CULVERT INSPECTION & RATING

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Introduction

- Approximately 63% of all structures are culverts
- Bridge sized culverts have an equivalent diameter of 1500mm or greater
- May also inspect if multiple small culverts are equivalent in hydraulic capacity to bridge-sized (e.g. 2-1200mm)
- May inspect certain other non-bridge sized culverts if several (e.g. LL Xing)

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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 and vertical ellipse
- Three culvert forms (Cul1, CulE, CulM)
- Same forms used for all types of culverts except for Timber pipe (TP) which is inspected using a TT form

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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) - single U/S & D/S section for all barrels
  - Includes 2 cell box extended with single steel
- CULE
  - Single culvert extended with different material and/or size
  - One U/S section, 2 or more Barrel sections and one D/S section
  - Original and extended barrels inspected and rated separately

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Inventory Information

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

- Extracted from BIS
- Span/Rise is original design shape
- If round, then only Rise is recorded as shown in example above
- 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 (Manual)
- Specific information is provided for all pipes
- If original design shape unknown or in question, inspector should consult CPI handbook and/or use the average of the U/S and D/S span and rise measurements.

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Culvert Span Types

FORM TYPE	DESCRIPTION	SPAN TYPE
TH	Through Trusses	TH
PT	Pony Trusses	PT
SG	Rolled Beams	RB RC
	Riveted Plate Girders	RG
	Welded Girders	WG
	Steel Rigid Frames	FR
SS	Other Trusses & Arches	SSB SSA SSS SSF SSC
DT	Deck Trusses	DT
TT	All Timber Bridges	TT UT XT TP
PCS	Standard Precast Bridges	HH HC VH PG GR PE PA PS MM HCO PGO HHO PX PES PEF
	Standard Prestress Bridges	VS SM SMC SC SCC SMO VSO SCM SL SLW SLC
PSR	Regular Prestress Bridge	RO FC VF PM VM PB DBT PQ PO PMO OM LF FM RM PJ NU CBT DBC CBC FCO PJO TSS
CON	All Cast in Place Concrete Bridge	CA CB CF CV CX CC CXP
	Concrete Tee Girder Bridges	CT
	Concrete Flat Slab Bridges	CS
CUL1	Single Culverts	RP SP FP MP WP CP BP AP BPR
CULM	Multiple Culverts	RPB CPA CPE SPE
CULE	Culverts extended with different material and/or size	PCB RPA RPE RPP MPB SCA SCR SSP CPP SPP SRA MPE
SIGN	Sign Structures	Z
THTT	Through Trusses with Timber Approaches	
THPCS	Through Trusses with Standard Precast Approaches	
THPSR	Through Trusses with Regular Prestress Approaches	
THSG	Through Trusses with Steel Girder Approaches	
THPT	Through Trusses with Pony Truss Approaches	
PTTT	Pony Trusses with Timber Approaches	
PTPCS	Pony Trusses with Standard Precast Approaches	
SGTT	Steel Beams with Timber Approaches	
SGPCS	Steel Beams with Standard Precast Approaches	
PSRPCS	Regular Prestress with Standard Precast Approaches	
SSSG	Special Steel with Steel Girder Approaches	
DTSG	Deck Truss with Steel Girder Approaches	

Table 1.1 – BIM report index

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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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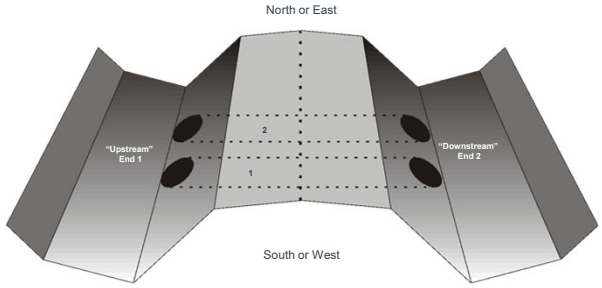
Numbering and Identification



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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.)

U/S and D/S 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. Note in explanation of condition which barrel is being inspected (i.e. south, west, #1)
- Upstream and Downstream sections are identical
- Items are inspected and rated the same way for both ends

U/S and D/S Ends - General

Downstream End				
Culvert Component		**Last**	**Now**	**Explanation of Condition**
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 RAP**)				
(Avg. Rock Size(mm) : **300**)				
Scour/Erosion		8	8	
Beavers (Y/N)	No			
Downstream End General Rating		**8**	**8**	

U/S and D/S Ends - End Treatment

- Purpose:
  - 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
  - Improve aesthetics

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 (headwall, collar and cut-off wall) - Type is "Concrete"

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End Treatment - Headwall

	Downstream End		
Culvert Component	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

	Downstream End		
Culvert Component	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

- Purpose:
  - Stiffen the bevel
  - Resist buoyancy force
  - Improve hydraulic efficiency of inlet or outlet
  - Concrete slope protection
    - protect against scour / erosion
    - reduces piping potential
    - works in conjunction with rip rap

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End Treatment - Collar

- 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 not connected to culvert, rate 4 or less
- If piping, rate 4 or less:
  - Also rated under bevel end and barrel

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End Treatment - Wingwalls

Wingwalls (Shape : **FLARE**)	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.

- Generally found at culverts that do not have bevels
- Shape is either Parallel, Perpendicular, 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 slab is 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 invert of the pipe
- 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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End Treatment - Bevel End

Culvert Component		Downstream End Last	Now	Explanation of Condition
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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End Treatment - 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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End Treatment - 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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End Treatment - 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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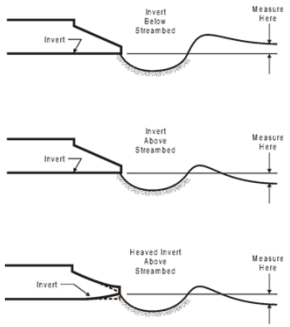
End Treatment - Bevel End



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End Treatment – Bevel End

- Look for:
  - Piping
  - Deformation
  - Impact damage
  - Corrosion that affects 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"
  - Ped and cattle underpasses often have square ends

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Scour Protection

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

- Usually, heavy rock riprap
- The current version of Std. Drawing S-1418-20 shows the minimum requirements for riprap
  - Coverage
  - Size
  - Minimum thickness
  - Gradation

https://www.alberta.ca/assets/documents/trans-bridge-culverts-drawings.pdf

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Scour Protection

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

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Scour Protection

- Record the type of Scour Protection
  - Rock, bagged concrete, concrete, gabion baskets, geotextile mats, MSE wall, natural
  - If none exists and none is required, record type as “NATURAL”
  - If none exists but 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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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 3 or less and 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 3 or less
- Cattlepasses that also handle drainage rate – otherwise X

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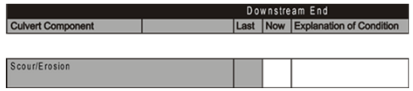
Scour / Erosion



- Removal of material from the streambed, banks or sideslopes by the action of flowing water and/or constrictions or obstructions
- Effects:
  - Undermine the culvert
  - Undermine the sideslope and/or road embankment
  - Alter culvert hydraulics
  - Impede fish passage

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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 sideslope
  - 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 protection systems

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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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Scour / Erosion

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Scour Protection

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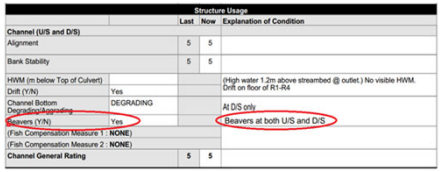
Beaver Activity



Structure Usage		Last	Now	Explanation of Condition
Channel (U/S and D/S)				
Alignment		5	5	
Bank Stability		5	5	
HWM (m below Top of Culvert)				(High water 1.2m above streambed @ outlet.) No visible HWM. Drift on floor of R1-R4
Drift (Y/N)	Yes			
Channel Bottom Degrading/Aggrading	DEGRADING			At D/S only
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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Beaver Activity

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

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U/S & D/S End 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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Barrel - Rigid Types

- Made from concrete or timber or heavy wall steel pipe
- 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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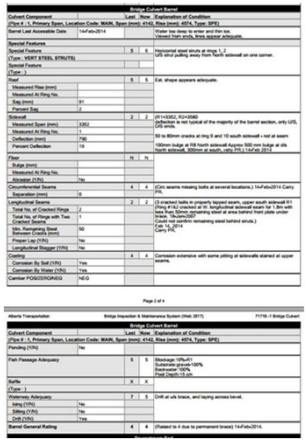
Barrel - Flexible Types

- Made from corrugated steel
- Low strength as a stand-alone structure
- 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



Barrel - General

- If barrel is accessible record current date
- If barrel is not accessible explain why, take photograph showing condition & retain the previous “last accessible date”. Then 3 possible rating scenarios:
  1. If the previous critical elements (roof, sidewall, longitudinal seam) ratings were **7** or higher AND the inspector is able to get good sight lines down the barrel from both ends to confirm the shape, the previous roof, sidewall, and Barrel General ratings can all be carried forward.
  2. If previous roof or sidewall ratings were **6** or less, barrel elements and General Rating are rated **N** (not visible). Previous comments are retained and dated.
  3. If previous critical element and Barrel General ratings were 4 or less, elements are rated N with comment indicating previous rating and Gen Rating carried over
- If more than one barrel indicate location (west) or span number

Barrel - Special Features

Special Features			
Special Feature	7	7	Struts installed in 1997. 3.5 heavy wall steel struts on 6" x 6" TT.
(Type : **VERT STEEL STRUTS**)			
Special Feature		X	
(Type :)			

- Cannot be rated under another component
- May be temporary or permanent
- Must be visible to inspect
  - Special design features sometimes not inspectable (ribs, thrust blocks, etc.)
- If birds nest present in barrel, note in Explanation of Condition

Barrel - Special Features

- Common Examples
  - Struts
  - Shotcrete beams
  - Concrete Floor
  - Storm Drains
  - Elbow
  - Beaver Control Device
- Record type
- Provide additional information in Explanation of Condition
  - Description
  - Location
  - Dimensions
- Provide rating based on condition /functionality

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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			Cracked seams.
Deflection (mm)	345			
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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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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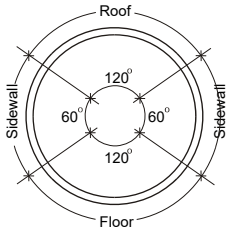
Barrel - Ring

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



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Barrel – Ring Defects

- Flexible Steel culverts look for:
  - Deformation (measure crest to crest)
  - Localized crimping or buckling
  - Longitudinal seam problems
  - Corrosion
  - Abrasion on floor or lower sidewall
- 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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Barrel - Roof

Flexible Culverts:

- Record lowest measured Rise in mm (crest-crest). Mark in culvert for future reference if deflections are ≥7%.
- Record Ring number where 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 rise – measured rise).
- Calculate and record % Sag (rounded up or down – e.g. 5.4% is recorded as 5%).
- 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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Barrel – Roof Ratings

Flexible culverts - continued

- Presence of temporary repairs has no influence.
- Sag 5% or <, no corrosion – rate 7
- Sag within 7%, corrosion with pitting - rate 5
- Sag within 10% – rate 4
- Sag 11-15% or isolated perforations – rate 3
- Sag >15%, roof flattening, reverse curvature, or 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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Barrel – Roof Ratings
Reverse Curvature-Rated 2

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Barrel - Sidewall

Flexible Culverts:

- Record greatest measured span in mm. (crest-crest). Mark in culvert for future reference if deflections are ≥7%.
- Record Ring number measurements taken.
- Calculate and record Deflection in mm (measured span – design span).
- Calculate and record % Deflection (rounded up or down (e.g. 7.7% = 8%)
- 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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Barrel – Sidewall Ratings

- Deflection within 5%, no corrosion - rate 7
- Deflection within 7%, corrosion with pitting - rate 5
- Deflection within 10% – 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

- 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 a 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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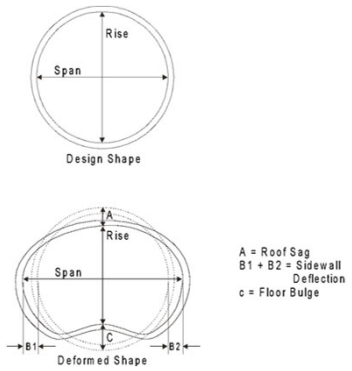
Barrel - Ring



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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

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- 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.
- Misalignment with visible fill but no soil infiltration - rate 4 or less.
- Misalignment or seperation with minor soil infiltration - rate 3 or less.
- Void in backfill from loss of material due to soil infiltration - rate 2 or less.
- Severe loss of material due to soil infiltration - rate 1.
- Cracking from over torquing 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 Material Loss and Void Rated 2

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Barrel - Circumferential Seam – Visible fill and minor loss but no void - Rated 3 or less

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Barrel - Longitudinal Seams

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			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 culverts with riveted seams
- 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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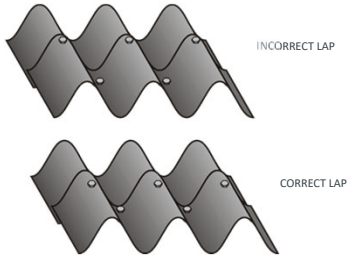
Barrel - Longitudinal Seams

- Typical longitudinal seams



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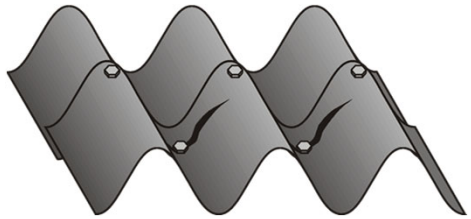
Typical longitudinal seams



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 (“65 mm rem. steel at R9 west sidewall”)
- Mark and date ends of worst cracks – pencil is best for marking ends of cracks. Record measurements with lumber crayon or sharpie.
- 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 torqueing
  - 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
- 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 or more cracked seams in same Ring – rate 2
- Rating for longitudinal seams also affect Roof, Sidewall and Floor ratings
- Rate riveted longitudinal seams in CSP

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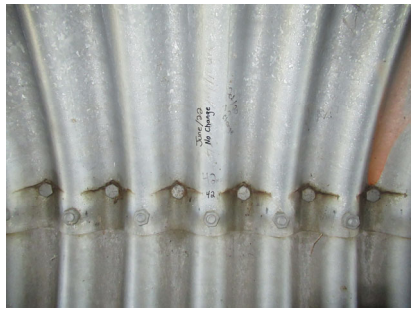
Barrel – Wrong Lap and Cracked Longitudinal Seam with <50mm Remaining Steel - Rated 2



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Barrel – Cracked Longitudinal Seam/Wrong Lap <100mm and >50 mm Remaining Steel – Rated 3

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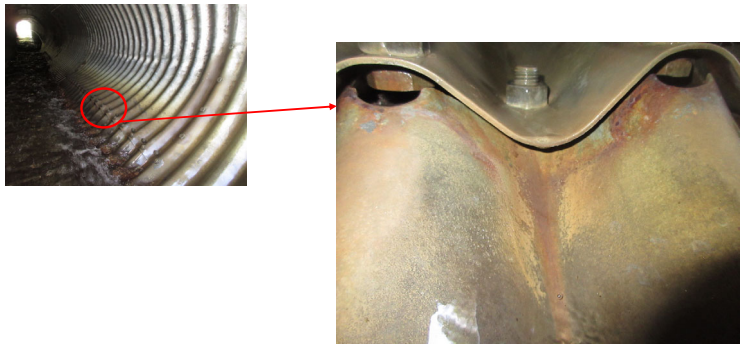
Barrel – Cracked Longitudinal Seam and Wrong Lap



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Barrel – Failed Longitudinal Seam

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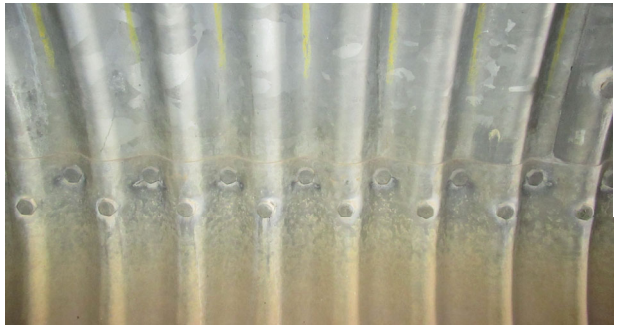
Cracks in Properly Lapped Seam
Bolt in valley is closest to visible edge



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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, polymer
- 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 first visible at the seams
  - Can lead to perforations
  - Difference in backfill resistivity
  - Corrosive chemicals in backfill or water in fill
- Water side corrosion usually occurs in lower sidewall and floor areas
  - Abrasion can remove protective coating
  - Water may have low pH or contain corrosive chemicals from agriculture
  - 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, sidewalls, or floor 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 – Lineal Sidewall Perforations – Rated 2

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Barrel Coating – Severe Floor Perforations – Rated 2

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Barrel - Camber

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

- Refers to longitudinal grade line 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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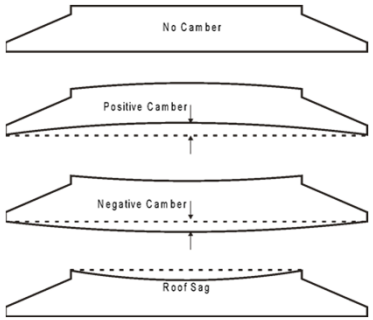
Barrel - Camber



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Barrel – Fish Passage Adequacy

Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
(Pipe # : 1, Primary Span, Location Code: MAIN, Span (mm): 5080, Rise (mm): 2388, Type: CPA)				
Ponding (Y/N)	No			
Fish Passage Adequacy		7	X	Block[illegible]% Drift Substra[illegible]5% Sand Backwa[illegible]50% Pool Depth[illegible]5 cm
Baffle		X	X	
(Type:)				

- No longer rated.
- The previous rating and information from the last inspection may be on the form.
- Change rating to X.
- Cross out / remove comments from the Explanation of Condition.

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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. Rate the condition and functionality of baffles including anchorages

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Barrel - Waterway Adequacy

		Bridge Culvert Barrel		
Culvert Component		Last	Now	Explanation of Condition
Waterway Adequacy				
Icing (Y/N)				
Silting (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 **Y**es or **N**o if Yes explain
  - 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 (Silting) by **Y**es or **N**o, if Yes explain
  - Invert normally below streambed
  - Minor accumulation of silt expected
- Indicate presence of drift in Barrel by **Y**es 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 (cattlepass, pedestrian underpass)
- Rate if cattlepass also handles water flow
- Adequate opening rate 5 or more
- 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
  - Floor rating of 3 or less
  - Circumferential seam rating of 2 or less
  - Corrosion rating of 2 or less
  - Waterway adequacy rating of 2 or less

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Barrel Not Accessible – Critical Element & General Rating

If barrel is not accessible for inspection – 4 possible rating scenarios

1. Previous Roof, Sidewall, and Barrel General ratings ≥7 **AND** can obtain sightline of barrel from ends to confirm shape, then previous Roof, Sidewall, and Barrel General ratings are carried forward with comments. Longitudinal Seam is rated N with comment indicating previous rating (e.g. P.R. 8)
2. Previous Roof, Sidewall, and Barrel General ratings are 5 or 6. Rate barrel elements and Barrel General rating "N"
3. Previous Barrel General Rating are 4 or less, then barrel elements are rated N and previous General Rating of 4 or less is carried forward with comment indicating "Gen. Rating carried forward"

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Barrel Not Accessible – Critical Element & General Rating

If barrel is not accessible for inspection – Continued

4. Previous Roof, Sidewall, and Barrel General ratings are 5 or more but obvious defect or change noted when viewed from ends (e.g. roof deflection). Reduce applicable element rating and General Rating based on visual evidence and recommend inspection during low water/winter, or Level 2 de-water inspection

- Refer to Section 13.6.2 for further information
- Barrels not accessible for 2 consecutive inspections recommend inspection during low water/winter, or Level 2 de-water inspection. Refer to 13.9.1.5

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Effects of Struts on Barrel General Rating

- Inspector may increase General Rating by 1 or 2 points but not exceed rating of 4.
- Conditions for increase to rating:
  - struts in place more than 2 years (permanent repair)
  - struts rated 5 or more
  - 1 permanent reference point for future 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

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Questions?

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