WisDOT Structure Inspection Series - Small Bridges, Culverts and Arches

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Welcome to the Wisconsin Department of Transportation's Bridge Inspection Refresher Series.

This module details important information on small bridge and culvert elements and assessments that inspection team leaders should use to improve their inspections.

This training module includes slides with audio as well as slides with clickable interactive features. When you finish a slide, click next.

There is a short quiz at the end of the training. Please start the training by clicking next.

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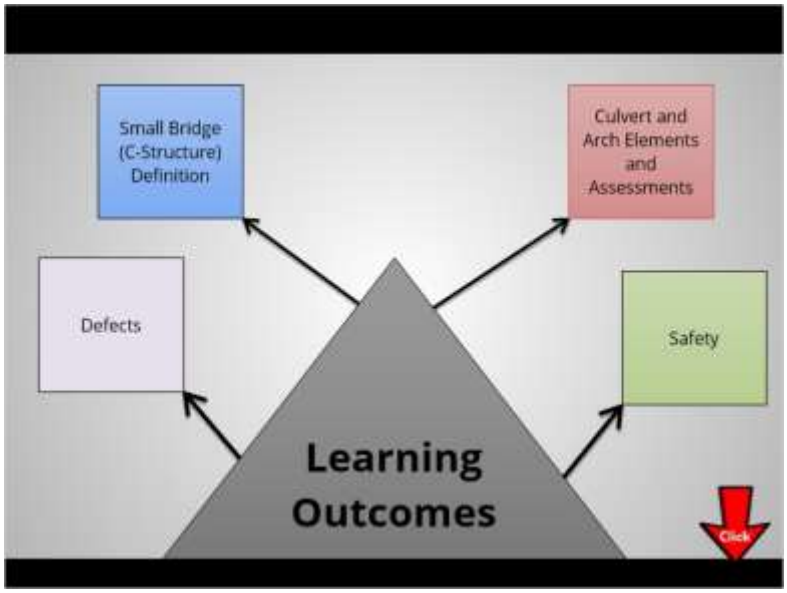

At the end of this session, you will be able to:

- Determine if a structure is a roadway culvert, a small bridge (C-structure) or a bridge (B-structure).
- Identify culvert elements and assessments, and properly code them.
- Identify steel and concrete rigid frame and arch elements, and properly code them.
- Identify common defects for culvert elements, and
- Identify common safety concerns and mitigation techniques regarding C – structure inspections.

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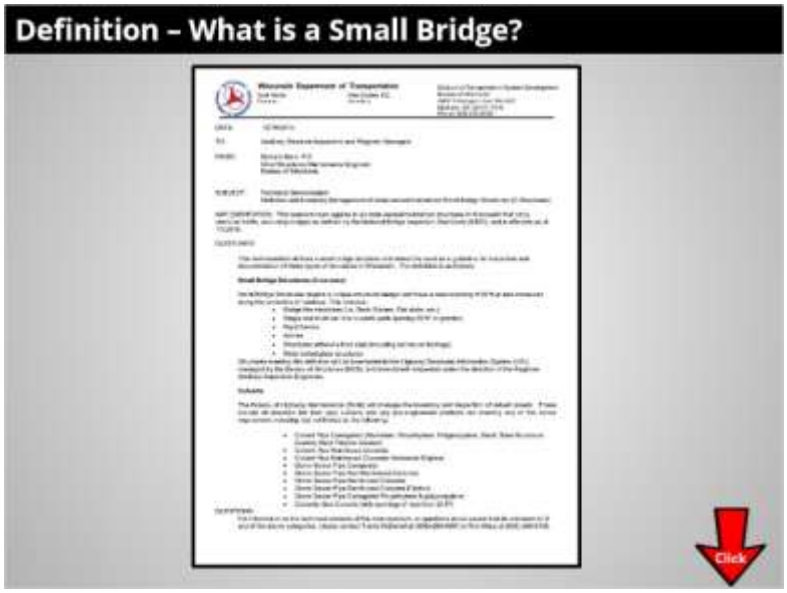

The Bureau of Structures defined small bridge structures in a policy memo in December 2015. “C” structure requirements consist of dimensions for span are measured along centerline of roadway.

Structures with a span greater than 20’, are classified as bridge or “B” structures. This would include multiple pipe culverts where the clear distance between them is less than half the smaller contiguous opening, regardless if there is a structural plate pipe or not.

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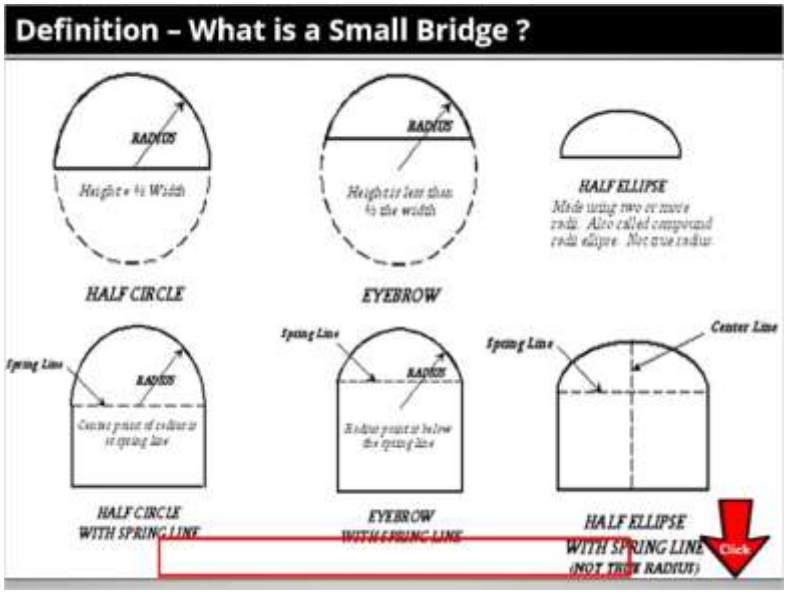

Small Bridge or “C” structures are defined as a structure with a span less than or equal to 20' between the under coping of abutments or spring lines of arches, or extreme ends of the openings for multiple boxes, and typically require a unique structural design. Multiple pipes would be considered “C” structures only if one or more of the pipes is a structural plate pipe. The span length for arches are measured at the spring line, which is defined as the point at which the arch begins to curve.

Structures that are covered under standard roadway culvert bid items or concrete boxes with an opening of less than 20 square feet that do not typically require unique designs are Culverts and are maintained by Bureau of Highway Maintenance.

While not specifically discussed in the memo, reinforced concrete box structures with an opening of less than 20 square feet, but a height greater than 4 feet, are considered as “C” structures in some regions and can be inspected easily. Box structures with areas less than 20 square feet and heights less than or equal to 4 feet are generally considered roadway culverts. Regional Ancillary program managers should be contacted if it's unclear whether the structure is a C-structure or roadway culvert.

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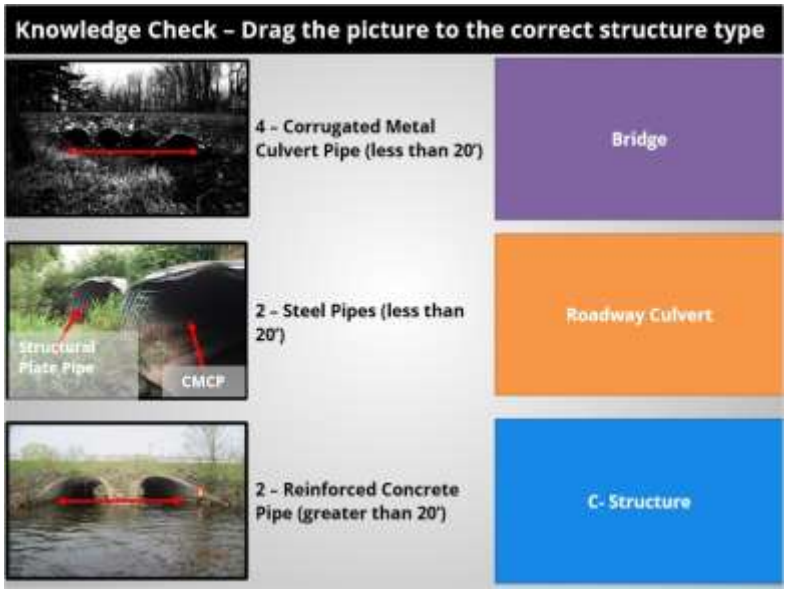

C-Structures can take many different forms. The most common forms are boxes and arches. Small bridge structures are also common, utilizing concrete slabs or a concrete deck on steel girders, for example, to span the 20 feet or less openings found with C-Structures. Bridge like C-Structures are to be coded with deck, superstructure and substructure elements used in bridges, please refer to those Refresher Modules for more information. The remainder of this module will discuss the pipe, box and arch type structures and the various elements, assessments and defects commonly noted with those structures.

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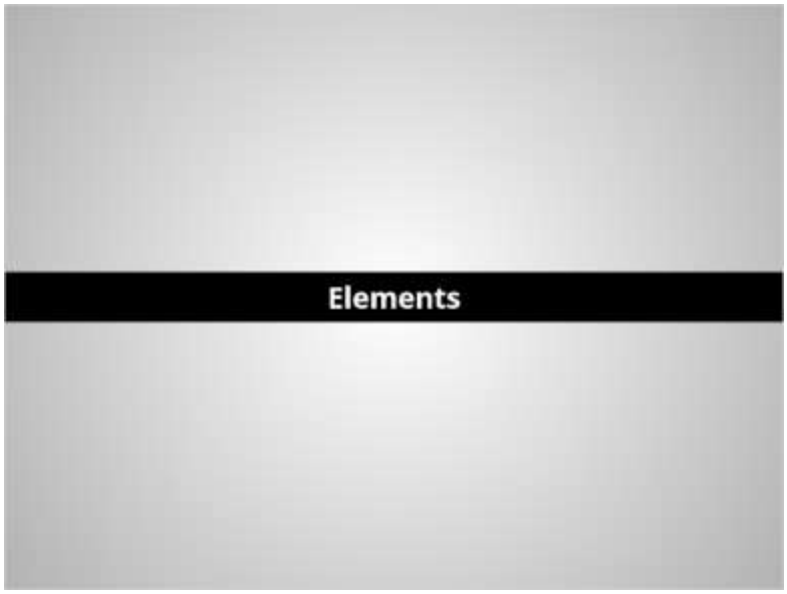

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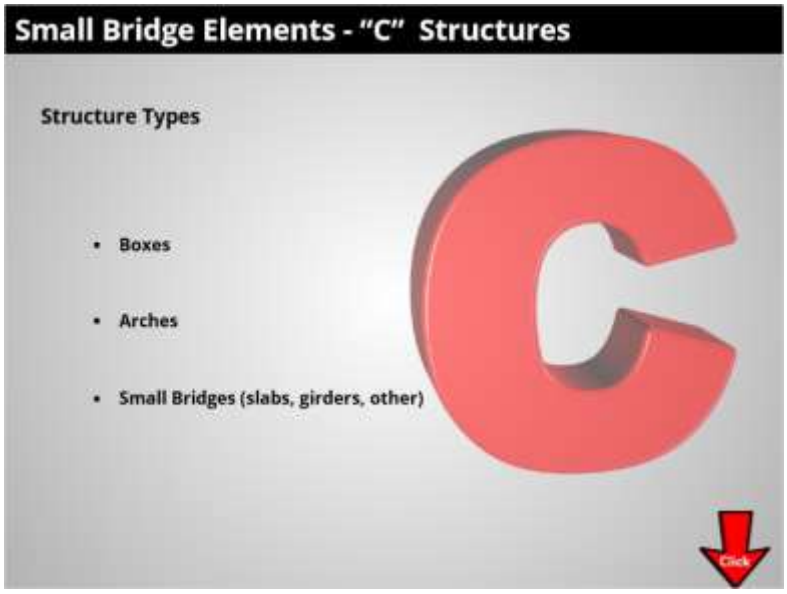

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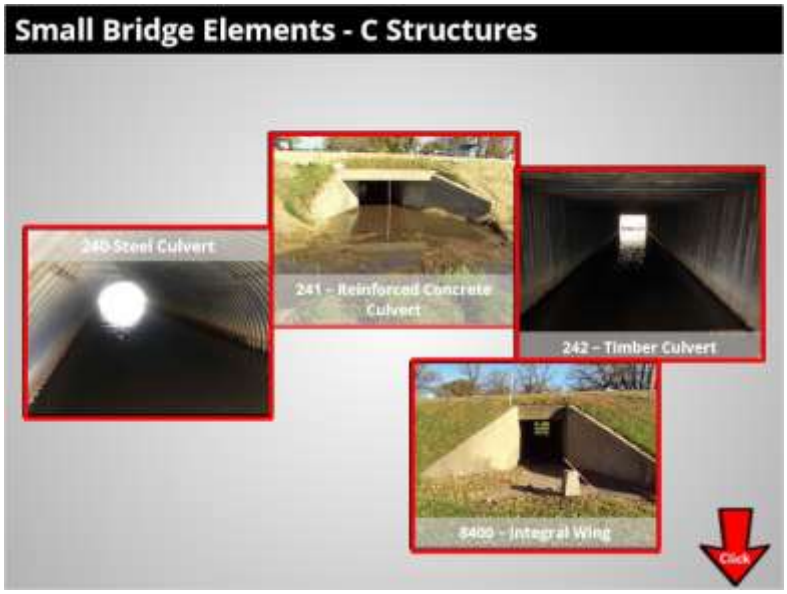

Inspection of small bridge or "C" structures, are documented by 5 barrel or pipe type elements and one element for wings. Barrel Elements depend on the material the structure is constructed with and are measured in terms of linear feet along the invert or flow line. The element for integral wing walls is used when the wings are fixed to the culvert, apron slab or both and are measured as each, regardless of material. If wings are independent of the apron and culvert, they are coded under the assessment for culvert end treatments.

Elements common to Wisconsin include:

- 240 - Steel Culvert
- 241 - Reinforced Concrete Culvert
- 242 - Timber Culvert

Other possible culvert elements include:

- 243 - Other Material Culvert
- 245 - Prestressed Concrete Culvert

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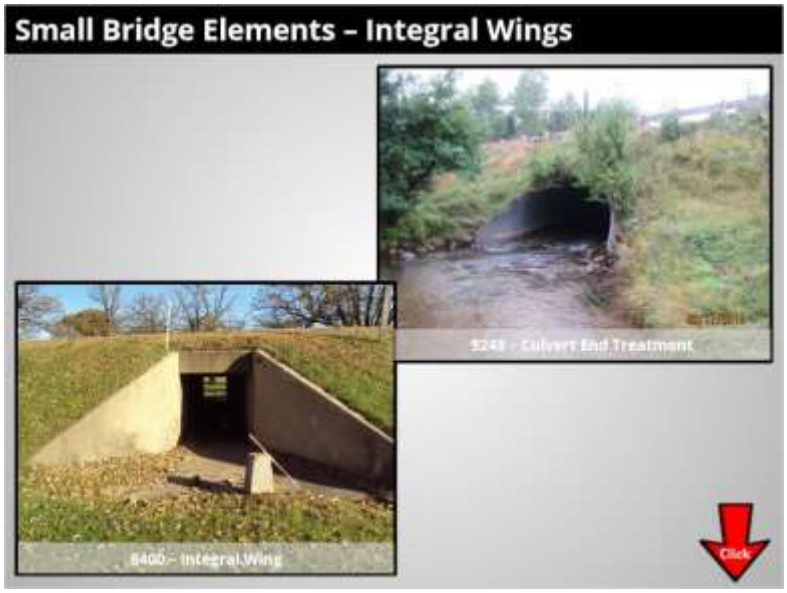

Element 8400 for integral wing walls are anchored to any combination of barrel, apron and/or headwall. Integral wings are typically reinforced concrete, but may be any material with a vertical or near vertical face. (animation - show steel culvert picture) The one exception would be steel culverts where the end of the pipe is sloped to match the embankment (see photo), although it's attached to the pipe, this is considered an end treatment.

Non-integral wings that are not anchored to the barrel, apron or headwall are to be coded as part of Assessment 9248 - Culvert End Treatments. R-numbered retaining structures that act as wings should be coded with the appropriate wall elements and assessments under a separate inspection report, but should be noted in the structure specific notes in the C structure inspection report.

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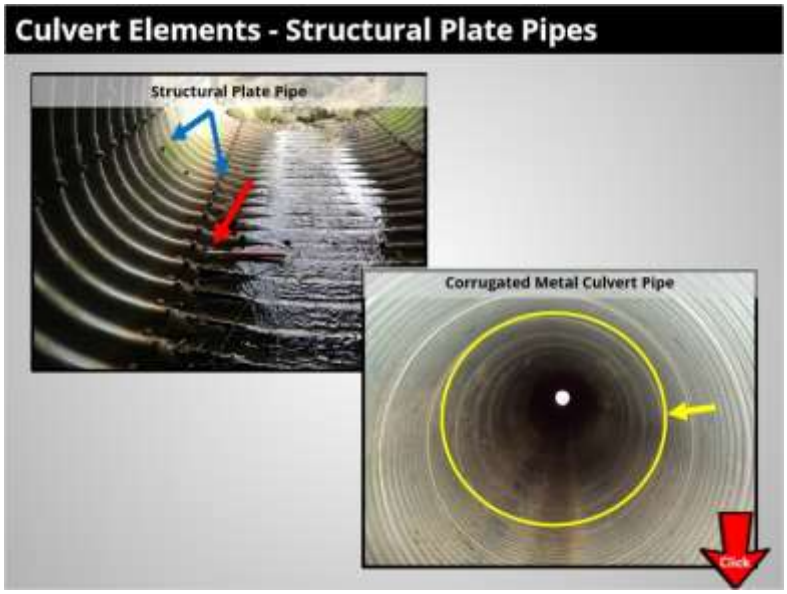

Structural plate culverts could be either steel or aluminum circular or arch culverts. They are field assembled, built-up of several pre-curved corrugated plates. The field assembled plate sections are fastened together with bolts to form a continuous pipe. Fastened plate edges oriented along the barrel length are called seams, while plate edges transverse to the barrel are called joints (blue arrows - note for animation only).
Steel or aluminum pipes are continuous sections bolted or banded together at the ends of the pipe sections (yellow circle and arrow - note for animation only).
Common defects for structural plate steel pipe culverts include perforations and section loss in structural plate pipes and arches, typically found at the flow line or water line (red arrow - note for animation only). Section loss can occur quickly leading to loss of bedding material. Loose, missing or corroded fasteners, deformation or misalignment of the barrel are also common defects noted.

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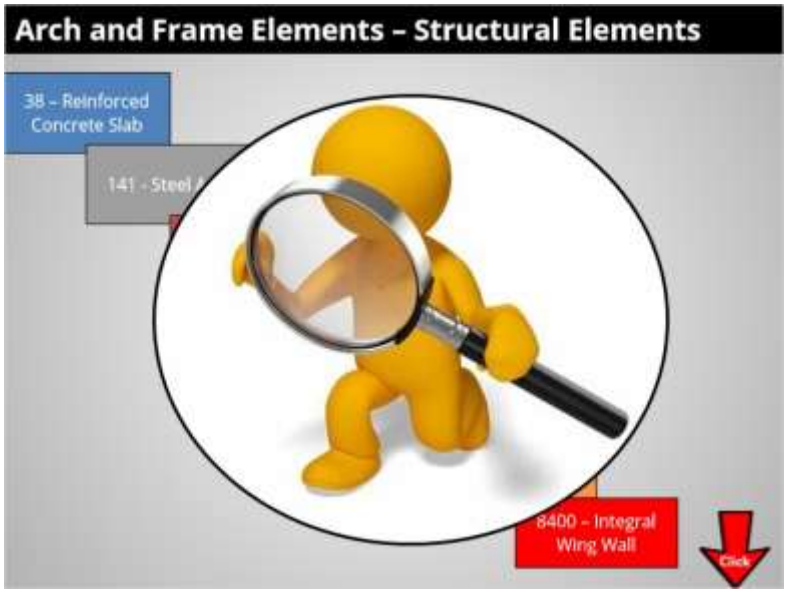

Inspection of arches are documented by a combination of elements for the barrels and one element for wings depending on arch type and arrangement. Barrel Elements depend on the material the structure is constructed with and are measured in terms of linear feet along the flow line.

Common elements for arches and rigid frames include:

- 38 - Reinforced Concrete Slab
- 141 - Steel Arch
- 144 - Reinforced Concrete Arch
- 210 - Reinforced Concrete Pier Wall
- 215 - Reinforced Concrete Abutment
- 220 - Reinforced Concrete Footing
- and 8400 - Integral Wing Wall

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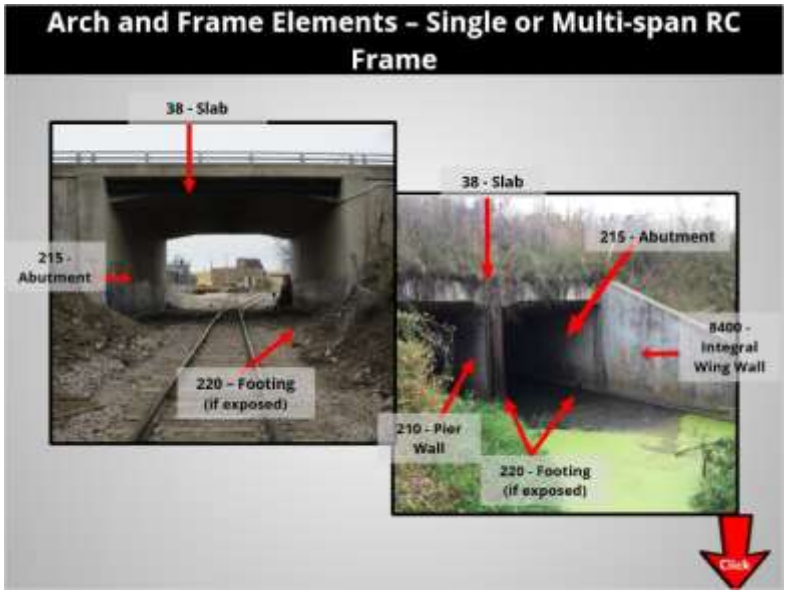

The first type is the single or multiple span rigid concrete frame. Similar to arches in that they are 3-sided structures, rigid frames have vertical walls connected by slabs with haunches and are similar to slab bridge structures. They do not have a structural floor slab.

Elements for a single or multiple span rigid concrete frame are:

- Element 38 - Slab
- Element 215 - Abutment
- Element 210 - Pier Wall (if present)
- Element 220 - Footing (if exposed)
- Element 8400 - Integral Wing Wall

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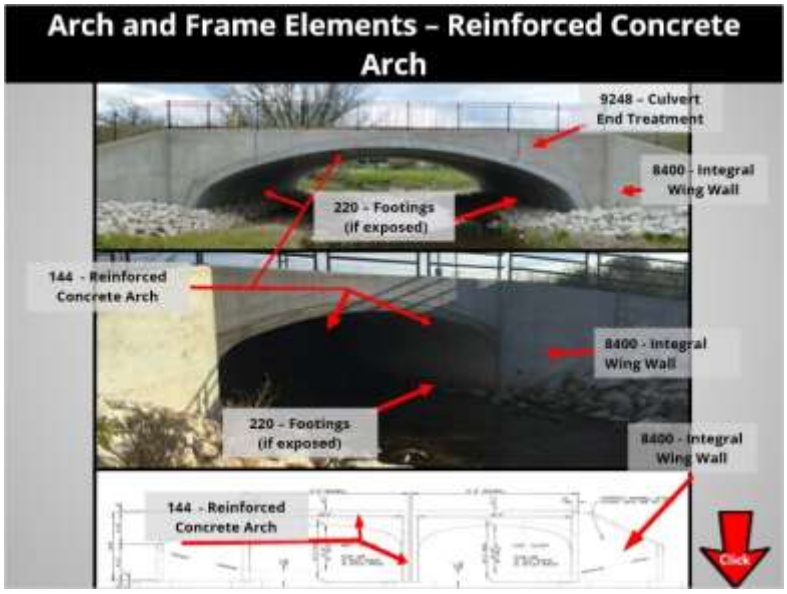

Reinforced concrete arches are the most common arch structures. These can be cast in place, but are generally precast. They can have sloped or vertical walls connecting to the main arch, but are coded the same. Elements for a reinforced concrete Arches are:

- Element 144 - Reinforced Concrete Arch
- Element 220 - Footing (if exposed)
- and Element 8400 - Integral Wing Wall

If there are multiple spans, the walls in the center (see sketch - note for animation only) are part of the arch, and are not coded as pier wall elements.

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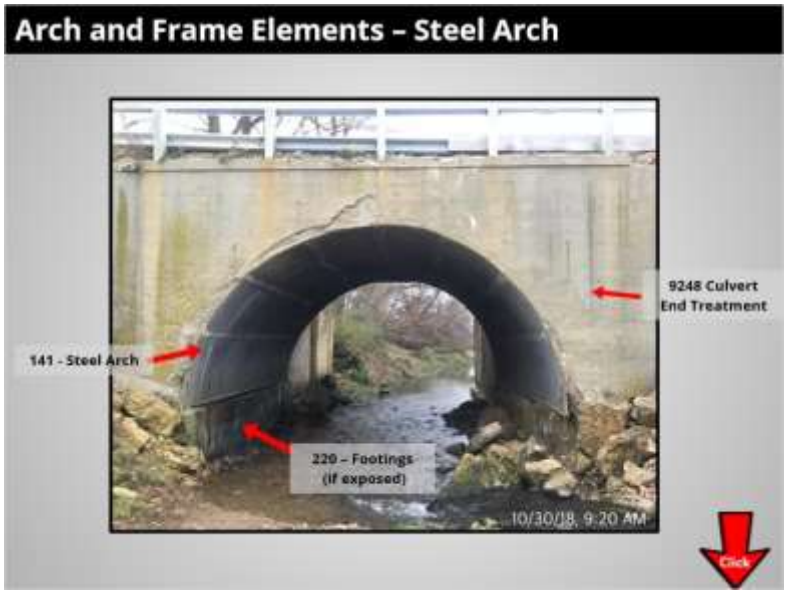

Steel arch elements are usually made up of structural plates connected to form the arch. These structures rest on a footing, which may or may not be exposed, and have head walls and wings to retain fill.

Elements for steel arches are:

- Element 141 - Steel Arch
- Element 220 - Footing (if exposed)
- and Assessment 9248 - Culvert End Treatment

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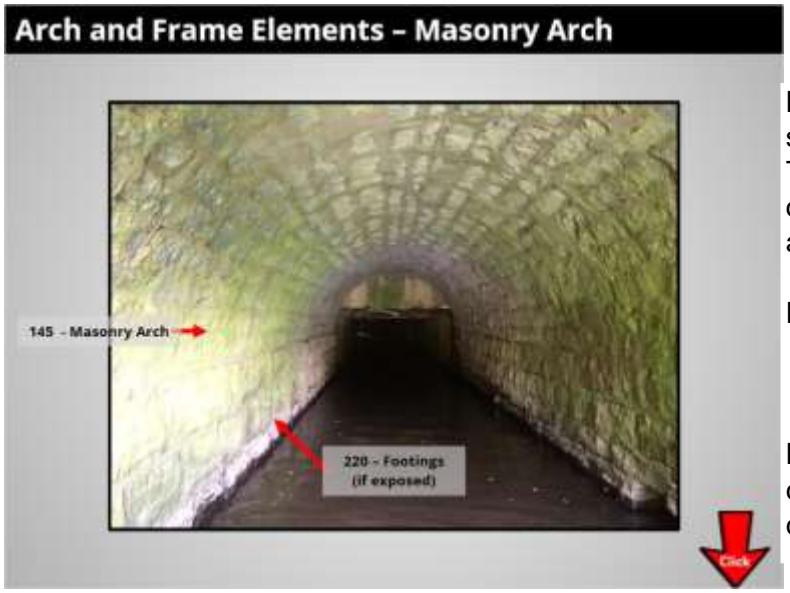

Masonry arch elements are stone or brick structures formed into the form of an arch. These structures rest on a footing, which may or may not be exposed, and have head walls and wings to retain fill.

Elements for Masonry arches are:

- Element 145 - Masonry Arch
- Element 20 - Footing (if exposed)

Masonry arches may have integral wings or culvert end treatments as well, depending on construction.

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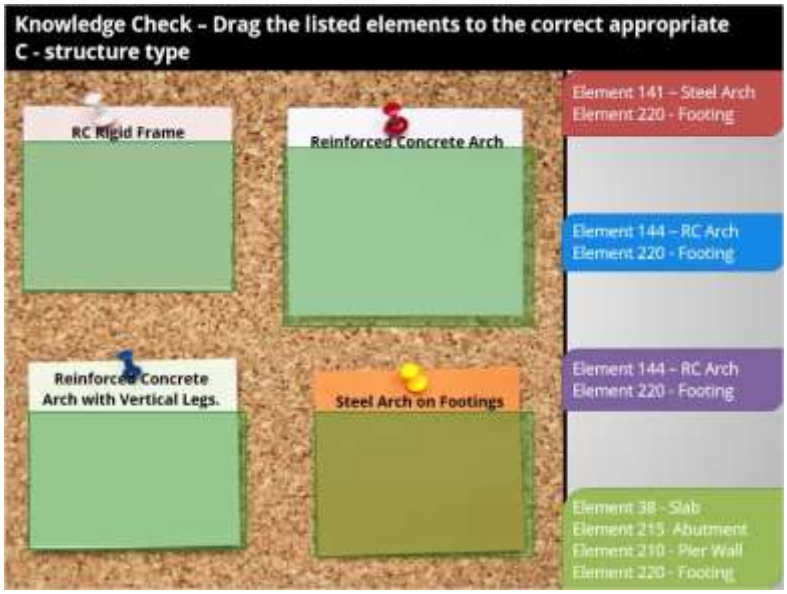

RC Rigid Frame:
Element 38 – Slab
Element 215 – Abutment
Element 210 – Pier Wall
Element 220 – Footing

Reinforced Concrete Arch
Element 144 – RC Arch
Element 220 – Footing

Reinforced Concrete Arch with Vertical Legs.
Element 144 – RC Arch
Element 220 – Footing

Steel Arch on Footing
Element 141 – Steel Arch
Element 220 – Footing

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WisDOT allows culvert liners. Current guidance focuses predominately for small pipes, but there are lining options for larger structures as well. Most lining systems incorporate a smaller diameter pipe (bolted together, slid, or blown in from one end) and grouted to fill the void. Spray liners are also possible and allow for minimum reductions for flow. The inverts of steel plate pipes can be paved to reinforce the flowline of the pipe and to resist the side pressures. Element 8802 is used when culvert liners are present and becomes the culvert element. Previous noted defects would no longer apply as the liner has strengthened or repaired the existing defects. Special attention should be paid to liners as any distortion or defects found could indicate a larger issue that was not fixed by the liner.

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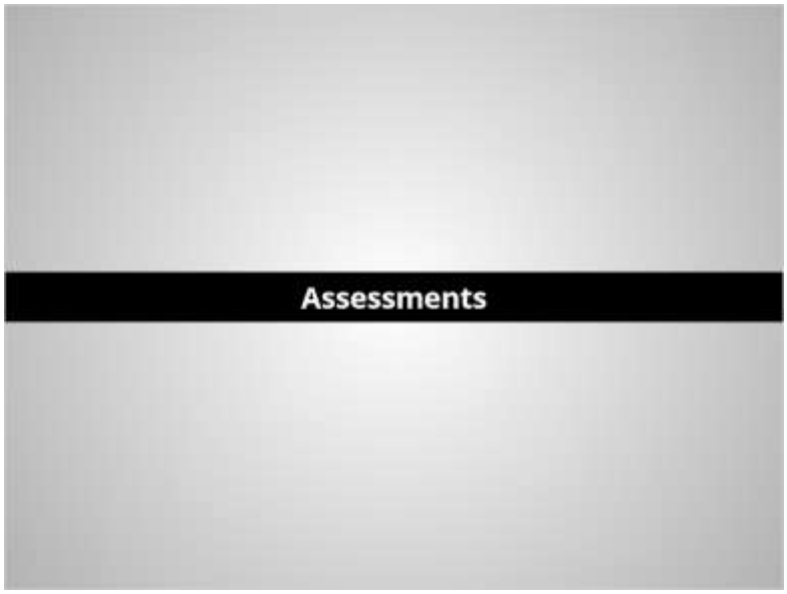

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Assessments are components found on structures that the department wants to track, but they may not be the main structural members. Assessments do not have defects associated with them, but are coded with four levels of Good, Fair, Poor, and Severe. As with bridge structures, culvert structures will typically have several assessments that must be inspected and recorded. It's the inspector's responsibility to determine the assessments that are associated with each and evaluate and record them. Assessments are not optional items. The inspector must capture all assessments during an inspection. This module will cover common assessments found on C-structures, as well as those commonly missed or incorrectly coded. For more details on all assessments, see the Assessment Refresher Module.

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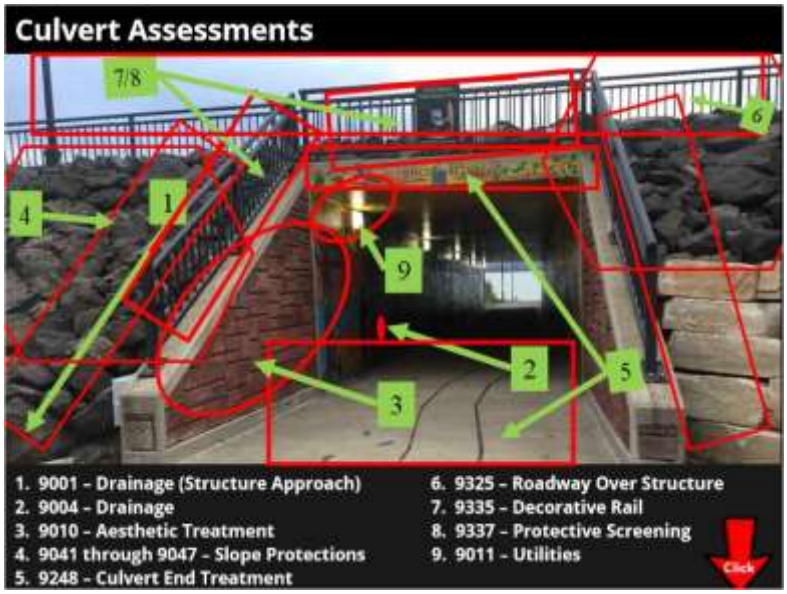

Common structure assessments for culverts are

- 9001 - Drainage - Structure Approach
- 9004 - Drainage
- 9010 - Aesthetic Treatment
- 9041 thru 9047 - Slope Protections
- 9248 - Culvert End Treatment
- 9325 - Roadway Over Structure
- 9335 - Decorative Rail or 9337 - Protective Screening (if chain link or mesh fencing is present)
- 9011 - Utilities

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The assessment 9001 Drainage - Approach is at each quadrant of a structure and captures the condition of the drainage from the edge of roadway down the slopes behind and limited to 20 feet from the wingtip. This item is not the same as assessments 9040-9047 for the various types of slope protection, those are to be coded separately. This assessment is present on all C Structures, regardless if drainage system is present.

Please note that the name of this assessment may vary between the Structures Inspection Manual, the Field Manual and HSIS, but the number is always 9001.

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The assessment 9004 Drainage Along Structures defines the drainage systems that are located on the structure and captures the condition of the drainage system. Examples where this assessment are used on C Structures are where other drainage pipes such as drop/median inlets, pipes, weep holes or other perforations intended for drainage purposes and/or attaching other drainage systems to the primary barrel(s), adding flow to the main stream, or in the case of pedestrian boxes, inlets for light/air movement. These are to be noted as 1 per each opening and notes on condition, location and functionality are recommended. Please note that the name of this assessment has been updated to “9004 - Drainage” in the Structures Inspection Manual, the Field Manual and HSIS.

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The assessment Culvert End Treatment applies to headwalls and aprons. If a culvert protrudes from the embankment without these, then this assessment would not apply (for example: steel pipe with no apron or headwall). Otherwise this assessment is to be coded as 1 for each end of the culvert.
Wingwalls are not included in this item as they are coded under element 8400.

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The assessment Roadway Over Structure evaluates the roadway over a buried bridge/ culvert where there's more than 9" (red circle animation) of fill at any point above the structure.
This assessment is recorded in units of “each”, photos shown would have a quantity of 1 each, divided highways would have a quantity of 2 and so on. For roadways where medians or sidewalks are observed on the roadway, these components shall be evaluated under the Roadway Over Structure assessment. If the maximum fill depth (including pavement) is less than 9”, the inspector should code the appropriate

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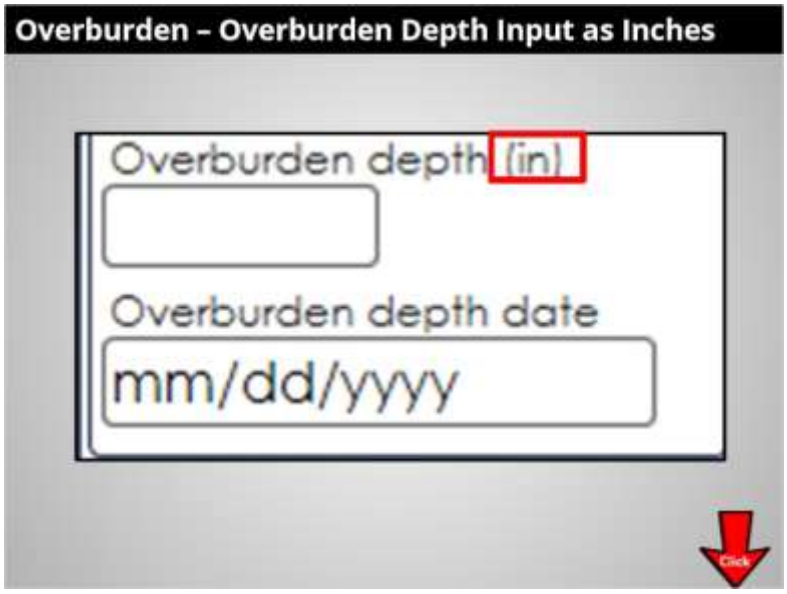

It's important to ensure that overburden is reported correctly and is in units of inches (red box animation - note for animation only). It's also important that the overburden reported is representative of what was built, not just what was noted on the plans. This is important to determine not only assessments to be used, but it may also have an effect on the strength or serviceability of the structure if the overburden is different that the design called for.

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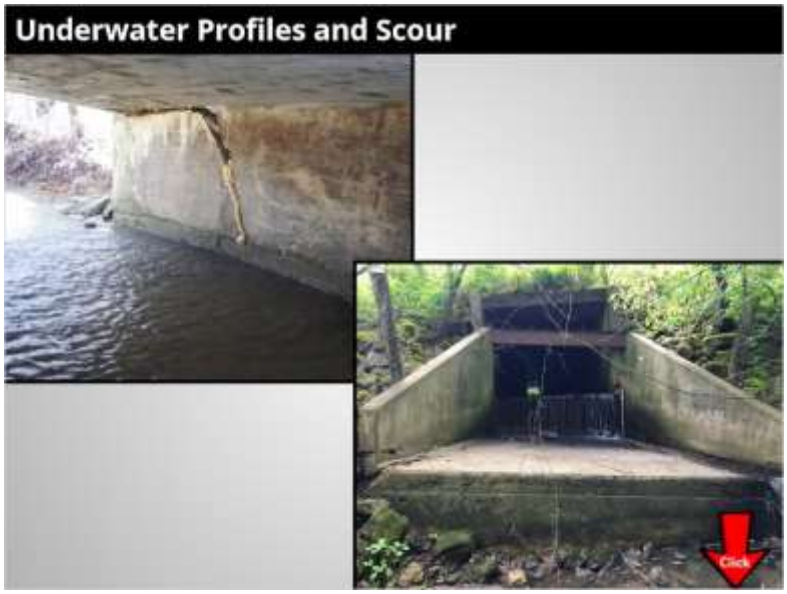

Underwater profiles are generally not needed for box and pipe culverts, as the floor is part of the structural system. Box culvert settlement due to scour or loss of fill can cause serious problems. While under water profiles are not required for C-structures with structural floors (box culverts), the flow lines, inlets and outlets should be probed for irregularities during inspections and after major flood events to determine if undermining and scour are present.

Profiles are required for bottomless structures, including buried slabs, rigid frames and arch structures, during the normal routine inspections and after flood events. The process for performing underwater profiles is discussed in the Underwater Profile Refresher Module.

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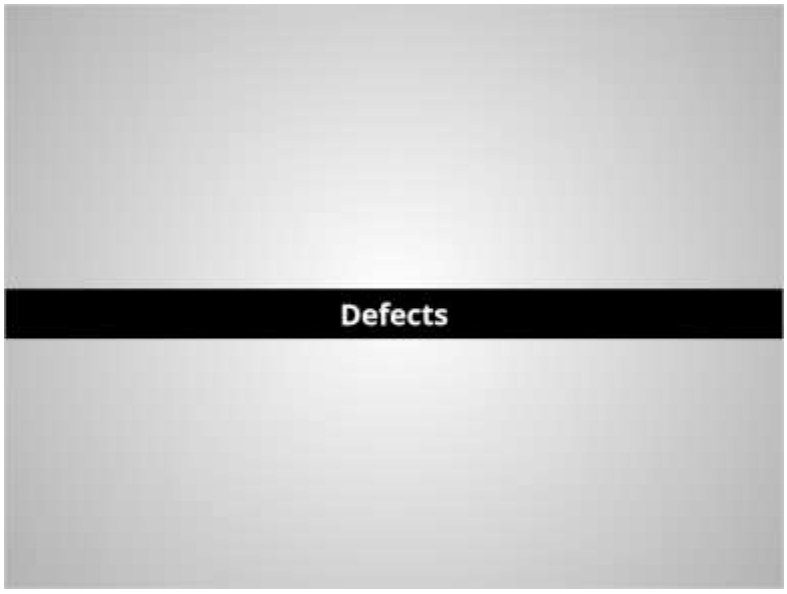

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Longitudinal separation of segments along the centerline of box due to construction placement, movement of the segments, cracks due to thermal effects or shrinkage due to lack of relief joints in original construction should be coded under the new defect 8907 - Concrete Culvert Connections. The defect name and description will be created in the Structures Inspection Manual and Field Manual to account for culvert connections, precast or prefabricated joints and construction joints for reinforced concrete C-structures.

For coding purposes, this defect will be coded as follows:

- CS1 indicates no deficiencies noted.
- CS2 indicates that minor longitudinal or lateral barrel movement at the joints may be present. The connection is still functioning as intended. No water seepage or loss of backfill is present.
- CS3 indicates cracking, spalling, and/or lateral or longitudinal movement indicating that the members are acting independently. Displacement of members is evident, but membranes are still in tack. Water seepage may be present, but fill is still retained.
- CS4 indicates the connection is failing or has failed. The structural capacity may be affected. Segments may be separating from the adjacent members and the joint has displaced or deteriorated allowing water and backfill to pass through the joint. Members may be acting individually under traffic loads.

Vertical movement in the structure will still be coded as defect 4000 - Settlement.

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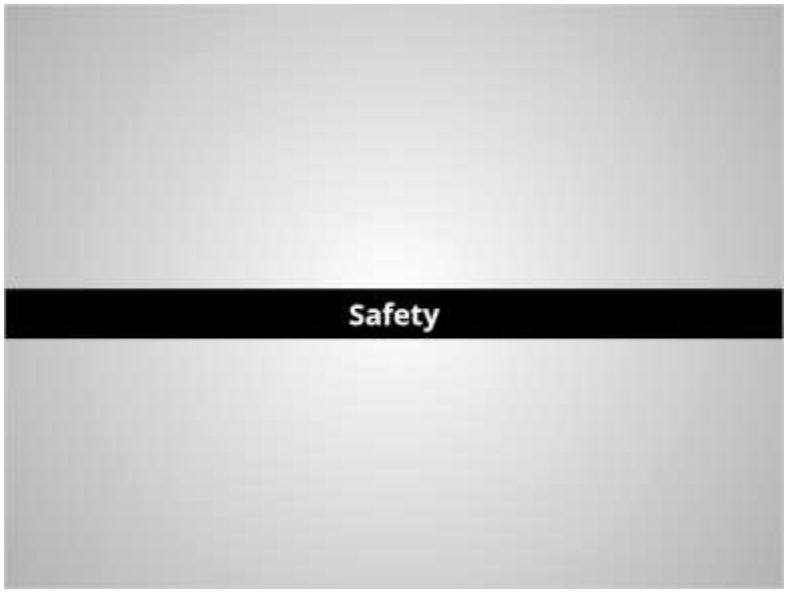

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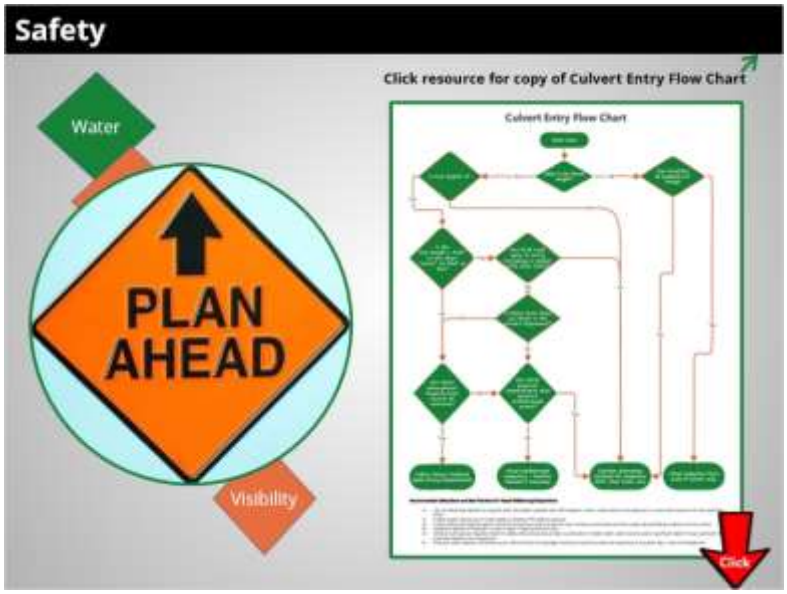

Culverts can be dangerous, and a plan is usually required. The details of the plan can vary depending on conditions at the culvert, so a pre-trip evaluation should be done. What am I going to be inspecting? Does someone know my expected schedule? What equipment or personnel are required?

Special items to keep in mind before inspecting: water depth and flow, sedimentation or debris, atmosphere, wildlife or vegetation, traffic control access and egress, and visibility. All present different hazards that require mitigation.

Click on the resource tab to download the Culvert Entry Flow Chart.

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