# 4. ASSESSMENT OF BEST PRACTICES FOR USE IN PILOT

Based on the results of the literature review and survey, best practices were developed for recommendation in the local agency pilot. These best practices are summarized in this section.

## 4.1. Culvert Sizes to be Inventoried

Culvert sizes to be inventoried and condition evaluated in this pilot will match the FHWA definition of a culvert; all structures under 20 feet. The nationwide literature review indicated that many agencies collecting data on culverts break them down into two categories; small structures that mostly serve hydrological roles, and larger structures that tend to be treated more like bridges when it comes to inspection and evaluation. MDOT has an established system for inspecting structures between 10 to 20 feet. While local agencies may not have inventory or condition evaluation data on structures less than 20 feet, there is a precedent for breaking the inventory down into two categories.

For the purposes of this pilot, it was decided that the culverts to be inventoried will range from 1 to <20 feet with no subdivision leading to different levels of effort in inventory or inspection. This was done to focus on one set of requirements for the pilot and to allow feedback from the participating agencies to determine if there was a need to subdivide culvert inventory or inspection by culvert size.

## 4.2. Inspection Frequency

The literature review found a great amount of variability in the inspection frequency practiced by states and local agencies with established culvert inspection programs. These frequencies varied between 1 and 10 years and set different intervals depending on culvert size and the last reported condition. Larger culverts and those with lower condition ratings were inspected with greater frequency than smaller culverts and those in better condition. The MDOT culvert pilot resulted in a recommended culvert condition evaluation frequency of two years for culverts 10 to <20 feet and five years for culverts 1 to <10 feet.

Since the duration of the culvert pilot is less than one year, there was no need to establish a frequency at the beginning of the pilot; however, condition evaluation frequency is one of the items to be recommended by the TAMC Bridge Committee as a result of feedback from this pilot.

## 4.3. Inventory Data

The TAMC Bridge Committee established the following list of items to be collected as part of the pilot:

1. Inventory ID
2. GPS Coordinates
3. Material Type
4. Asset Collection Date
5. Shape
6. Skew Angle
7. Length
8. Span (width)
9. Rise (height/diameter)
10. Depth of Cover
11. Roadway Surface Type
12. Culvert Condition Rating
13. Photographs (optional)

Detailed descriptions of these inventory items were provided to pilot participants during the training sessions and as a handout, both of which are located in the Appendix D. The items selected for the minimum data to be collected as part of the pilot were commonly referenced in the literature review, survey results, and had been used as part of the data collected in the previous MDOT pilot. Additional condition ratings, such as waterway, road surface, and inlet and outlet structure condition ratings were not selected for this pilot to maintain simplicity. Other inventory data was excluded for varying reasons; for example, date installed was excluded because this information is not readily obtainable during a field inspection, and may be unknown, although an agency could maintain this information for their records. Data such as municipality and road name are included in the inventory ID, and therefore do not need separate entries in data collection. A comparison was performed between the data selected for this pilot and the data collected in the MDOT pilot; inventory data inputs in Roadsoft; and inventory inputs to the Michigan Geographic Framework to ensure all required data could be stored in existing databases and was consistent with other pilots conducted in Michigan. A table showing this comparison is displayed in Appendix E.

## 4.4. Data Collection Software

Roadsoft was selected as the software data collection tool to be used for training aspects of the pilot. Roadsoft is a roadway asset management system for collecting, storing, and analyzing data associated with transportation infrastructure. Roadsoft is built on an optimum combination of database engine and GIS mapping tools. Roadsoft is provided at no cost to all local road agencies in the state. Survey results showed that local agencies were already familiar with Roadsoft, thereby lessening any learning curve and making the overall training process more efficient. Use of a common software program helps ensure data consistency, format, structure, and compliance statewide. Roadsoft was not required for participation in the pilot, however. Participants were free to use their own data collection system as long as they were able to upload their data electronically into the statewide data system.

## 4.5. Recommended Data Collection Equipment

Recommended equipment to be used in the pilot included:

- Standard Personal Protective Equipment (PPE, for safety)
- A flashlight (for inspection)
- A tape measure (for measuring culvert width and height/diameter)
- A probe rod / shovel (for inspection and culvert locating)
- A chipping hammer (for inspection)
- Magnet (to assist in identifying steel culverts)
- A rugged tablet with:
    - Roadsoft LDC (or similar software for data storage)
    - A compass app (for measuring skew angle)
    - Camera (for photographs)
- A laser distance measure (for culvert length, was selected over a measuring wheel for safety by reducing the need for crossing the road to make measurements)
- An auto level and grade rod (for depth of cover).

### 4.5.1. *Windows 10 Ruggedized Tablet*

With Roadsoft LDC and Roadsoft being the primary software tools for the collection and storage of culvert data for the pilot project, the CTT investigated several mobile and portable computing devices to streamline collecting data in the field. It was assumed that field conditions would be challenging with difficult terrain, moisture, and heavy cover all making it difficult to use a typical laptop during data collection. The CTT wanted to find devices that had a built-in GPS for geolocating the culverts, had the computing power to efficiently run Roadsoft LDC, had a built-in camera, and most of all was rugged enough to withstand field-use conditions. After a thorough search and comparison of various devices on the market, it was decided that a ruggedized Windows tablet would meet the criteria.

The CTT then did a comprehensive comparison of ruggedized tablets on the market taking into consideration the tight timeframe of the pilot project, the availability of the tablets as there would potentially be forty or more needed, specifications, performance, user reviews, and price. The CTT found that to ensure accuracy and software compatibility, a dedicated GPS receiver chip was needed, not a shared LTE chip that many mobile network compatible computers use. During the research it was discovered that the vast majority of the tablets on the market with dedicated GPS receivers all used the same internal GPS chip manufactured by u-blox. With that being the case, it was assumed that all the tablets would perform equally regarding GPS performance. Based on specifications (screen size, memory, processor, battery, etc.) the CTT narrowed the choices down to three possible tablets – Getac F110, MobileDemand T1600, and Trimble T10. All three tablets had similar specifications, similar physical size, the same GPS receiver, and were all roughly in the $2-3k range.

Based on comments and technical support calls received, there was a learning curve and general issues with running Windows 10 in tablet mode, as well as some GPS connection issues. Even with these minor issues, the tablets ran Roadsoft LDC well and worked as intended in the field.

Based on technical support calls and emails, and comments received in person and over the phone, the CTT created a short guide for tablet users to configure Roadsoft LDC to work with the built-in GPS. The instructions are included in Appendix F.

## 4.6. Condition Evaluation Method

The FHWA condition evaluation method, as presented in the 1986 *Culvert Inspection Manual,* was selected as the method to be used for the pilot because it is well established and widely implemented by numerous agencies. The FHWA method was modified to include a rating approach for plastic pipe and timber culverts based on content found in the literature review. Other condition evaluation methods were considered but not selected. Due to its additional qualitative and quantitative rating descriptions to the FHWA *Culvert Inspection Manual*, the 2017 Ohio DOT *Culvert Inspection Manual* was used as the primary source for developing the rating descriptions for corrugated metal; concrete; plastic; masonry; and slab and abutment culvert types. It was also used to develop descriptions for joints/seams, blockage, and scour. These rating descriptions were supplemented with rating descriptions directly from the FHWA manual when necessary, such as for the CMP Section Deformation rating chart. Because there was limited information for evaluating timber culverts in these sources, the rating chart for timber culverts was created based on the 2018 Wisconsin DOT *Bridge Inspection Field Manual,* which provided useful descriptions of problems affecting timber structures and associated ratings. Rating evaluation charts were developed to assist inspectors with assigning ratings in the field. These charts are provided in Appendix G along with supporting documentation.

*Figure 4-1: Antrim CRC inspecting a concrete box culvert*

The NCHRP method was not selected due to its draft status pending implementation as an AASHTO standard. The 2008 Midwest Regional UTC method was not picked due to its complexity and the resulting single overall rating value was not considered helpful for asset management practices as it makes maintenance assessment difficult. For example, debris could lower the culvert's overall rating as could structural failure of a pipe. Debris can be removed through standard maintenance whereas the structural failure likely requires replacement of the culvert.

## 4.7. Inventory and Condition Evaluation

Culverts were rated based on six condition criteria:

- **Invert deterioration** is the condition of the invert of the culvert, or the condition of the structure's footings if no invert is present on the structure. Conditions affecting inverts include abrasion-related damage and corrosion.
- **Structural deterioration** refers to the state of the culvert outside of the invert area. Conditions related to structural deterioration include corrosion-related damage resulting from soil acidity.
- **Section deformation** can be identified as changes from a culvert's original shape; deflections, and buckling, mainly due to stresses from loading. Section deformation is evaluated by inspecting the culvert shape and comparing it to the original design.
- **Joint/seam condition** describes the condition and alignment of the culvert segments or plates. Joints and seams are inspected for misalignment, offset, soil infiltration, and water exfiltration.

- **Channel blockage** from soil and/or debris affecting the flow of water through the culvert is evaluated and reported as the amount of blockage in the culvert and whether there is presence of pooling water.
- **Scour** is erosion of the embankment or trenching of the inlet/outlet due to water flow or debris. Inspectors will look for scour holes and their severity, condition of the embankment erosion as it affects any cutoff walls or headwalls, and any undermining of the footings at the inlet/outlet.

Roadsoft LDC allows inspectors to input individual ratings for each of these culvert components, and Roadsoft LDC will automatically select the lowest of these six ratings as the overall culvert condition rating. Inspectors can, however, overwrite this lowest rating selection with the rating of another culvert condition if it is believed to be more representative of the overall culvert condition.

Rating evaluation charts were developed to assist inspectors with assigning ratings in the field. A chart was developed for each culvert type considered in the pilot; corrugated metal pipe (CMP), concrete, plastic, masonry, slab and abutment, and timber culverts. These charts are provided in Appendix G along with supporting documentation.

# 5. DEVELOPMENT OF PILOT TRAINING AND RESOURCES

Statewide training programs for local agencies and consultants were developed to help ensure inventory and condition evaluation data were collected, reported, and submitted consistently. Three training webinars were developed; one for inventory collection and data storage, another for condition evaluation, and a third to demonstrate how to submit the collected culvert data. The first two training sessions, which were held prior to the culvert pilot commitment deadline, were each offered twice for increased participation in an effort to give potential participating agencies the information they needed to decide whether to participate in the pilot project. Recordings of all three training webinars were made available for viewing shortly after the conclusion of each of the training sessions.

## 5.1. Culvert Pilot Training

### 5.1.1. *Culvert Data Collection Using Roadsoft*

This training module was developed to provide an overview of the pilot and focus on three of its primary aspects: equipment, data collection, and data validation. The webinar included details on recommended equipment for culvert data collection, completing data collection with Roadsoft using visual walk-throughs of the software to explain the processes needed to collect each piece of information, and covered the overall process of data management and reporting methods for the completion of the pilot.