Ontario

MINISTRY OF TRANSPORTATION

Culvert Inspection Guide

For

Culverts less than 3000mm

September 2022

Standards & Contracts Branch

Highway Design Office

Table of Contents

For Inquiries, Contact:
Highway Design Office
301 St. Paul Street, 2nd Floor, S&SB
St. Catharines ON L2R 7R4
Phone: 905-704-2293

1.0 Introduction

A culvert is a buried structure under an embankment or roadway that provides an opening. **This guide will address culverts utilized only for water flow and that are less than 3000 mm in total diameter or span of all cells**. Inspection of buried structures greater than 3000 mm is as prescribed in the Ontario Structure Inspection Manual (OSIM).

Proper maintenance is vital to realize the design life of a culvert, protect transportation infrastructure from damage due to natural stream water fluctuation and precipitation runoff, prevent upstream flooding, and to comply with environmental standards.

Regular inspection of culverts is a critical component of MTO's drainage asset management program. There are numerous benefits of regular inspections including:

- Identifying minor issues before they become safety hazards.
- Minimizing repair costs with regular fixes of minor issues.
- More accurate budgeting for repairs and rehabilitation.
- Obtaining information regarding the condition of culverts for better short- and long-term program planning.
- Quantifying total value of transportation infrastructure assets.
- Eliminate safety hazards.

The structural integrity, hydraulic performance, and roadside compatibility of the culverts inspected must be adequately and routinely evaluated to maximize these benefits.

2.0 Inspection Schedule

Inspection of culverts should be conducted under the following schedules.

2.1 Type 1 – Annual Inspection Program

When culverts are initially inventoried, a condition assessment is conducted and a Culvert Rating Index (CRI*) is assigned. Following the initial inventory, culverts are to be scheduled for inspection based on the most recent assigned CRI as follows:

If CRI ≥ 85	Inspect every 10 years
If 84 > CRI > 75	Inspect every 5 years
If 74 > CRI > 35	Inspect every year
If 34 > CRI	Take immediate action

*CRI is equivalent to the Culvert Maintenance Index (CMI)

The following culverts are to be inspected:

- All culverts that cross under the centerline of a highway, under a ramp or under an intersecting highway.

- Culverts within MTO's right of way that service a municipal drain.
- Culverts within the MTO's right of way in flood prone areas.

Where culverts are encountered during the annual inspection program that are not included in the existing inventory, the inspector shall inventory these culverts and perform the condition assessment.

Annual inspections may be performed through Area Maintenance Contracts (AMC), or Managed Outsourcing (MO) as included in the contract. In addition to maintenance contracts, annual inspections may be conducted by MTO staff or through consultant assignments.

Data gathered from the annual condition assessments is to be submitted through the regional ArcGIS drainage inventory application using Field Maps, or compatible process, which will enable automated updating of the Ministry Provincial Drainage Infrastructure Inventory Management System (DIIMS)

For culverts with a CRI less than 75 where visual inspection is impeded, enhanced inspection technologies shall be considered on a cost/benefit analysis. An overview of available enhanced inspection technologies is provided in Appendix 1.

2.2 Type 2 – Inspections for scoping of programmed capital projects

When a project comes on the five-year capital program, either all culverts within the contract limits or select ones of interest are to be inspected during the scoping phase of the project.

Culverts can be selectively identified based on the previous/annual inspection data. An audit of a sample set should be done when using previous/annual inspection data.

Inspections are typically conducted by ministry's staff from Transportation Infrastructure Management Division - Project Delivery, Structural Section or Contracts Office. Data gathered from these condition assessments should be submitted through the regional ArcGIS drainage inventory application using Field Maps, or compatible process, which will enable automated updating of the Ministry Provincial Drainage Infrastructure Inventory Management System (DIIMS). Where trenchless technologies are being considered for repair/ rehabilitation, additional inspection technologies may be considered on a cost/benefit analysis. An overview of available enhanced inspection technologies is provided in Appendix 1.

2.3 Type 3 – Post Construction Inspections

New culverts should be inventoried as part of the post construction inspection.

The Construction Administrator should perform this task. Data should be submitted through the regional ArcGIS drainage inventory application using Field Maps, or compatible process, which will enable automated updating of the Ministry Provincial Drainage Infrastructure Inventory Management System (DIIMS).

3.0 Preparation for Inspection

Ministry staff should complete the OHS Field Guidelines for TIMD/OD Divisions training course before any field inspection activity.

Culvert inspections should be planned and scheduled to achieve both maximum efficiency and effectiveness with the resources and time available. Some preparation guidance is given below:

- Prior to going for the field investigation, review available information and data such as:
  - Watershed plans, flood plain maps and site maps
  - Highway engineering drawings, past contracts, SWM reports etc.
  - Current and past reports
- Inspect culverts that are close to each other in groups to minimize travel times.
- Whenever possible, schedule inspections during lowest flow periods of the year for best access to the interior of the culverts, embankments, and foundations.
- Carry out inspections during or immediately after a heavy rainstorm when inspecting for hydraulic capacity.
- Schedule inspections soon after cleaning, if the culvert is cleaned on a known schedule, to maximize the quality of the data obtained through visual inspection.
- Rotate inspectors, if possible, so that the same culvert is inspected by different inspectors for consecutive inspections. In this way, independent verifications can be provided of previous ratings.
- Identify any need for special equipment or access; group inspections of culverts with similar needs to maximize efficiency.
- Identify and address any requirements for coordination with other entities such as environmental permits and emergency responders, utility companies, or notification of landowners and businesses.
- Identify locked gates and access points along the entry points to the culvert and make pertinent requests to gain entry.
- Review previous inspection records to gain familiarity not only with the structure of the culvert being inspected and help identify changed conditions but also with the highway and site conditions.
- Identify and address potential aquatic habitat and stream morphology impacts
- Always contact the regional maintenance office for any history of drainage/flooding issues as they have first-hand knowledge.

4.0 Safety

It is important to prioritize personal safety when conducting culvert inspections. The MTO Working Alone Guideline and the OPS Working Alone Tip Sheet provide additional detailed information on communication procedures when working alone. These are informative

resources to be aware of and take precautions to reduce the risk of the following types of hazards:

Confined Spaces

Culverts have limited means for exit or entry and may also contain hazardous or combustible gases such as hydrogen sulfide or methane; thus, culverts can pose a serious threat to the health and safety of the inspector. The MTO Confined Space Entry Program provides additional detailed information on confined spaces.

Precautionary steps:

- Consult the Occupational Health and Safety Act (OHSA) for guidance on entry procedures if the culvert
  - part of a combined sewer system.
  - There are potentially polluted or hazardous materials contained in the culvert.
  - The Culvert is too long or configured such that the inspector cannot see the other end from one end or maintain vocal contact with people outside the culvert.
  - Ongoing work within the culvert potentially creates a toxic atmosphere (use of generator or combustion powered equipment, welding, lining, coating, painting, etc.).

- Do not conduct in person entry inspections; consider non-entry inspections or remote-entry inspections instead if the culvert:
  - Has a diameter of 900mm or less.
  - Barrel is plugged or dammed by debris such that it could retain water.
    or
  - Conveys flow that has high velocity.

Traffic Hazards

Culvert inspection or the parking of inspection vehicles near or on roadways presents a potential hazard to passing motorists and pedestrians and vice versa.

Precautionary steps:

- Avoid such roadways if possible.
- Deploy traffic controls as per OTM Book 7 to assist with inspection activity if required.

Drowning Hazards

Scour holes and the erosion of the streambed during peak flows may cause pockets of deep water to form and present a drowning hazard. The depth of water in these pockets may be deceptive and inspectors should probe the streambed with a walking stick or rod to verify the depth of water before venturing into the water. High intensity events may cause water levels

inside culvert barrels to reach a hazardous level very quickly, even before rain actually falls at the site of the culvert, upstream runoff may have already filled the culvert barrel to a high level.

Precautionary steps to take:

- Check the weather forecast for the site of the culvert and the surrounding region for the time of inspection.
- The requirements for working around water are prescribed in Ontario Regulation 213/91 Construction Projects and must be implemented.

Embankment Hazards

Steep and high roadway embankments, as well as, overhanging embankments, may be hazardous and make it difficult to find stable and safe footing. In addition, plants on the embankment may present slipping or stumbling hazards.

Precautionary steps:

- Exercise caution when walking up and down the embankment.
- Use the heel-first method for stability.
- Equipment should be lowered by rope to the site of the culvert inspection if the embankment is too steep or high.

Animals and Insect Hazards

Animals such as rodents and snakes as well as spiders, wasps, and biting insects may all pose health hazards to the inspector.

Precautionary steps:

- Use insect repellant.
- Conduct inspections fully clothed.
- Exercise caution when walking through tall grass or bushes, or when removing debris or vegetation from inside the culvert barrel.

Poisonous Plants Hazards

Plants like poisonous ivy, poisonous oak, giant hogweed, wild parsnip and poisonous sumac can cause allergic reactions resulting in rashes or even anaphylaxis. Sap from these plants may be retained on shoes, clothes or equipment and induce a reaction in someone who handles the items later.

Precautionary steps:

- Familiarize oneself with these common poisonous plants to recognize and avoid them.

Equipment Safety

Equipment that is improperly used or faulty can have dire consequences and may even result in loss of life.

Precautionary steps:

- Have an OHSA competent person inspect all equipment to verify that it is in good working order as according to the manufacturer's guidelines.
- Ensure any rigging or scaffolding being used is properly installed and that cables and planks are tightly secured.
- Ensure that shock absorbing lanyards and safety harnesses are installed properly as per OHSA guidelines when working with elevated features.

5.0 Tools and Equipment

Access Tools

- **Inspection Vehicle** for access to the inspection site and hauling other tools and equipment. Inspection Vehicles shall be equipped with SPOT system specially in Northern regions.
- **GPS** for locating culverts and updating and confirming inventory records.
- **Ladders** for access to elevated features.
- **Waders/Rubber Boots** – For wading into shallow streams.
- **Probes** for checking for safe footing beneath the water surface.
- **Manhole Lid Hook** for access to sites behind manholes.
- **Rope and Carabiners** for securing items and lowering tools down grade separations.

Cleaning Tools

- **Whisk Broom** for removal of loose dirt and debris.
- **Wire Brush** for removal of loose paint and loose corrosion from steel members.
- **Scrapers** for removal of corrosion or growth from surfaces.
- **Flathead Screwdriver** for general cleaning of debris and corrosion from surfaces.
- **Shovel** for removal of dirt and debris from bearing areas.
- **Machete** for removal of overgrowth at the inlet and outlet.

Inspection Tools

- **Chipping Hammer** for loosening dirt and rust scale, sounding concrete, and checking for sheared or loose fasteners.

- **Ice Pick** for surface examination of timber surfaces, the extent of steel corrosion, and deteriorated concrete depth.
- **Plumb Bob** for measuring vertical alignment or barrel lateral racking.

Measurement Tools

- **Tape Measure** for obtaining measurements of component dimensions.
- **30 m Tape** for measuring longer lengths, such as culvert lengths and distress areas.
- **Measuring Wheel** for measuring/marking stationing and measuring longer lengths.
- **Caliper/Micrometer** for measuring the thickness of a member beyond an exposed edge.
- **Crack Comparator** for obtaining precise measurements of crack widths.
- **Pit Depth Gauge** for measuring depth of pitting corrosion of steel structures.
- **Paint film gauge** for measuring coating thickness, particularly in areas of suspected lining or coating section loss.
- **Carpenter's Level with Digital Inclinometer** for measuring culvert slope and extent of racking/tilting of structures.
- **Electronic Distance Meter** for measuring span lengths and clearance heights, useful for measuring inaccessible structures where standard measuring devices will not reach.
- **Line Level and String Line** for measuring offset or assessing alignment.
- **Utility Knife** for marking locations being measured.
- **10 ft Straightedge** for determining rutting, sag, or humps in pavement.

Visual Aid Tools

- **Binoculars** for examining members at distances and previewing areas prior to inspection.
- **Light Magnifying Glass** for closer examination of cracks and areas prone to cracking.
- **Inspection Mirror** for inspection of inaccessible areas.
- **Signal Mirror** for reflecting sunlight into culverts for visual evaluation during non-entry inspections; often provide better illumination than flashlights.
- **High-Power Flashlight** for providing illumination during inspections.
- **High-Power Headlamp** for providing illumination during inspection activities that require the use of both hands.

Documentation Tools

- **Cell phone and tough notebook** for visual documentation of culvert conditions.
- **Digital Camera** for obtaining visual documentation of culvert conditions.
- **Field Book with Waterproof paper** for recording technical sketches.

- **Straightedge** for drawing straight lines for technical sketches.
- **Centre Punch** for applying reference marks to steel or concrete members for movement documentation.
- **Inspection Forms, Permits, Clipboard and pencil, or Laptop or Tablet** for keeping record of the inspection results.

6.0 Inspection Procedure and Rating Guide

The inspection process includes:

1. Taking a minimum of 5 photographs; one of the inlet and one of the outlet showing the condition of the culvert opening and upstream/downstream state of the channel, one of each embankment, and one of the road surface above the culvert. Additional photographs should be taken where issues are identified such as inside the culvert barrel, extensions, contiguous pipe sections and special sections.

2. Evaluating the culvert condition by applying a rating as per the rating guide below. The rating guide provides a description of each component of the culvert and the assignment of a score to assess the condition of the culvert.

3. Confirming, updating or creating new inventory records for the culvert database/DIIMS, including the input of the culvert condition ratings. Guidance on the use of the ArcGIS Collector / ArcGIS Field Maps application is provided in Appendix 2.

6.1 Rating Guide

The rating guide is divided into sections to ensure all critical aspects to the proper functioning of the culvert are rated. The following describes the elements that are to be evaluated. Detailed descriptions of the numeric ratings to be assigned to each element are provided in Section 6.2.

Material

The condition of the culvert barrel is important to the culvert's ability to serve its function. Excessive cracks and erosions of the culvert barrel can cause leakages which compromise the culvert's ability to convey water. Defects in the material lower the culvert's ability to bear applied loads, making it more likely to collapse or lose its structural integrity.

Joints

Joints are critical components in the performance of culverts. Joint quality and performance affect the stability of the pipe, the retention of backfill supporting the roadway above the culvert, and the stability of the embankment. Poor joint conditions can trigger sinkholes formation and localized settlements.

Shape

Shape examination is important in flexible structures, such as corrugated metal and plastic culverts. Culverts compromised by dents and deformations have decreased hydraulic capacity, have a decreased ability to resist applied loads (thereby exacerbating its deformation) and may impede rehabilitation with trenchless technologies.

Capacity

Accumulated sediment within and around the barrel of the culvert creates blockage and reduces the structure's capacity to convey water and handle peak flow conditions. Sediment build-up can result in:

- Roadway overtopping.
- Culvert washout.
- Potential for damage due to buoyant forces;
- Excessive ponding.
- Scour of the stream banks and roadway embankments.
- Surface erosion concrete culverts resulting in early rehabilitation costs.

Embankment

It is important to identify embankment issues to establish the need for maintenance or repair of surficial drainage system. Eroded embankments may indicate that the roadway and shoulder surface storm water collection systems are not performing adequately. Sloughing, sliding or collapsing of a soil slope, can facilitate the opening of pipe joints and destabilize the culvert and roadway embankment. Unstable embankments from seepage or piping, where water flows along outside the pipe, may be an indication of culvert barrel blockage or other factors that is causing increased headwater depth. Evidence of overtopping and ice jams should also be documented.

Channel

Changes in the channel post installation may result in the culvert becoming inadequate to handle future flows as initially designed. The channel should be inspected to identify:

- Aggradation, degradation and artificial deepening.
- Bed and banks roughness/type of liner or vegetation.
- If the channel upstream (US) or downstream (DS) of the culvert is blocked with debris.
- If the stream changes course near the opening of the culvert.
- Changes in US or DS land use such as deforestation due to fire or flooding, clearing, and beaver dams may decrease channel stability.
- Dams and other stream controls such as lakes, waterfalls, or larger watercourses US or DS
- Location of other culverts or bridges downstream
- Beaver Dams observation:
    - Location, approximate height / size and water levels.
    - Ownership of the land on which beaver dam is built.
    - Any flood or other damage likely caused by flows from the dam or dam breaks.

- Duration of the existence of the dam and any history of dam being built by the beavers after mitigation controls being in place.

Roadway Conditions

The roadway condition above the culvert can indicate issues with the culvert. Roadway settlements, sinkholes, potholes, and pavement distresses may indicate the following:

- Voids and anomalies around the buried pipe from piping or improper installation.
- Pipe joint separation or material deformation.
- Soil infiltration into the culvert is occurring and impacting the embankment and consequently pavement support.

Scour

Scour is the lowering of the stream bed at the inlet and outlet of the culvert due to erosion by flowing water. Localized scours at the site may be indicative of flow obstruction and inadequate streambed material.

Headwalls / Endwalls

The integrity of the headwalls and endwalls (no cracks, joints in adequate condition) is crucial for proper functionality, specifically, to direct flow and protect against erosion.

6.2 Numerical Rating Descriptions

When assigning ratings:

- Apply the criterion that results in the poorest rating if a system component has multiple criteria for evaluation.
- Note significant changes in condition compared to the previous inspection, even if the structure is still in fair or good condition, to gauge the rate of deterioration or changes in system function.
- Obtain and record physical measurements where required if numeric criteria are given
- Assign NR (not rated) to components of culverts that are not able to be evaluated onsite or are not applicable to the system.

Barrel Material Rating Criteria

Barrel Material Rating Criteria – Corrugated Metal Culverts	
Rating	**Description**
0	New condition, may also exhibit slight discolouration of surface, galvanizing partially gone along invert.
1	Discolouration of surface, galvanizing completely gone along invert but no layers of rust. Minor pinholes in pipe material located at end of pipe but not located beneath roadway.
2	Layers of rust forming. Sporadic pitting of invert, minor pinholes forming throughout pipe.

3	Heavy rust, thick scaling throughout pipe. Deep pitting, perforations throughout invert.
4	Extensive heavy rust, extensive perforations throughout pipe. End sections corroded away. Bottom portion completely corroded exposing underlying granular. Partially to fully collapsed.

0

1

2

3

4

Barrel Material Rating Criteria – Concrete Culverts	
Category Rating	**Description**
0	New condition, hairline cracking without rust staining or delamination, surface in good condition, isolated damage from construction.
1	Hairline cracking parallel to the direction of traffic with no crack greater than 1 mm and without rust staining. Light scaling on less than 10% of the exposed surface area and greater than 3 mm deep. Delaminated/spalled area less than 1% of surface area.
2	Map cracking. Cracks parallel to traffic no greater than 4 mm, cracks transverse to traffic no greater than 2 mm. Rust staining and leakage occurring. Scaling on less than 30% of exposed area and less than 5 mm deep. Spalled areas with exposed reinforcing less than 10%.
3	Transverse cracks greater than 3 mm wide with extensive rust staining. Spalling at numerous locations, extensive surface scaling on invert greater than 15 mm Extensive cracking with cracked open more than 4 mm. Spalling has caused exposure of heavily corroded reinforcing steel in bottom or top slab. Extensive surface scaling on invert greater than 25 mm.
4	Full depth holes. Extensive cracking greater than 15 mm. Spalled areas with exposed reinforcing greater than 25%. Totally delaminated, spalled concrete areas are greater than 50% of surface area. Perimeter of reinforcing bars is completely exposed.

0

1

2

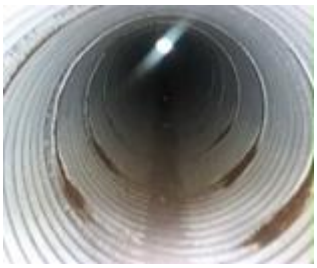
3

4

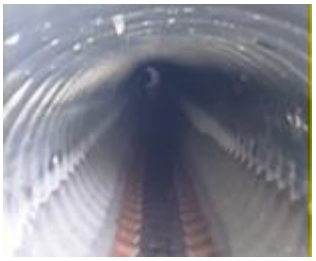
Barrel Material Rating Criteria – Plastic Culverts	
Category Rating	**Description**
0	Minor isolated rip caused by floating debris or construction. Minor discolouration.
1	Slit no longer than 150 mm and no wider than 10 mm at two or three locations. Damage (cuts, gouges or distortions) to ends sections from construction or maintenance. Perforations caused by abrasion located within 1.5 meters of outlet and not under roadway.
2	Slit longer than 150 mm and wider than 10 mm at two or three locations.
3	Slit longer than 150 mm and wider than 10 mm at several locations. Perforations throughout the pipe.
4	Slits in pipe causing the loss of backfill. Section loses throughout the pipe caused by abrasion. Invert eroded away. Partially collapsed.

0

1



2



3

4

Barrel Material Rating Criteria – Timber Culverts		
Category	**Rating**	**Description**
Weathering, Checks, Splits and Shakes	0	New condition, no deficiencies found.
	1	Tissue separations are short and extend for less than 5% into the member.
	2	Tissue separations are long and extend for 5% to 10% into the member.
	3	Tissue separations are long and extend for 10% to 20% into the member.
	4	Tissue separations are long and extend for more than 20% into the member.

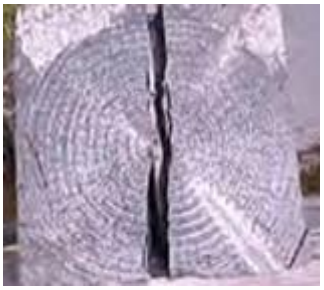
0

1

2

3

4



Barrel Material Rating Criteria – Timber Culverts		
Category	**Rating**	**Description**
Rot or Decay	0	New condition with slight changes in colour
	1	Slight change in colour. The wood sounds solid and cannot be penetrated by a sharp object.
	2	Surface is discoloured with black and brown streaks. The wood sounds hollow when tapped and offers limited resistance to penetration by a sharp object.
	3	Surface is fibrous, checked or crumbly and fungal fruiting bodies are growing on it. The wood sounds hollow when tapped and offers little resistance to penetration by a sharp object.
	4	The wood can be crumbled and disintegrated with ease

0

1

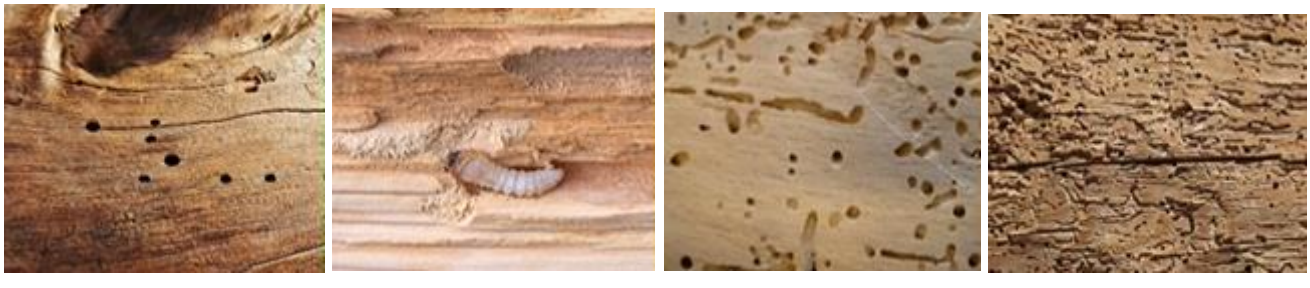
2

3

4

Barrel Material Rating Criteria – Timber Culverts		
Category	**Rating**	**Description**
Insect Damage	0	New condition with no entrance or exit hole present
	1	Occasional entrance or exit holes are present. The wood is solid and cannot be easily penetrated by a sharp object.
	2	Several entrance or exit holes are visible, and larvae or mature insects may be observed. The wood sounds hollow when tapped and offers limited resistance to penetration by a sharp object.
	3	Extensive tunneling and holes are present in the wood. Larvae and insects are readily visible. The wood sounds hollow when tapped, and offers little resistance to penetration by a sharp object.
	4	Extensive tunneling, holes, larvae and insects present. Wood can be crumbled and disintegrates with ease.

1 **2** **3** **4**



Barrel Material Rating Criteria – Timber Culverts		
Category	**Rating**	**Description**
Cracking, Splintering, Crushing and Shattering	0	New condition, not damage from construction
	1	Damage is mainly superficial with less than 5% section loss.
	2	Considerable damage with 5% to 10% section loss.
	3	Significant damage with 10% to 20% section loss.
	4	Extensive damage with section loss in excess of 20%.

Note: There are no pictures of cracking, splintering, crushing, or shattering in timber culverts currently available.

Barrel Material Rating Criteria – Timber Culverts		
Category	**Rating**	**Description**
Fire and Chemical Damage	0	New condition, no evidence of fire or chemical damage
	1	Slight charring or softening of the wood surface with less than 5% section loss. Connectors unaffected.
	2	Deeper charring or softening with 5% to 10% section loss. Connectors slightly loosened.
	3	Section loss between 10% and 20% with several connectors loosened or deformed.
	4	Extensive damage with section loss greater than 20% at critical locations. Many loose and severely deformed connectors.

Note: There are no pictures of fire or chemical damage in timber culverts currently available.

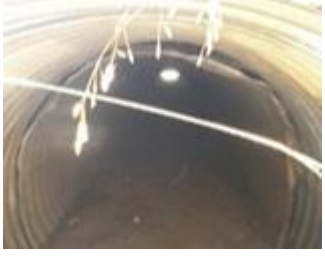
Joint Rating Criteria

Joints Rating Criteria – Steel Culvert	
Rating	**Description**
0	New condition. Tight; no openings in joints or seams.
1	Tight, no openings or displacement. Minor pitting at the joints.
2	Minor cracking at a few bolt holes; minor joint or seam openings; Some water infiltration no backfill infiltration.
3	Plate cracking from bolt to bolt on one seam near top of pipe; deflection of pipe end caused by loss of backfill through open joints.
4	Significant separation at joints has compromised the integrity of culvert, plate cracking from bolt to bolt at multiple seam locations within the culvert.

0

1

2



3

4

Joints Rating Criteria – Concrete	
Rating	**Description**
0	New condition with tight joints.
1	Tight, no openings or displacement. Minor hairline cracking / tears. Minor spalling in concrete
2	Minor joint separation, <10 mm. Minor joint displacement, <1/4 wall thickness. Significant cracking / tearing <10 mm in width. Spalling in concrete, <5 mm thickness lost. Pitting in metal <5 mm thickness lost.
3	Significant joint opening / displacement (over 1.5 wall thickness) with piping or infiltration of backfill material into culvert.
4	Significant separation at joints has compromised the integrity of culvert.

0

3

4

Joints Rating Criteria – Plastic Culverts (HDPE and PVC)	
Rating	**Description**
0	New condition. No deficiencies found.
1	Minor movement in the joint but no infiltration/exfiltration of water or soil particles at the joint.
2	Some movement in the joint but no separation. Evidence of water infiltration/infiltrations. No backfill infiltration at joints.
3	Differential movement and separation of joints; significant infiltration or exfiltration at joints; deflection caused by loss of backfill through open joints.
4	Significant openings; dislocated joints in several locations exposing fill materials; infiltration or exfiltration causing misalignment and deflection of pipe and roadway settlement.

0 **1** **2** **4**

Shape Rating Criteria

Shape Rating Criteria	
Rating	**Description**
0	Smooth curvature in barrel. Span dimension within 3% of design
1	Smooth curvature in top half of barrel with flattening on bottom portion. Span dimension up to 5% greater than design.
2	Slight distortion in one location on the top portion. Bottom has slight reverse curvature in one location. Span dimension up to 10% greater than design. Non-symmetrical shape.
3	Significant distortion throughout length. Lower 1/3 may be kinked. Span dimension up to 15% greater than design.
4	Extreme deflection at isolated locations. Flattening at top of arch or crown. Bottom has reverse curvature throughout. Span dimension greater than 15% of design. Extremely non-symmetrical

0

1

2

3

4

General Conditions Surrounding Culvert Barrel

This condition category describes the condition of the different elements surrounding the culvert barrel. This condition corresponds to the rating value that will be used in the development of the overall culvert rating. These elements, depending on their condition, will require repair and will not affect any replacement decision of the culvert barrel itself.

Capacity Rating Criteria

General Conditions - Capacity Rating Criteria	
Rating	**Description**
0	Little to no sediment build-up in pipe. Culvert ends are undamaged. Little to no debris blocking flow.
1	Minor debris and sediment, less than 30% blockage. Possible infiltration of fine roots. No evidence of flooding of roadway or adjacent land.
2	Major debris and sediment more than 30% blockage, flooding of roadway and/or adjacent properties. Possible infiltration of tap roots causing major flow restriction.

0

1

2

Embankment Slope

General Conditions- Embankment Slope Criteria	
Rating	**Description**
0	Embankment slopes are intact and stable.
1	Minor erosion of embankment, less than 100 mm around ends. Still protected or well vegetated.
2	Major erosion of slope, greater than 200 mm around culvert ends, guardrail displaced / settled, posts loosened / separated from soil.

0

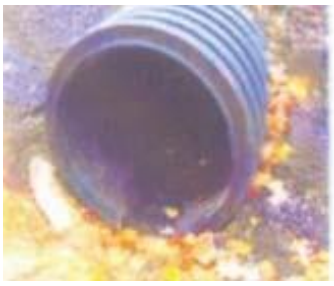
1

2

Channel Upstream and Downstream

General Conditions– Channel Upstream and Downstream	
Rating	**Description**
0	No evidence of channel bed or bank erosion. Intermittent patches of grass and exposed earth.
1	Minor channel erosion. Minor damage to channel protection.
2	Bank protection eroded. Bank protection debris causing blockage and more significant channel erosion. Channel alignment causing scour holes, bank erosion, and is threatening end treatment. Major erosion of channel.

0



1

2

Roadway Settlement Rating Criteria

General Conditions - Roadway Settlement Rating Criteria	
Rating	**Description**
0	Minor hairline pavement cracks over culvert.
1	Hairline cracks in pavement, less than 20 mm gaps between the bottom of a 3 m straight edge and the pavement surface.
2	Broken pavement, moderate to major potholes, settlement in excess of 30 mm with deteriorated ride quality.

0

1

2

Scour/Footing Rating Criteria

General Conditions - Scour/Footing Rating Criteria	
Rating	**Description**
0	Minor scour holes developing at inlet or outlet. Top of footing not exposed.
1	Scour holes developing at inlet or outlet that are 300 mm or less in depth. Footings along sides are exposed. Probing indicates soft material in scour hole.
2	Scour holes at inlet or outlet that are in excess of 600 mm in depth. Erosion occurring behind headwall that threatens to undermine culvert.

0

1

2

Headwall/Endwall Condition Rating Criteria

Headwall/Endwall Condition - Concrete	
Rating	**Description**
0	New condition, hairline cracking without rust staining or delamination, surface in good condition.
1	Spalled area measuring between 100 mm to 300 mm in any direction or between 25 mm and 50 mm in depth. Cracking: some cracks, less than 3 mm wide.
2	Spalled area greater than 300 mm in any direction or greater than 50 mm in depth. Joint separation from culvert. Cracking: multiple crack greater than 3mm wide.

Headwall/Endwall Condition - Steel	
Rating	**Description**
0	New condition, may also exhibit slight discolouration of surface, galvanizing intact
1	Layers of rust forming. Sporadic pitting at the bottom of the wall, minor pinholes forming throughout pipe.
2	Heavy rust, thick scaling throughout wall. Deep pitting, perforations in lower section of wall. Joint separation from culvert.

Rating Modification Factors

Rating modification factors are a means to identify the importance of a culvert and reflect this consideration in the Culvert Rating Index. Rating modification factors are tracked for Roadway Classification, Culvert Size and Culvert Purpose. Only Culvert Purpose will be identified in the field.

Rating Modifiers for Road Classifications

ID	Description	Importance Modifier
1	Expressway or another urban freeway	1.1
2	Principal Arterials and Collectors (urban and rural)	1.1
3	Minor Arterials	1.0
4	Secondary Highways	1.0
5	Tertiary and Rural Minor Highways	0.9
6	Local Road	0.9

Rating Modifiers for Culvert Purpose

ID	Drain Type	Description	Importance Modifier
1	Main	Under the roadway.	1.1
2	Edge	Runs parallel to roadway, may be under shoulder lane, supports embankment, driveway, etc.	1.0
3	Lateral	Drains land adjacent to roadway, typically not under roadway.	0.9
4	Slope	Drains slope adjacent to the roadway, typically not under roadway.	0.9

Rating Modifiers for Culvert Size

ID	Minimum Span Rise	Maximum Span Rise	Importance Modifier
1	0	600	0.9
2	600	1200	1.0
3	1200	3000	1.1

Culvert Rating Index (CRI) Calculation

The Condition Rating Index is calculated by identifying the highest rating given to any element and multiplying by the rating modification factors. The CRI can be calculated by entering the values highlighted in yellow in the table below.

Ratings	Enter Values Below
Overall Rating (highest of all individual ratings)	4
Road Class Modifier	1
Purpose Modifier	0.9
Size Modifier	0.9
Final Results ***(Will Update Automatically as Values are Entered Above)***	
Total Modifier	**0.81**
Modified Rating	**3.24**
CRI	**39**

Appendix 1: Enhanced Culvert Inspection Technologies

Current inspection procedures rely primarily on manual visual inspections performed at the inlet and outlet of culverts using simple tools such as flashlights, handheld probes and mirrors. For culverts of small to medium diameter (250 mm to 1000 mm) which may qualify as confined spaces, the effectiveness of these procedures is limited. Culverts may only be accessible from one side and/or their lengths are such that only a cursory examination can be performed. Moreover, many culverts contain water or soil at the time of inspection that can obstruct the view of the actual element, which further inhibits determination of its integrity and function.

The following summarizes technologies that can be utilized when a more thorough evaluation is required.

Push Cameras

Push cameras can be used during visual inspections to capture the inside condition of the culvert on video. Push cameras are around 50 mm in diameter, waterproof, equipped with LED illumination, remote focus, able to calculate distance, and have pan and tilt features.

Push cameras are primarily intended for vertical deployment as they do not have the rigidity required for easy viewing in the horizontal plane. They also do not possess side-scanning features and do not yield a digitized image.

Crawler Mounted Closed-Circuit Television (CCTV)

Crawler mounted CCTV can be used during visual inspections. This technique involves mounting a CCTV camera on a tethered robot that has the capacity to run along the pipe. The 360-degree pan and tilt type cameras generally used are remotely operated. The setup should produce a clear focused viewing image and video recording ranging from a minimum of 0.6 m to about 3 m from the lens. The CCTV cameras send out recordings to the inspection vehicles in real time where the inspector manually assesses the pipe condition.

CCTV crawlers challenges include frequent stopping to pan, tilt and zoom in on defects, time consuming video reviewing and high digital bandwidth requirements to share and store large video files.

Side Scanning Evaluation Technology (SSET)

Side scanning technology may be employed to overcome the CCTV challenges. Side Scanning Evaluation Technology (SSET) is deployed similarly to a CCTV crawler; yet it captures panoramic images at high speeds. Offline personnel can quickly review the entire pipe interior as a flat image scan or navigate a virtual model of the pipe with this technology. The technology also allows personnel to make further investigations of the culverts off site when necessary.

The challenge of SSET is the need for manual interpretation of the scan results.

Laser Profiling Systems

Laser profiling systems are more advanced that CCTV/video systems as they use light scatter geometry to assess the distance between the culvert surface and laser source to develop a complete profile of the inspected culvert. The greatest advantage of laser profiling is its capability to be deployed without the need for daylight.

This technology is limited, however, as it can only be used in culverts that have no obstructed pathways. As such, culverts must be drained and taken out of service before deploying laser profiling technologies.

Sonar profiling

Sonar profiling is similar in principle to laser profiling as it uses sound wave propagation to interrogate objects on or under the water surface. Impact echo testing and spectral analysis of surface waves (SASW) are paired acoustic techniques that can locate anomalies such as delamination, cracks, voids, and honeycombing in the culvert wall. These are generally applicable to culverts composed of concrete, stone, plastic, and masonry materials greater 150 mm in diameter.

Sonar profiling requires more experience to accurately analyse and inspect the culverts.

For Detecting Bedding/Cover voids and Wall thinning:

Ground Penetrating Radar (GPR)

Ground penetrating radar (GPR) can be used for concrete liner deterioration studies and anomaly detection from within the pipeline. GPR systems work by emitting short pulse of electromagnetic energy into the ground. These pulses are reflected to a frequency-tuned antenna. The time delays in reflection or absorption are used to evaluate subsurface conditions. The method is versatile as it can be operated from the road surface, as well as, inside the culvert. GPR can also detect the soil structure around the culvert, interface between the culvert and the surrounding soil, and leakage through the culvert either by detection of underground voids in the soil created by leaking water or by detecting anomalies in the depth of the pipe.

Ultrasonic Scanning

Ultrasonic scanning uses high frequency sound waves that can provide information regarding the presence and location of boundaries within a pipe wall that result from the presence of delimitations, voids, and excessively dense or highly corroded zones. This method is versatile and can be applied to culverts of any material and of diameters greater than 100 mm.

Backscatter Computer Tomography (BCT)

Backscatter Computer Tomography (BCT) is a form of radiographic testing that is used to map “undermining” occurring in the soil supporting the culvert barrel. This method involves the non-medical application of CT-scans to capture images through the culvert wall into the surrounding backing material. These images can discern between solid back fills and those where undermining had occurred.

Infrared Thermography (IRT)

Infrared Thermography (IRT) is a non-contact method for detecting subsurface anomalies in concrete culverts. In this method, the target surface is heated using a heating source and its cooling characteristics are measured using an infrared camera. The infrared radiation is converted to a visible image. This is known as active IRT. Conversely, passive IRT does not require an external heating source and is a preferred method.

Appendix 2: ArcGIS Collector (ArcGIS Field Map) Inspection User Guide

Getting Started

In-field input of inspection data requires the ArcGIS Collector (or ArcGIS Field Maps) application and an account setup through the Ministry of Transportation.

The following guidance assumes that you are using a device that has a data plan and can connect to the internet to upload & download information to and from the cloud at each culvert location.

Offline data collection is possible, but not explained in this document.

This guide can be used for both ArcGIS Collector and ArcGIS Field Map.

Note – *This guide uses screenshots taken from ArcGIS Collector (ArcGIS Field Maps) App on a Windows 10 device and an iOS device. The layout will change based on the device you are using. For example, on a smartphone, the map and any attribute data are on different pages.*

Opening the ArcGIS Collector App/ArcGIS Field Map

1. Open the ArcGIS Collector (ArcGIS Field Maps) app and navigate to the map of culverts to be inspected. You will only have access to the maps shared with you by the MTO GIS coordinator.
2. Click on the map to open it.
3. There will be a blue or grey dot ● that will indicate your location on the map.

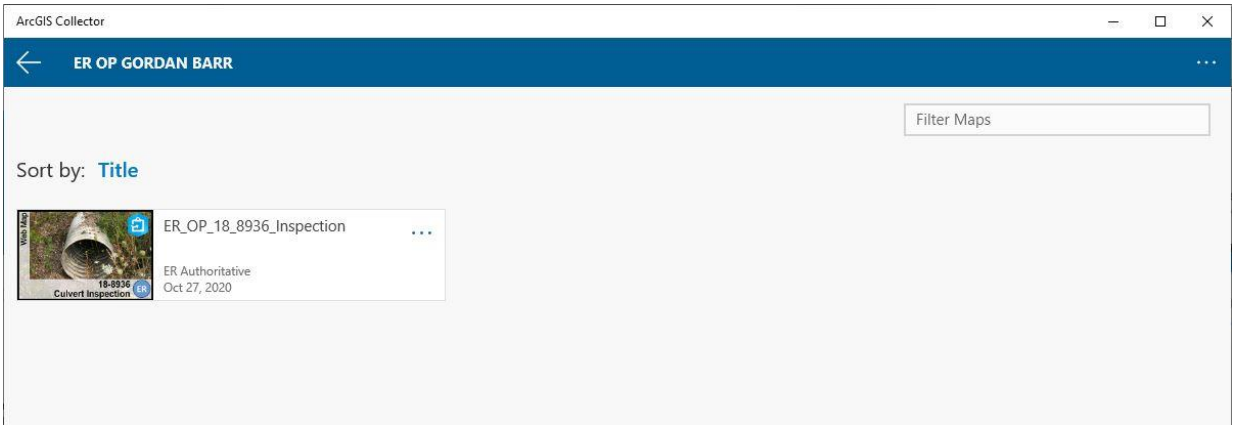


Figure 1 – Map Shared

Updating the Asset Information

4. When you arrive at the culvert, click on the culvert to be inspected. Once it has been selected it will be highlighted in blue. Check to ensure the correct culvert has been selected.

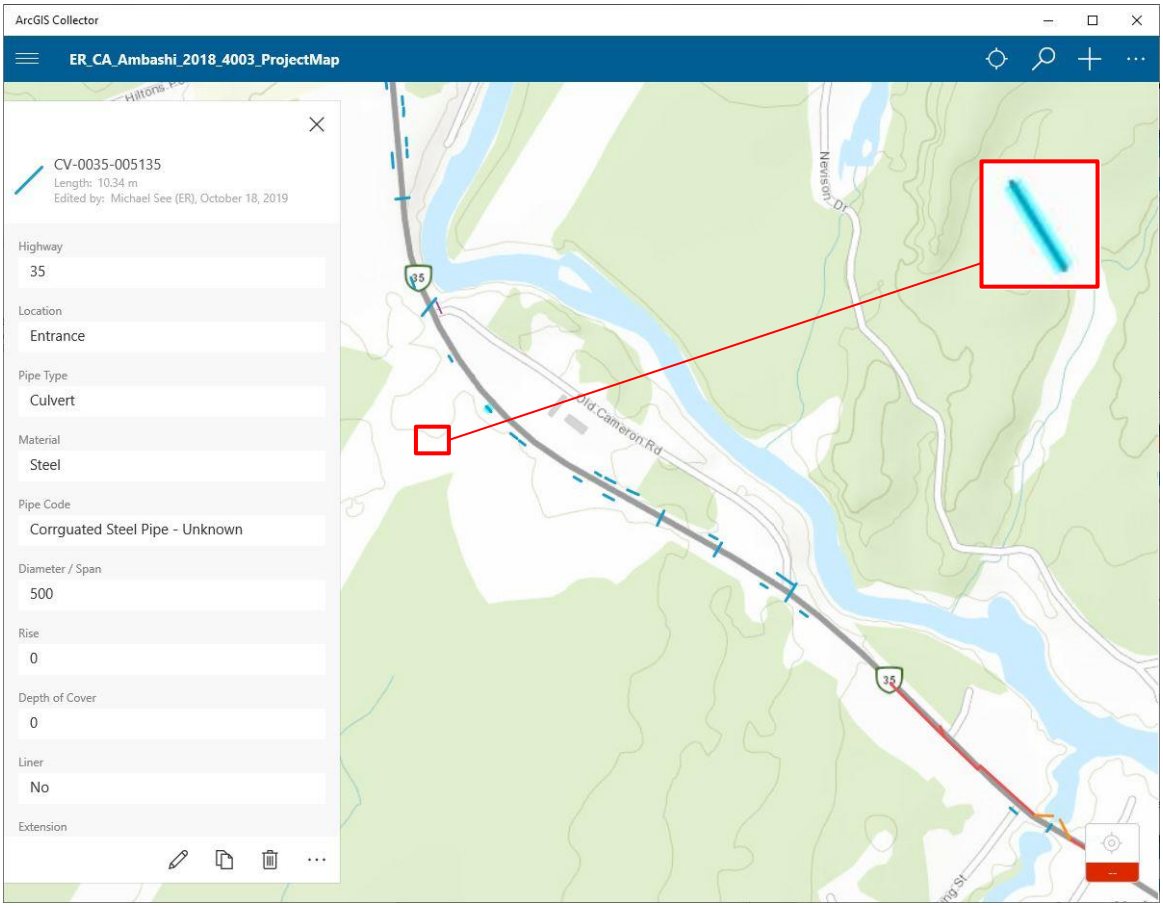


Figure 2 – Selected Culvert

- If you are too zoomed out multiple culverts will appear on the side panel. Either zoom in further or select the required culvert from the panel.

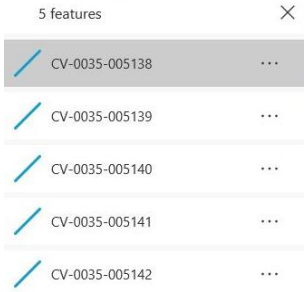


Figure 3 – Multiple Culvert Selected

- Once you select a culvert, the details of that culvert will appear on a side panel.

5. To update the culvert data and input current inspection condition ratings, open the inspection table.

    - On the side panel scroll to the bottom and underneath the inspection table hit ‘Add’.

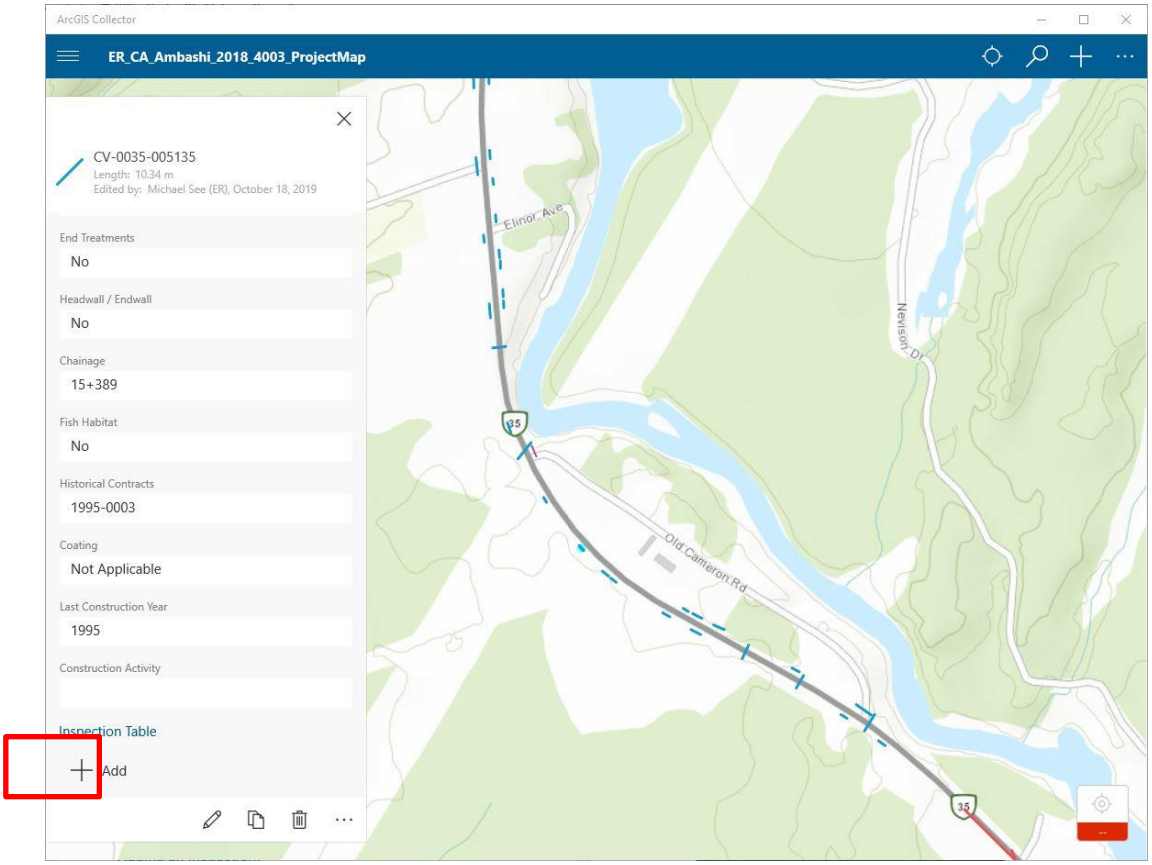


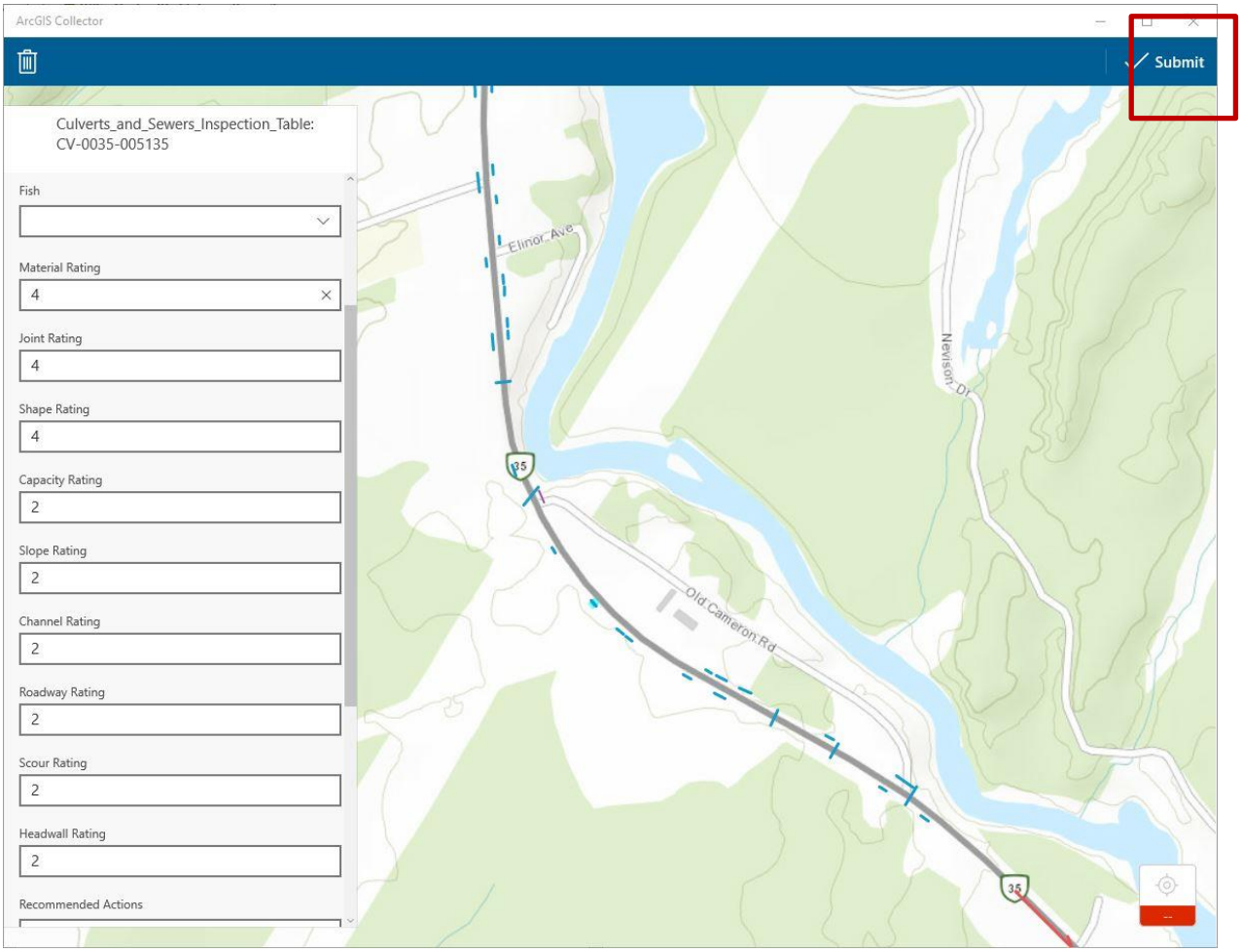
Figure 4 – Editing the Inspection Table

6. This is where you can make edits to the existing culvert information. Fill out all the fields where the information is available.

    - All the fields listed are defined in the ***Drainage Assets Field Definitions*** PDF except for the *Construction Activity* field which is unique to the CA assignment inspections. Choose one of the following for that field:

Replacement	Rehabilitation
Liner Installed	Cleanout
Abandoned	No Action
Other – See Notes	

7. To add inspection photos, scroll to the bottom. Under Attachments there are camera and folder icons.
    - If you are taking a picture to add, select the camera icon to take a picture and upload the attachment.
    - If you have already taken the picture, select the file folder and navigate to the location where the picture is stored to select and upload.
8. In the inspection table, fields with an * are mandatory to fill in. Some of the fields have a pre-set drop list.
9. Once you have completed the inspection table click Submit.



Adding a Culvert

New culverts require a new record to be created.

1. Select the + (The add button that is circled in the image below) in the Collector map or Field Maps.
2. Once you start making a new record an option will come up for what type of structure you are adding. Select *Culvert* (will often be the only option).
3. Draw the culvert by selecting the start and ending point.
4. If there are any mistakes when creating the new culvert. You can cancel and discard the editing. Then start another editing session.
5. Once the culvert has been drawn make any adjustments to the line.
    - The red circle indicates where the line starts, and the blue square indicates where it ends.
6. Update the inspection table.
7. Once you are done adding the new culvert information hit *Submit*.

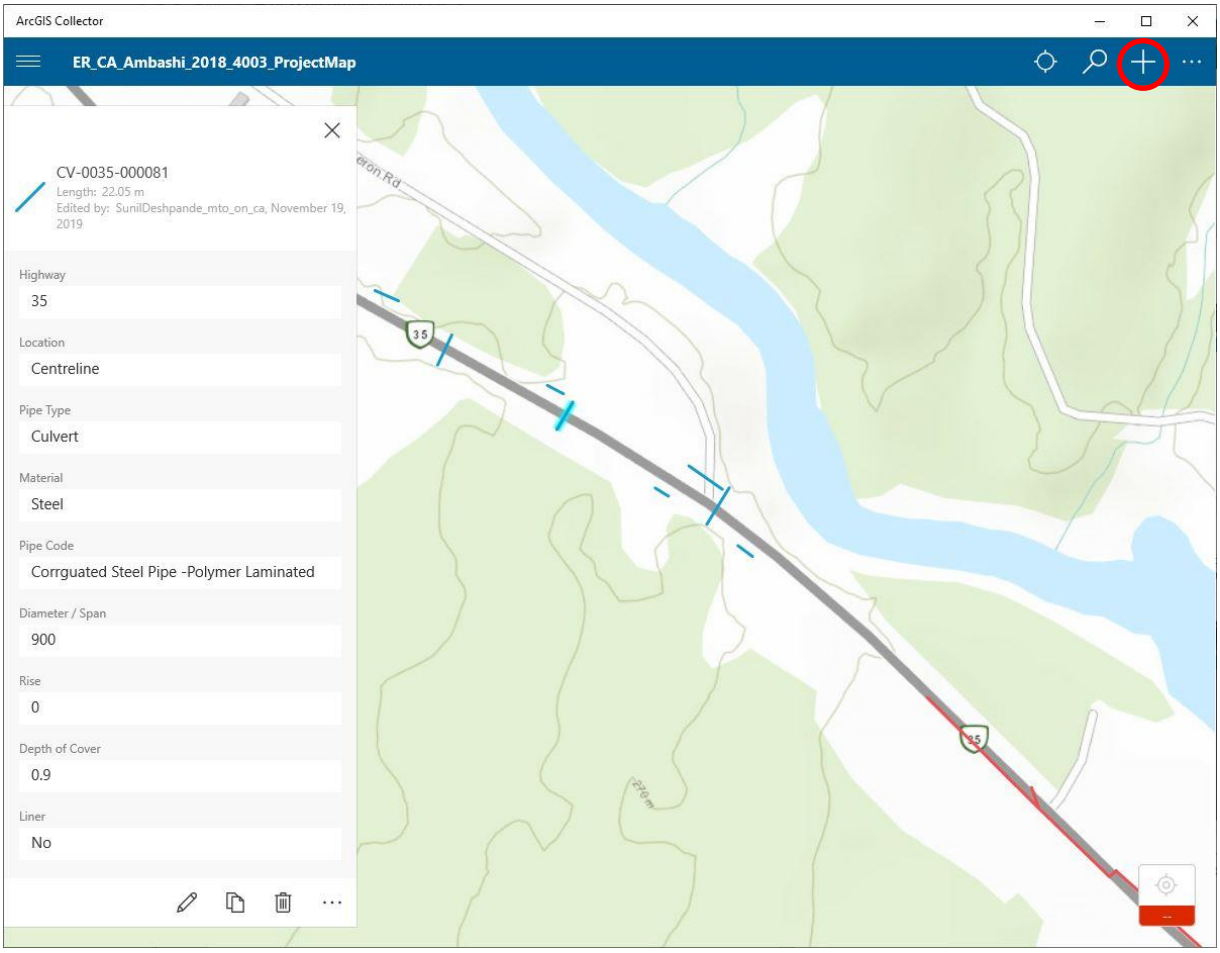


Figure 7A – Adding a Culvert

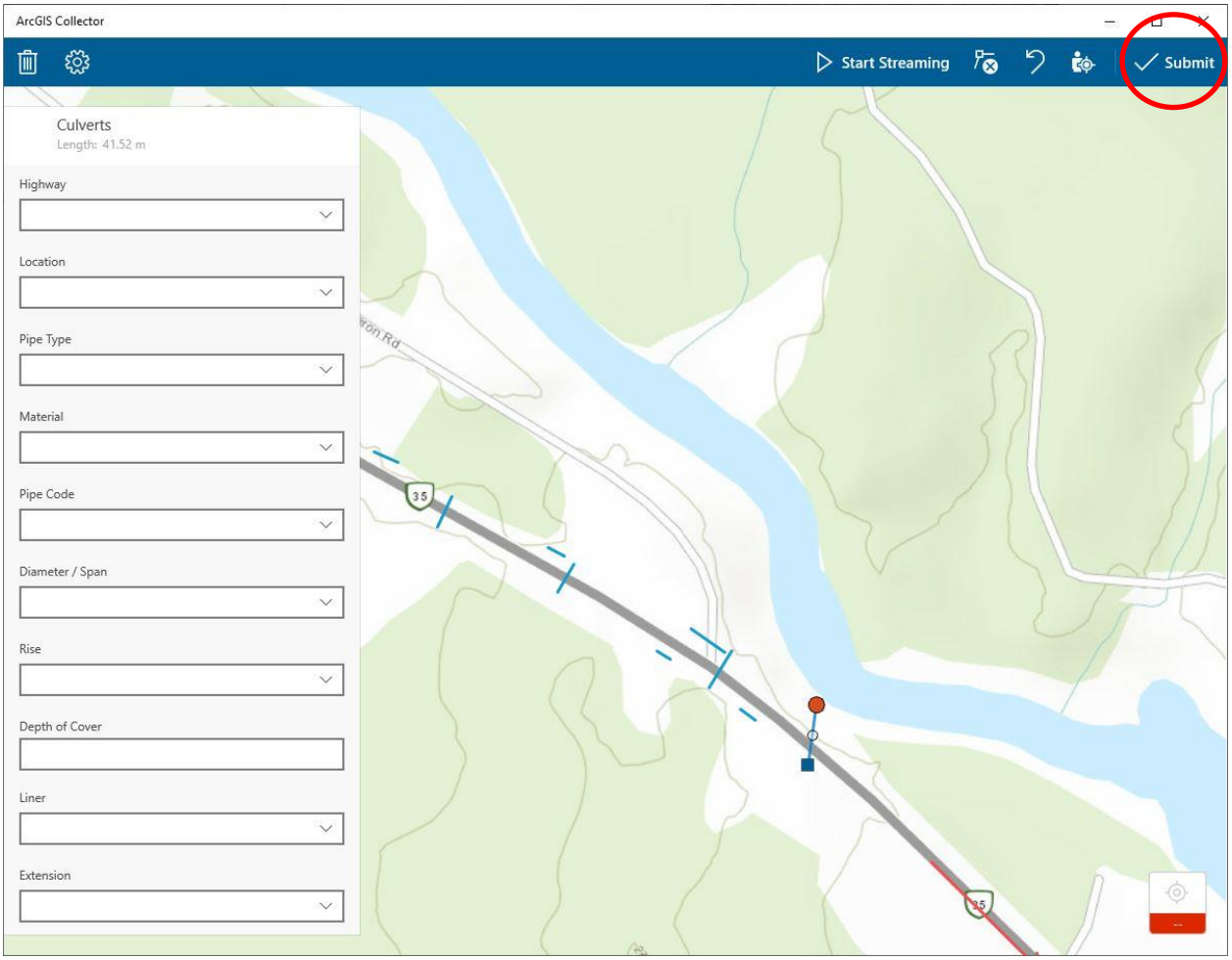


Figure 7B – Adding a Culvert

Errors

If an incorrect input was done (i.e. Adding inspection to incorrect culvert) simply use the “back” or “exit” action is, and this pop up should appear. Click discard and no changes will be saved.

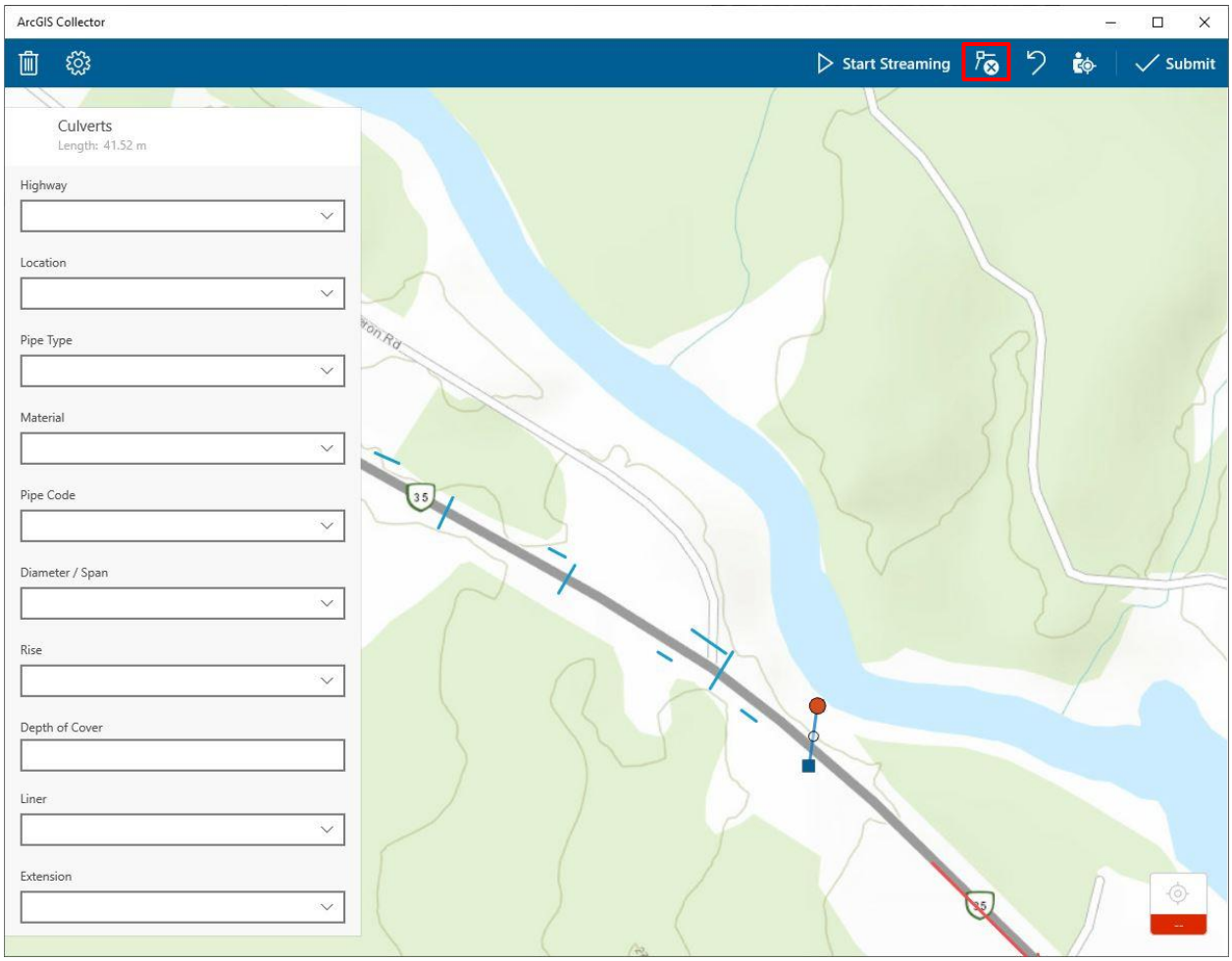


Figure 8 – Removing a Culvert