Culvert Inspection and Rating

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)

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

Form Types

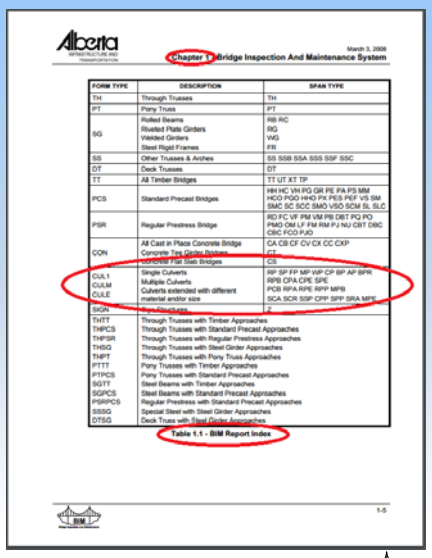
- CUL1
  - Single culvert or single culvert extended with same material and size
- CULM
  - Two or more culverts (MP, SP or BP etc.)
  - Includes 1 Upstream & 1 Downstream End section for each Barrel section
  - Exception is Concrete Boxes (BP) where single U/S and single D/S sections for all barrel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

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
- 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)

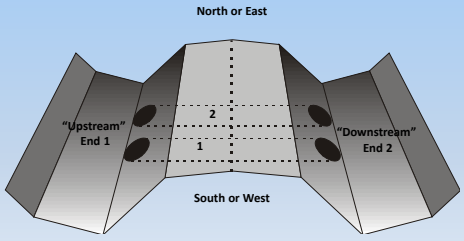
Culvert Span Types



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

Numbering and Identification



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.)

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

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**	

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

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

Bevel Ends – End Treatment Type is "Steel"

Bevel Ends with Full Concrete End Treatment - Type is "Concrete"

Bevel End with Full Concrete End Treatment - Type is "Concrete"

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

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

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

End Treatment - Collar / Slope Protection

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

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

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 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

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

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

End Treatment – Flared Wingwalls

End Treatment - Cutoff Wall

		Downstream End		
Culvert Component		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

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

Ends - Bevel End

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

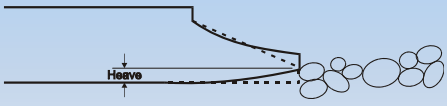
- Sloped section at the end of the culvert
- Permanently attached to the barrel
- Generally parallel to the culvert axis
- Bevel types
  - Full bevel
  - Step bevel

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

Ends - Bevel End

- Measure or estimate heaving of bevel and record amount

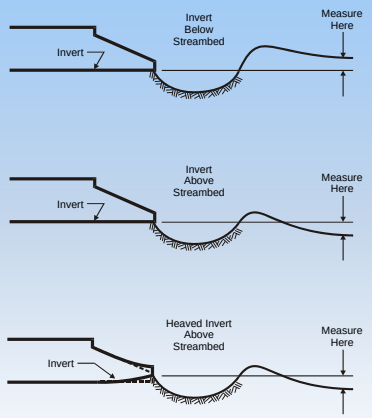


- Often best place to estimate is from inside barrel looking back to Bevel
- Use waterline as level
- Some heave is tolerable as long as water is entering Bevel

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

Ends - Bevel End



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

Ends - Bevel End

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

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

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 require, 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

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

Ends - Scour / Erosion

		Downstream End		
Culvert Component		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

Ends - Scour / Erosion

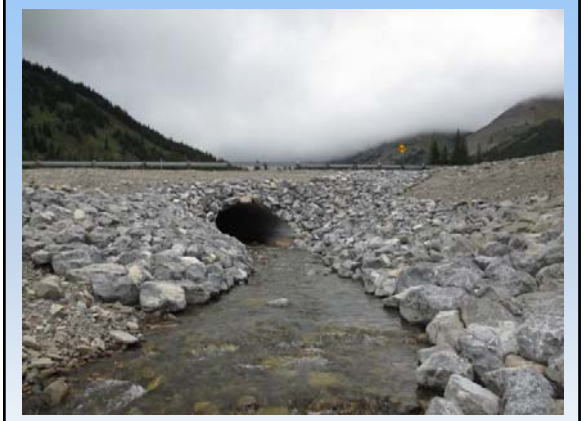
- Two types:
  - General – uniform lowering of original stream
  - Local – occurring at specific locations
- Look for:
  - Scour holes, especially at downstream ends
  - Undermining of culvert end or sideslopes
  - Slumping of sideslope or banks
  - Areas where flow impinges on banks, sideslopes or protection 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

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

Ends - Scour / Erosion

Ends - Scour / Erosion



Ends - 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

Ends - 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

Ends - General Rating

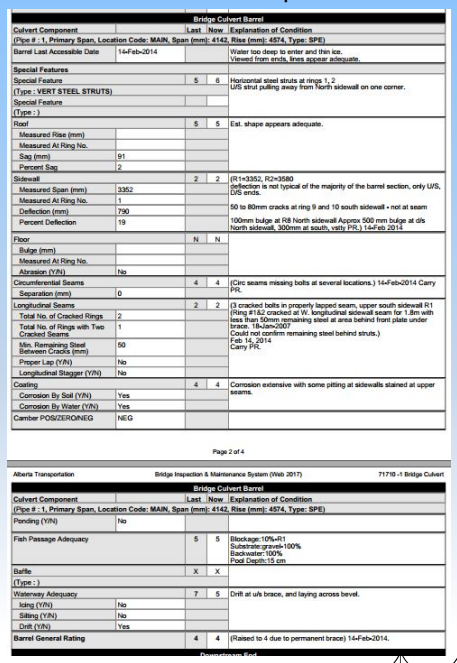
- Governing elements: (Refer to 1.10.7 & 13.5.10)
  - Headwall
  - Collar
  - Wingwall
  - Cutoff Wall
  - Bevel end
  - Scour protection
  - If all are rated “X” then provide rating based on general condition of culvert end

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.

Barrel - Flexible Types

- 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



Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
(Pipe # :1, Primary Span, Location Code: MAIN, Span (mm): 4142, Rise (mm): 4574, Type: SPE)				
Barrel Last Accessible Date	14-Feb-2014			Water too deep to enter and thin ice. Viewed from ends, lines appear adequate.
Special Features				
Special Feature		5	6	Horizontal steel struts at rings 1, 2 U/S strut pulling away from North sidewall on one corner.
(Type : VERT STEEL STRUTS)				
Special Feature				
(Type :)				
Roof		5	5	Est. shape appears adequate.
Measured Rise (mm)				
Measured At Ring No.				
Sag (mm)	91			
Percent Sag	2			
Sidewall		2	2	(R1=3352, R2=3580 deflection is not typical of the majority of the barrel section, only U/S, D/S ends.
Measured Span (mm)	3352			
Measured At Ring No.	1			50 to 80mm cracks at ring 9 and 10 south sidewall - not at seam
Deflection (mm)	790			
Percent Deflection	19			100mm bulge at R8 North sidewall Approx 500 mm bulge at d/s north sidewall, 300mm at south, vstly PR.) 14-Feb 2014
Floor		N	N	
Bulge (mm)				
Measured At Ring No.				
Abrasion (Y/N)	No			
Circumferential Seams		4	4	(Circ seams missing bolts at several locations.) 14-Feb-2014 Carry PR.
Separation (mm)	0			
Longitudinal Seams		2	2	(3 cracked bolts in properly lapped seam, upper south sidewall R1 (Ring #1&2 cracked at W, longitudinal sidewall seam for 1.8m with less than 50mm remaining steel at area behind front plate under brace. 18-Jan-2007 Could not confirm remaining steel behind struts.) Feb 14, 2014 Carry PR.
Total No. of Cracked Rings	2			
Total No. of Rings with Two Cracked Seams	1			
Min. Remaining Steel Between Cracks (mm)	50			
Proper Lap (Y/N)	No			
Longitudinal Stagger (Y/N)	No			
Coating		4	4	Corrosion extensive with some pitting at sidewalls stained at upper seams.
Corrosion By Soil (Y/N)	Yes			
Corrosion By Water (Y/N)	Yes			
Camber POS/ZERO/NEG	NEG			

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Alberta Transportation — Bridge Inspection & Maintenance System (Web 2017) — 71710 -1 Bridge Culvert

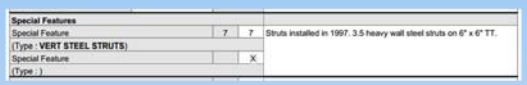
Bridge Culvert Barrel				
Culvert Component		Last	Now	Explanation of Condition
(Pipe # :1, Primary Span, Location Code: MAIN, Span (mm): 4142, Rise (mm): 4574, Type: SPE)				
Ponding (Y/N)	No			
Fish Passage Adequacy		5	5	Blockage:10%-R1 Substrate:gravels-100% Backwater:100% Pool Depth:15 cm
Baffle		X	X	
(Type :)				
Waterway Adequacy		7	5	Drift at u/s brace, and laying across bevel.
Icing (Y/N)	No			
Silting (Y/N)	No			
Drift (Y/N)	Yes			
Barrel General Rating		4	4	(Raised to 4 due to permanent brace) 14-Feb-2014.

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

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 inspecct
  - Special design features not usually inspectable (ribs, thrust blocks, etc.)

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

Barrel - Special Features Shot-crete Beam

Barrel - Special Features Struts – Rated 3

Barrel - Deformation

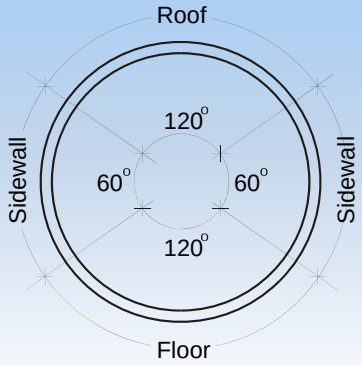
Roof		3	3	Rating due to deflection.
Measured Rise (mm)	2170			
Measured At Ring No.	9			
Sag (mm)	374			
Percent Sag	15			
Sidewall		2	2	Where bolted correctly sidewalls are crimping & cracked @ R11, 13, 15.
Measured Span (mm)	2670			
Measured At Ring No.	9			Cracked seams.
Deflection (mm)	345			
Percent 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			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			

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

Barrel - Ring

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



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

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.

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

Barrel – Roof Ratings Reverse Curvature-Rated 2

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.

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

Barrel Sidewall Severe Inward Movement

Barrel – Sidewall Buckling – Rated 3 or less

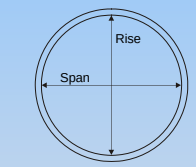
Barrel - Floor

- 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.

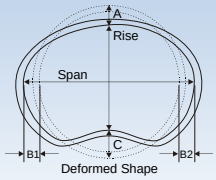
Barrel - Floor

- 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

Barrel - Ring



Design Shape



Deformed Shape

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

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

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

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 rate4 or less.
- May affect Roof, Sidewall or Floor rating if severe (2 or less).

Barrel - Circumferential Seam Void Rated 2

Barrel - Circumferential Seam – Material Loss and Voids Rated 2

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			
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			

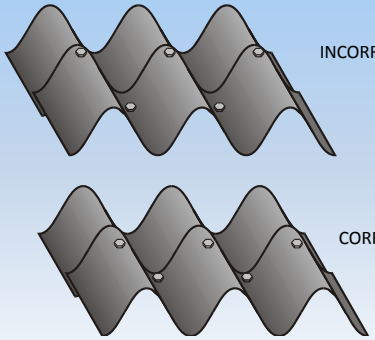
- Applies to SPCSP and CSP riveted culverts
- All others, Rate “X”

Barrel - Longitudinal Seams

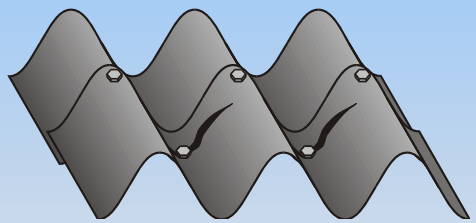
- Purpose
  - Join individual plates in ring
  - Transmit loads between plates
  - Approx. 75% bending strength of plates
- Indicate if all seams properly lapped by Yes or No
  - If No, provide comment
- Indicate if seams staggered by Yes or No
  - Within same arc only
  - At change of arc should not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

Barrel - Longitudinal Seams

- Typical longitudinal seams



Typical longitudinal seams



Cracked Seam

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

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

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

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

Barrel – Cracked Longitudinal Seam and Wrong Lap

Barrel – Failed Longitudinal Seam

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

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

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

Barrel Coating – Sidewall Perforations and Separation

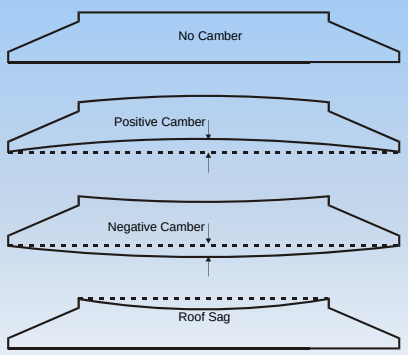
Barrel Coating – Floor Severe Perforations

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 **P**OSITIVE, Zero (**0**), or **N**EGATIVE
- If significantly **P**OSITIVE or **N**EGATIVE provide Explanation

Barrel - Camber



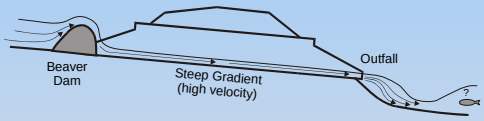
Barrel – Fish Passage Adequacy

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	7	Blockage: 20% Drift Substrate: 25% Sand Backwater: 50% Pool Depth: 35 cm
Baffle		X	X	
(Type:)				

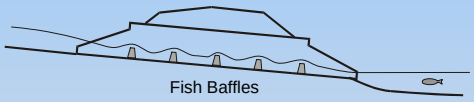
Barrel – Fish Passage Adequacy

- 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

Barrel - Fish Passage Adequacy



Barrel - Fish Passage Adequacy



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

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

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:

<u>Debris Blockage:</u>

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

<u>Substrate in Culvert:</u>

- Note if present and dominate type (sand, gravel, cobble, boulder, silt, other).
- Est. and note % of length that contains substrate.

Fish Passage Adequacy-Bulletin #5

<u>Backwater in Culvert:</u>

- 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).

<u>Outlet Pool Depth:</u>

- 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.

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

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

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

Barrel - Waterway Adequacy

- Indicate presence of ice build up (icing) by **Y**es or **N**o 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 (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

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

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

Barrel - Waterway Adequacy-100% Blockage

Barrel - Waterway Adequacy - 50% Blockage

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"

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

Questions??