  - Undermine the culvert
  - Undermine the sideslopes
  - Cause the formation of sand bars




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## Ends - Scour Protection

- Record the type of Scour Protection
  - If none exists and none is required, record type as “NATURAL”
  - If none exists and some is required, record type as “NONE”
- Estimate and record the average size (rock only)
- Look for:
  - Durability of riprap - e.g. sandstone is not acceptable
  - Shape – flat rocks not desirable
  - Displacement or movement
  - Scour
  - Current standards on S- 1418




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## Ends - Scour Protection Ratings

- No scour/erosion or displacement rate 7 or more
- If none exists and none is required record type as “NATURAL” and rate 7 or more
- If none exists but is required record type as “NONE” and rate 4 or less (also make recommendation)
- Generally not rated higher than Scour rating – especially when Scour is 4 or less
- Protected area is smaller than required or rock gradation or quality is inadequate rate 4 or less
- Concrete protection with excessive settlement or undermining rate 4 or less
- Cattlepasses that handle drainage rate – otherwise X



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## Ends - Scour / Erosion

Culvert Component	Downstream End		
	Last	Now	Explanation of Condition
Scour/Erosion			

- Removal of material from the streambed, banks or sideslopes by the action of flowing water and/or constrictions or obstructions (refer to Section 16.2 in manual).
- Effects:
  - Undermine the culvert
  - Undermine the sideslopes
  - Impede fish passage
  - Alter culvert hydraulics




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## Ends - Scour / Erosion

- Two types:
  - General – uniform lowering of original stream
  - Local – occurring at specific locations
- Look for:
  - Scour holes, especially at downstream ends
  - Undermining of culvert end or sideslopes
  - Slumping of sideslope or banks
  - Areas where flow impinges on banks, sideslopes or protection systems
  - Areas susceptible to high velocities and undermining
    - culvert footings
    - ends or bottoms of wingwalls and cutoff walls
    - sides of collars
    - ends or bottoms of ends of protection systems



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## Ends - Scour / Erosion

- Rate the presence and extent of scour and adverse effects on culvert, embankment, streambed and banks
- If culvert and embankment are not affected, rate 5 or more
- Scour/erosion affecting culvert, rate 4 or less




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## Ends - Scour / Erosion






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## Ends - Scour / Erosion





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### Culvert Inspection and Ratings


## Ends - Beaver Activity

	Structure Usage		Explanation of Condition
	Last	Now	
Channel (U/S and D/S)	5	5	
Alignment			
Bank Stability	5	5	
HWM (m below Top of Culvert)			(High water 1.2m above streambed @ outlet.) No visible HWM.
Drift (Y/N)	Yes		Drift on floor of R1-R4
Channel Bottom Degradation/Regrading	DEGRADING		
Beavers (Y/N)	Yes		Beavers at both U/S and D/S
(Fish Compensation Measure 1 : NONE)			
(Fish Compensation Measure 2 : NONE)			
Channel General Rating	5	5	

- Beavers frequently construct dams at inlet or inside culverts
- Effects:
  - reduced flow capacity
  - Flooding upstream
  - Scour
  - Ponding of water inside culverts preventing inspection




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## Ends - Beaver Activity

- Indicate the presence of beaver dams in or near the culvert by **Yes** or **No**
- If “yes”, provide comment
- No rating required but may affect
  - End General Rating
  - Scour
  - Waterway Adequacy in Barrel section




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### Culvert Inspection and Ratings

## Ends - General Rating

- Governing elements: (Refer to 1.10.7 & 13.5.10)
  - Headwall
  - Collar
  - Wingwall
  - Cutoff Wall
  - Bevel end
  - Scour protection
  - If all are rated “X” then provide rating based on general condition of culvert end




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### Culvert Inspection and Ratings

## Barrel - Rigid Types

- Made from concrete or timber
- Designed to carry loads without deflection (Rise and Span measurements normally not necessary).
- Culvert carries entire load with no reliance on surrounding fill for support.
- Generally more expensive but more durable, last longer and require less structural maintenance.




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### Culvert Inspection and Ratings

## Barrel - Flexible

- Made from corrugated steel
- Low strength
- Dependent on surrounding backfill for support
- Culvert deflects under load until the backfill picks up the stress
- Entire load carrying system cannot be inspected directly (I.e. can inspect culvert but not backfill)
- Flexible culverts more susceptible to failure by:
  - Change in shape due to excessive deflection
  - Defective joints - cracks, open joints, cusped seams, etc.
  - Severe corrosion
  - Uplift of ends due to buoyancy forces



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### Culvert Inspection and Ratings


Bridge Culvert Barrel			
Culvert Component	Level	View	Explanation of Condition
<small>(Type # - 1, Primary Span, Location Code: MAIN, Span (mm): 4142, Rise (mm): 4574, Type: SPE)</small>			
Barrel Last Accessible Date	14-Feb-2014		Water too deep to enter and thin ice. Viewed from 400m. Does appear adequate.
<b>Special Features</b>			
Special Feature	5	6	Hydraulic steel struts at rings 1, 2 US strut pulled away from North sidewall on one corner.
<small>(Type - VERT STEEL STRUTS)</small>			
<b>Special Feature</b>			
<small>(Type - )</small>			
Roof	5	5	Ext. shape appears adequate.
<small>Measured Size (mm)</small>			
<small>Measured At Ring No.</small>			
Sag (mm)	91		
<small>Parsons Sag</small>			
<small>2</small>			
<b>Skew</b>			
<small>2 2</small>			
Measured Span (mm)	3352		01+3352, 42+3380
Measured At Ring No.	11		Deflection is not typical of the majority of the barrel section, only US, 2nd 4th.
Deflection (mm)	790		50 to 80mm cracks at ring 9 and 10 south sidewall - not at seam
Parsons Deflection	19		100mm bulge at 08 North sidewall Approx 500 mm bulge at 08 North sidewall, 300mm at south, with 20, 1 14-Feb-2014
<b>Floor</b>			
<small>N N</small>			
<small>Measured At Ring No.</small>			
<small>Abatement (Y/N)</small>			
<small>No</small>			
<small>Separation (mm)</small>			
<small>0</small>			
<small>Longitudinal Seams</small>			
<small>2 2</small>			
<small>Total No. of Cracked Rings</small>			
<small>2</small>			
<small>Total No. of Rings with Two Cracked Seams</small>			
<small>1</small>			
<small>Min. Remaining Steel Between Cracks (mm)</small>			
<small>50</small>			
<small>Proper Lap (Y/N)</small>			
<small>No</small>			
<small>Longitudinal Stagger (Y/N)</small>			
<small>No</small>			
<b>Corrosion</b>			
<small>4 4</small>			
<small>Corrosion By Soil (Y/N)</small>			
<small>Yes</small>			
<small>Corrosion By Water (Y/N)</small>			
<small>Yes</small>			
<small>Condition: POOR/DAMAGED</small>			
<small>HEC</small>			

Bridge Culvert Barrel			
Culvert Component	Level	View	Explanation of Condition
<small>(Type # - 1, Primary Span, Location Code: MAIN, Span (mm): 4142, Rise (mm): 4574, Type: SPE)</small>			
Pending (Y/N)	No		
<b>Fish Passage Adequacy</b>			
	5	5	Blockage: 100%+1 Substrate: 100% Bankstream: 100% Pool Depth: 15 cm
<b>Baffle</b>			
	X	X	
<small>(Type - )</small>			
<b>Waterway Adequacy</b>			
	7	5	Drift at abut. braces, and laying across bed.
<small>Ising (Y/N)</small>			
<small>No</small>			
<small>Silting (Y/N)</small>			
<small>No</small>			
<small>Drift (Y/N)</small>			
<small>Yes</small>			
<b>Barrel General Rating</b>			
	4	4	(Planned to be done by permanent crews) 14-Feb-2014.



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## Barrel - General

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
Barrel Last Accessible Date			

- If barrel is accessible provide current date
- Not accessible explain why & retain previous date
- Rate elements **N** if not visible
- Previous comments are retained and dated
- If more than one barrel indicate location (west) or span number



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## Barrel - Special Features

<b>Special Features</b>			
Special Feature	7	7	Struts installed in 1997. 3.5 heavy wall steel struts on 6" x 6" TT.
<small>(Type - VERT STEEL STRUTS)</small>			
Special Feature			
<small>(Type - )</small>			

- Cannot be rated under another component
- May be temporary or permanent
- Must be visible to inspect
  - Special design features not usually inspectable (ribs, thrust blocks, etc.)




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## Barrel - Special Features

- Examples
  - Struts
  - Shotcrete beams
  - Abrasion plates
  - Concrete Floor
  - Storm Drains
- Record type
- Provide additional information in Explanation of Condition
  - Description
  - Location
  - Dimensions
  - Inspection procedures
- Provide rating based on condition /functionality




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52



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## Barrel - Special Features Shot-crete Beam






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## Barrel - Special Features Struts – Rated 3





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## Barrel - Deformation

Roof		3	3	Rating due to deflection.
Measured Rise (mm)	2170			
Measured At Ring No.	9			
Sag (mm)	374			
Percent Sag	15			
Sidewall		2	2	Where bolted correctly sidewalls are crimping & cracked @ R11, 13, 15.
Measured Span (mm)	2670			
Measured At Ring No.	9			
Deflection (mm)	345			Cracked seams.
Percent Deflection	15			
Floor		4	4	(Rating due to floor bulge. 02-Sep-2011)
Bulge (mm)	200			Could not confirm bulge due to depth of water.
Measured At Ring No.	6			
Abrasion (Y/N)	No			
Circumferential Seams		4	4	Bolts pulled through @ 4 rings.
Separation (mm)	0			
Longitudinal Seams		2	2	Cracks in both W & E sidewalls at R2-5 and R7.
Total No. of Cracked Rings	9			
Total No. of Rings with Two Cracked Seams	5			
Min. Remaining Steel Between Cracks (mm)	25			R11 is cracked where bolted correctly at W side.
Proper Lap (Y/N)	No			At ring 6, E sidewall.
Longitudinal Stagger (Y/N)	Yes			



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55



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**Barrel - Ring**

- Different elements make up a complete ring:
  - Roof
  - Sidewall
  - Floor
  - Bolted or riveted seams
  - Circumferential seams (bolted (SPCSP) or external coupler (CSP))
- Purpose:
  - Carry water flow or traffic
  - carry loads and transmit to surrounding soil
  - Prevent infiltration of fill



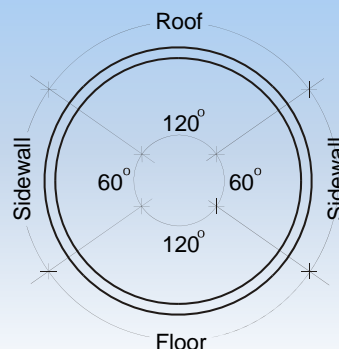
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## Culvert Inspection and Ratings

**Barrel - Ring**

- For round culverts, use approximate arcs shown
  - Use longitudinal seam if close



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## Culvert Inspection and Ratings

**Barrel – Ring Defects**

- Flexible Steel culverts look for:
  - Deformation (measure crest to crest)
  - Localized crimping or buckling
  - Longitudinal seam problems
  - Corrosion
  - Abrasion on floor
- Rigid Timber culverts look for :
  - Material defects – rot decay
- Rigid Concrete culverts look for :
  - Structural problems - cracking
  - Material defects - corrosion, scaling, freeze-thaw damage



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## Culvert Inspection and Ratings

**Barrel - Roof**Flexible Culverts:

- Record lowest measured Rise in mm (crest-crest). Mark in culvert for future reference.
- Record Ring number measurements taken.
- If floor bulge occurs at same location add bulge to measured rise and explain in comments.
- Calculate and record Sag in mm (design –measured rise).
- Calculate and record % Sag.
- Rate Roof based on % Sag (Table 13.3) or other visual defects.
- If not able to measure Rise due to ice, silt, concrete floor, etc. a Roof rating is still required based on visual evidence and estimated sag.



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## Culvert Inspection and Ratings

**Barrel – Roof Ratings**Flexible culverts - continued

- Presence of temporary repairs has no influence.
- Sag within 5% , no corrosion - rate 7
- Sag within 7% , no pitting - rate 5
- Sag within 10%, corrosion pitting – rate 4
- Sag 11-15%, isolated perforations – rate 3
- Sag >15%, roof flattening, reverse curvature , extensive perforations – rate 2.
- Reverse curvature in flat HE or round under low cover, severe perforations – rate 1.
- Consider Longitudinal Seam rating if in Roof.

Rigid Culverts:

- Rate Roof based on visual evidence, defects
- Measurements not required



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## Culvert Inspection and Ratings

**Barrel – Roof Ratings  
Reverse Curvature-Rated 2**

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## Culvert Inspection and Ratings

**Barrel - Sidewall**Flexible Culverts:

- Record greatest measured Span in mm. (crest-crest). Mark in culvert for future reference.
- Record Ring number measurements taken.
- Calculate and record Deflection in mm (measured rise - design).
- Calculate and record % Deflection.
- Rate Sidewall based on % Deflection (Table 13.3) or other visual defects.
- If not able to measure Span due to size, ice, etc. a Sidewall rating is still required based on visual evidence and estimated deflection.



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## Culvert Inspection and Ratings

**Barrel – Sidewall Ratings**

- Deflection within 5% , no corrosion - rate 7
- Deflection within 7% , no pitting - rate 5
- Deflection within 10%, corrosion pitting – rate 4
- Deflection 11-15%, crimping or buckling, isolated perforations – rate 3 or less.
- Deflection >15%, crimping/buckling with plate shear, extensive perforations – rate 2 or less.
- Consider Longitudinal Seam rating if in Sidewall (e.g. - Longitudinal Seam in Sidewall rated 2 governs Sidewall rating).

Rigid Culverts:

- Rate Sidewall based on visual evidence, defects
- Measurements are not required




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## Barrel Sidewall Severe Inward Movement






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## Barrel – Sidewall Buckling – Rated 3 or less





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## Barrel - Floor

- Note and record substrate type and %.
- Check timber floors for rot, missing sections.
- Check concrete floors for cracking, spalling, missing sections.
- Check steel floors for cracks, crimping/buckling, defective seams, corrosion, abrasion.
- Measure or estimate floor bulge and record ring number.
- For flexible culverts - If greatest floor bulge is occurring in same ring as worst roof deflection add bulge to measured Rise
- Indicate abrasion on floor by Yes or No. if yes provide comment.



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## Barrel - Floor

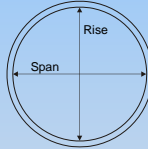
- Rate flexible culvert floors as per Table 13.3:
  - Isolated perforations rate 4
  - Extensive perforations rate 3
  - Severe perforations rate 2
  - <5% bulging, minor abrasion and corrosion, no buckling or seam defects rate 6 or more
  - Seam rating may govern if located in floor


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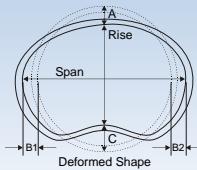


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## Barrel - Ring




Design Shape




Deformed Shape

A = Roof Sag  
 B1 + B2 = Sidewall Deflection  
 c = Floor Bulge



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## Barrel - Circumferential Seams

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
Circumferential Seams			
Separation (mm)			

- Refers to seams joining individual rings or sections of culvert
- Found on most types of culverts
  - Bolted seams on SPCSP
  - Couplers on CSP or Riveted pipes
  - Joints in precast concrete
  - Construction joints in cast-in-place concrete




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## Barrel - Circumferential Seams

- Purpose**
  - Join rings
  - Prevent infiltration of backfill
- Most common problems are separation caused by settlement or corrosion of couplers
  - Especially CSP and precast concrete (settlement)
- Potential for safety problem if void develops in fill
- Look for:
  - Separation
  - Loose or missing couplers (corrosion)
  - Bent or broken edges on the rings
  - Misalignment of rings
  - Infiltration of backfill
  - Voids in surrounding fill




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## Barrel - Circumferential Seams

- Record width of worst separation.
- Gap but no soil infiltration - rate 4.
- Gap with minor soil infiltration - rate 3.
- Void from loss of material due to soil infiltration - rate 2.
- Severe loss of material due to soil infiltration - rate 1.
- Cracking from over torqueing of bolts but no growth or problems – rate 5.
- Cracking due to roof sag rate 4 or less.
- May affect Roof, Sidewall or Floor rating if severe (2 or less).

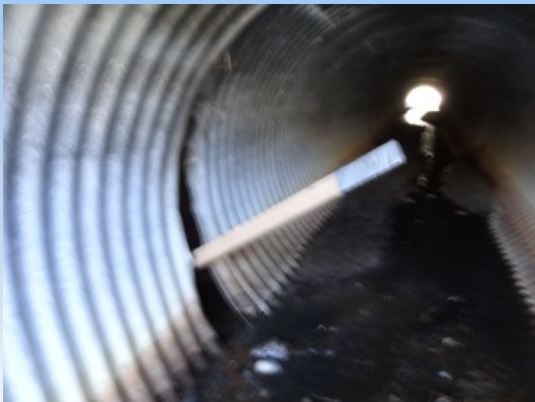



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## Barrel - Circumferential Seam Void Rated 2






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## Barrel - Circumferential Seam – Material Loss and Voids Rated 2





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## Barrel - Longitudinal Seams

Longitudinal Seams		2	2	Cracks in both W & E sidewalls at R0-5 and R7.
Total No. of Cracked Rings	9			
Total No. of Rings with Two Cracked Seams	5			R11 is cracked where bolted correctly at W side.
Min. Remaining Steel Between Cracks (mm)	25			At ring 6, E sidewall.
Proper Lap (Y/N)	No			
Longitudinal Stagger (Y/N)	Yes			

- Applies to SPCSP and CSP riveted culverts
- All others, Rate "X"



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## Barrel - Longitudinal Seams

- Purpose
  - Join individual plates in ring
  - Transmit loads between plates
  - Approx. 75% bending strength of plates
- Indicate if all seams properly lapped by Yes or No
  - If No, provide comment
- Indicate if seams staggered by Yes or No
  - Within same arc only
  - At change of arc should not be staggered
  - If No provide comment
  - Most common problem is cracking
  - Especially on improperly lapped seams



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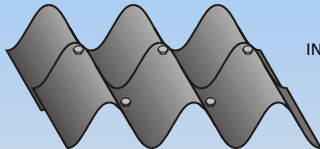


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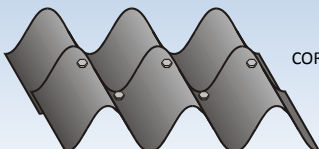
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## Barrel - Longitudinal Seams


- Typical longitudinal seams




INCORRECT LAP



CORRECT LAP

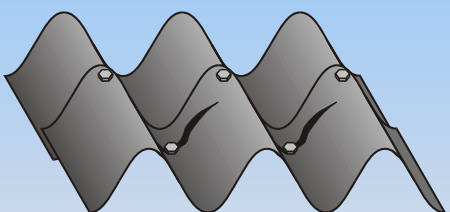


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## Typical longitudinal seams



Cracked Seam




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## Barrel - Longitudinal Seams Cracked Seams

- Record and comment on number of rings with cracked seams
- Record and comment on number of rings with 2 or more cracked seams (may cause catastrophic failure)
- Record least remaining steel between cracks and record location in comments ("At R9")
- Mark and date ends of worst cracks – pencil is best
- Properly lapped seam has bolt in valley nearest visible edge of plate




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## Barrel - Longitudinal Seams Other Problems

- Poorly nested plates
  - Improper fabrication and/or poor assembly
- Cusping
  - Sharp break or discontinuity in curvature
  - Occurs most often at longitudinal seams
  - Improper fabrication , poor assembly/plate rotation during torquing
  - Improper backfill
- Bolt tipping
  - High ring compression causing plate slippage and/or hole elongation
- Plate distortion
  - High ring compression, improper assembly and backfill
- Corrosion




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## Barrel - Longitudinal Seams Rating

- Rate as per Table 13.3
- All seams properly lapped and no defects rate 9
- If seams are not properly lapped but in otherwise excellent condition - rate 7
- >100mm remaining steel between cracks rate 4
- 50 – 100mm remaining steel between cracks - rate 3
- <50mm remaining steel between cracks rate 2
- Two cracked seams in same Ring – rate 2
- Rating for longitudinal seams may also affect Roof, Sidewall and Floor ratings
- Rate riveted longitudinal seams in CSP





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## Barrel – Wrong Lap - Cracked Longitudinal Seam - <50mm Remaining Steel-Rated 2







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## Barrel – Cracked Longitudinal Seam and Wrong Lap






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## Barrel – Failed Longitudinal Seam





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## Barrel - Coating

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
(Pipe # : , Primary/Secondary Span, Location Code : , Span (mm) : , Rise (mm) : , Type : )			
Coating			
Corrosion By Soil (Y/N)			
Corrosion by Water (Y/N)			

- Applicable to steel culverts only
- Applies mainly to zinc or aluminized coating
  - Can include other types - bituminous
- Purpose is to protect the steel from corrosion
  - Zinc & aluminum protect by sacrificial action




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## Barrel - Coating

- Corrosion can occur on soil or water side of culvert
- Soil side corrosion is generally visible above waterline and most common at seams
  - Can lead to perforations
  - Difference in backfill resistivity
  - Corrosive chemicals in backfill or water in fill
- Water side corrosion usually occurs in lower areas
  - Abrasion can remove protective coating
  - Water may have low pH or contain corrosive chemicals
  - Anaerobic bacteria may live in stagnant water




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## Barrel - Coating

- Look for:
  - Fabrication or installation defects or damage
  - Loss of coating - Corrosion
  - Rust stains from bolt holes or seams
  - Perforations
- Record if corrosion is on SOIL and/or WATER side – provide comment if Yes
- Rate according to Table 13.3
- Superficial corrosion no pitting – rate 5 or 6
- Corrosion with pitting in roof or sidewall rate 4
- Isolated perforations in roof or sidewall, extensive perforations in floor - rate 3
- Extensive perforations in roof or sidewall, severe perforations in floor - rate 2
- Severe perforations in roof or sidewall - rate 1
- Rating of Coating may affect other elements ratings





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## Barrel Coating – Sidewall Perforations and Separation






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## Barrel Coating – Floor Severe Perforations





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## Barrel - Camber

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
Camber POS/ZERO/NEG			

- Refers to longitudinal gradeline of invert
- No rating is required
- If water line is level can be used to determine camber
- Record whether camber is POSITIVE, Zero (0), or NEGATIVE
- If significantly POSITIVE or NEGATIVE provide Explanation

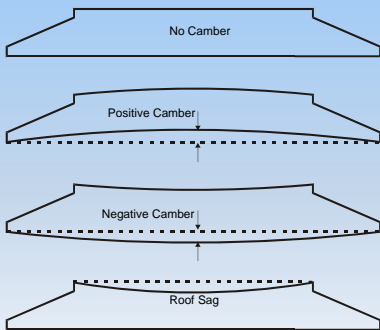



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## Barrel - Camber






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## Barrel – Fish Passage Adequacy

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
<small>(Pipe #: 1, Primary Span, Location Code: MAIN, Span (mm): 5080, Rise (mm): 2388, Type: CPA)</small>			
Ponding (Y/N)		No	
Fish Passage Adequacy		7	7 Blockage: 20% Drift Substrate: 25% Sand Backwater: 60% Pool Depth: 35 cm
Baffle (Type:)		X	X




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## Barrel – Fish Passage Adequacy

- Refer to BIM Bulletin #5
- Inspector should assume ALL culverts are fish bearing even when dry, and rate accordingly
- Refers to ability of culvert to accommodate fish passage U/S and D/S
- May have fish baffles to:
  - provide rest areas
  - reduce velocities
  - provide minimum water levels

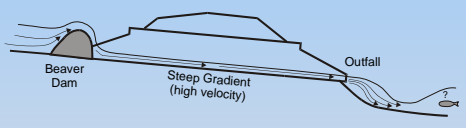



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## Barrel - Fish Passage Adequacy



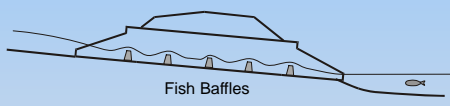



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## Barrel - Fish Passage Adequacy





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## Barrel - Fish Passage Adequacy


- Types of baffles
  - Spoilers
    - Concrete or steel projections
  - Large boulders
  - Weirs
    - Extend fully across floor
    - May have notches
  - Bolted to floor to prevent displacement

Record type of baffle or NONE

Condition and functionality of baffles including anchorages



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## Culvert Inspection and Ratings

## Barrel - Fish Passage Adequacy

- Look for:
  - Excessive velocities
    - Scour
    - Silt deposition downstream
  - Steep gradient in culvert
  - Drops at ends of culvert
  - Anything which could block flow or affect water levels
    - Dirt
    - Beaver dams



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## Culvert Inspection and Ratings

## Fish Passage Adequacy-Bulletin #5

- Additional information is recorded for Fish Passage Adequacy for all W/C culvert sites.
- Multiple culvert sites - record for primary culvert only, or for the worst case culvert (from a fish passage perspective) when no obvious primary exists.
- Note if fish are observed in stream or in culvert
- Record information under the following:

### Debris Blockage:

- If obstructed by debris record % of culvert diameter and the cause of obstruction.

### Substrate in Culvert:

- Note if present and dominate type (sand, gravel, cobble, boulder, silt, other).

- Est. and note % of length that contains substrate.



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## Culvert Inspection and Ratings

## Fish Passage Adequacy-Bulletin #5

### Backwater in Culvert:

- U/S extension of standing water outlet pool into the culvert (Flowing water is not backwater).
- Estimate and record how far up into the culvert (% of culvert length from the outlet).

### Outlet Pool Depth:

- Record depth of the pool to the nearest cm at the outlet .
- Take measurement within one culvert diameter of the end of the culvert.
- If outlet pool depth is highly variable, take several measurements and record the average.



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## Culvert Inspection and Ratings

## Barrel - Fish Passage Adequacy

- Fish Passage Adequacy rated according to Section 13.6.12 of the BIM Inspection Manual.
- Culverts used as Cattlepass, Ped. Underpass or Grade Separation Rate X unless also designed to handle flows
- Rate whether flowing or dry
- If in line with or below streambed rate 5 or more
- U/S or D/S ends above streambed rate 4 or less



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Culvert Inspection and Ratings


## Barrel - Waterway Adequacy

Bridge Culvert Barrel			
Culvert Component	Last	Now	Explanation of Condition
Waterway Adequacy			
Icing (Y/N)			
Siltting (Y/N)			
Drift (Y/N)			

- Refers to the ability of the culvert to safely pass the design flow
  - Maintain Freeboard
  - Pass drift without damage
  - No damage from backwater created



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## Barrel - Waterway Adequacy

- Adequately sized culvert may be affected by:
  - Ice build up
  - Silt deposition
  - Drift accumulation
  - Beaver dams
  - Ponding
  - Repair or rehabilitation work
    - Shotcrete beams
    - Struts



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## Barrel - Waterway Adequacy

- Indicate presence of ice build up (icing) by Yes or No if Yes explain
  - Not normal freezing of ponded water
  - Results from active springs which freeze and causes layers of ice to build up
  - If previously Yes - leave and retain comments adding date of previous inspection
- Indicate presence of silt build up (Siltting) by Yes or No, if Yes explain
  - Invert normally below streambed
  - Minor accumulation of silt expected
- Indicate presence of drift in Barrel by Yes or No
- If “yes”, explain



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## Barrel - Waterway Adequacy

- Look for:
  - High water marks (not normal flow lines)
  - Potential damage from backwater
  - Potential for drift
  - Evidence of high velocities
    - Scour
    - Silt deposition downstream
  - Presence and effect of items which can affect adequacy



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## Barrel - Waterway Adequacy

- Rate "X" if not a drainage culvert
- Adequate opening rate 5
- HWM above crown, 4 or less
- Culvert blockage 50% or more rate 3 or less





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## Barrel - Waterway Adequacy-100% Blockage







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## Barrel - Waterway Adequacy - 50% Blockage






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## Barrel - General Rating

- Governed by the following element ratings : (refer to 1.10.8 and 13.6.14)
  - Roof
  - Sidewalls
  - Longitudinal seams
  - Circumferential seam rating of 2 or less
  - Corrosion rating of 2 or less
- Barrel not accessible - rate barrel elements "N"
- If previous Barrel General Rating was 4 or less then carry over previous General Rating rating and provide Explanation of Condition ("carried forward")
- If previous Barrel General Rating was 5 or more rate current General Rating "N"



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## Culvert Inspection and Ratings

## Effects of Struts on Barrel General Rating

- Inspector may increase General Rating by 1 or 2 points but not exceed rating of 4.
- Rating Conditions
  - struts in place more than 2 years
  - struts rated 5 or more
  - 1 permanent reference for monitoring
  - struts inspected after any significant event
  - consider culvert size and depth of cover (failure of large diameter culvert under high fill may not be as serious as under low fill)
  - does not apply when deflections >30% or cracked seams with less than 25mm remaining steel
  - applied to general rating only, element ratings remain unchanged

## Culvert Inspection and Ratings

## Questions??