

## 3. REVIEW OF CURRENT BEST PRACTICES

### 3.1. Literature Review

The purpose of the literature review was to identify best practices used by county, state, and federal agencies that may be applicable to the pilot. This included identifying current data collection, storage, and evaluation tools in use by these agencies. A detailed literature review is included in Appendix A and summarized here. Once these tools, techniques, and methodologies were identified, an assessment was undertaken to determine those which warranted inclusion in the pilot.

#### 3.1.1. Pilot Studies

Numerous pilot studies have been conducted throughout the country. A 2014 FHWA study stressed the importance of getting a system in place. Once locations are established with some capacity for condition assessment, the assessment portion can be improved with time by adding additional data. “Internal groups and stakeholders can identify large lists of potential data to be collected; however, the agency should make sure it knows how the data will be used and how often it may be used” (Venner 2014).

In September 2016, the MDOT published the *Asset Collection & Condition Assessment Guide for 1’-<10’ Span Culverts*. The guide can be viewed at [https://www.michigan.gov/documents/mdot/MDOT\\_RFP\\_SS\\_REQ2435\\_Tams\\_Culvert\\_Collection\\_616748\\_7.pdf](https://www.michigan.gov/documents/mdot/MDOT_RFP_SS_REQ2435_Tams_Culvert_Collection_616748_7.pdf).

This assessment guide highlights the pilot project to collect location and assessment data for 1 to <10 foot culverts under MDOT-owned roadways in six counties; Eaton, Ingham, Isabella, Mackinac, Osceola, and Saginaw. Isabella County was inventoried under a separate pilot program in 2016, and condition evaluation was performed as part of the larger pilot in 2017. The MDOT report describes the Transportation Asset Management System (TAMS) interaction and integration in the collection of culvert data. In addition to the data collection process using TAMS, the guide provides information on attribute and condition assessment. The guide provides a comprehensive overview of the process of locating and assessing culverts and associated attributes (end treatments, footings, etc.). It should be noted that MDOT effectively considers 10 to 20 foot culverts as bridges, and inspections are included as a subset of their bridge inventory (MDOT 2016). Table 3-1 summarizes the number of culverts that MDOT collected data on with a breakdown of the miles covered by road class.

Table 3-1: MDOT culvert pilot summary

County	Final Invoice	Culverts Collected 1 to <10 ft	Culverts Collected 10 to <20ft	Trunk Line Miles	Freeway Miles	Non-Freeway Miles	Total Federal-Aid Non-Trunk Line Miles
Eaton County	\$61,506.95	479	24	155	39	116	377
Ingham County	\$88,667.92	1103	11	158	55	103	493
Mackinac County	\$84,174.38	561	13	178	28	150	212
Osceola County	\$75,211.75	376	8	99	25	74	253
Saginaw County	\$62,353.00	356	60	199	33	166	566
<b>Total</b>	<b>\$371,914.00</b>	<b>2,875</b>	<b>116</b>	<b>789</b>	<b>180</b>	<b>609</b>	<b>1,901</b>

### 3.1.2. Culvert Size

Culverts are defined as structures that span less than 20 feet. In general, agencies with established programs tend to collect data on culverts that span from 1 to 20 feet and many choose to divide these into at least two categories based on size (1 to 10 foot and 10 to 20 foot sets are common) with different inspection criteria applied to each.

### 3.1.3. Frequency of Inspections

The frequency of culvert inspections varied widely by agency. Some choose to conduct annual inspections, while others spread them out up to once every six years. Some states require more frequent inspections for culverts with poor condition evaluations. Culvert size is another factor in establishing inspection frequency. Some agencies choose to inspect smaller culverts with less frequency than larger culverts. The National Cooperative Highway Research Program (NCHRP) Report 14-26, *Culvert and Storm Drain System Inspection Manual*, recommends establishing an inspection frequency based on both the condition and size of the culvert, but leaves the frequency decision to the agency. Under the recommended system, culverts that span greater than 10 feet should be inspected every two years regardless of condition, and culverts less than 10 feet should be inspected at intervals depending on their size and last reported condition.

### 3.1.4. Commonly Used Equipment

The following equipment was commonly cited in the literature review as needed for culvert inspection and condition evaluation programs:

- Data collection device (paper template, laptop, tablet, etc.)
- Database software or spreadsheet for data storage
- Camera
- Personal protective equipment (PPE)
- Measuring tape and wheel
- Flashlight
- Shovel

- Waders
- Stability pole
- Probing rod or rock hammer
- Global Positioning System (GPS) device

### **3.1.5. Condition Evaluation**

FHWA issued report number FHWA-IP-86-2, *Culvert Inspection Manual: Supplement of the Bridge Inspector's Training Manual* in 1986. This manual provides information on culvert types, inspection procedures, and a culvert components inspection guide for approaches, end treatments, waterways, corrugated metal, precast concrete, cast-in-place concrete, and masonry culverts. The report provides guidance on data that should be collected for inventory and data that should be collected for condition evaluation of the culverts. The recommended rating system is a 0 to 9 scale, with 9 indicating that no repairs are needed and 0 indicating that the facility is closed for repairs.

The Ohio Department of Transportation (Ohio DOT) developed their own Culvert Management System, detailed in their 2017 *Culvert Inspection Manual*. This document is based on the FHWA system but provides additional quantitative and qualitative rating descriptors for rating corrugated metal, concrete, masonry, and plastic culvert structures beyond what is described by the FHWA (ODOT 2017).

The 2018 Wisconsin Department of Transportation (Wisconsin DOT) *Bridge Inspection Field Manual* provides descriptors for condition rating timber bridges whereas timber culvert condition ratings are not covered under the existing FHWA system. These condition ratings relate to deterioration problems experienced by culverts as well, and thus is a useful resource in developing a timber culvert condition rating system (WisDOT 2018).

The NCHRP 14-26, *Culvert and Storm Drain System Inspection Manual*, was published in May, 2016 and serves as a proposed update to the FHWA *Culvert Inspection Manual*. The NCHRP report contains several changes from the FHWA method. The largest change is a proposed five-point rating system which the authors feel more directly correlates to observed conditions. Rating descriptions have been reorganized to a component-level evaluation to be consistent with the American Association of State Highway and Transportation Officials (AASHTO) *Bridge Element Inspection Manual*.

The Midwest Regional University Transportation Center (UTC) developed a culvert rating procedure in 2008 in an attempt to give more insight for asset management of culverts. In this method, individual element ratings are combined into a single rating value based on a weighted average algorithm that uses an analytical hierarchy process (AHP) based on a pairwise comparison approach (i.e. "this is \_\_\_ more important than that").

## 3.2. Local Agency Survey – Data Availability and Extent

A comprehensive survey of Michigan local road-owning agencies was conducted to determine the extent of culvert inventory and condition evaluation data already being collected by local agencies. The results showed that local agencies range from not having a data collection program, to having a general inventory, to having a detailed inventory including culvert type, geo-referenced location, maintenance records, condition assessment, and other attributes. The survey also helped identify tools used for data collection and best practices employed by local agencies.

The *Michigan Local Agency Culvert Inventory Survey* was created by the TAMC Bridge Committee and distributed to local agencies with a letter summarizing the importance of this survey. The survey was conducted from March 6, 2018 through March 14, 2018 and is included in Appendix B. Response to the survey was overwhelming; 141 responses were received from local agencies. From this survey, conclusions were made about the current status of local agency culvert inventories; the data available in these inventories; condition rating methods; data storage methods; inventory/inspection differences related to culvert size; inspection equipment; frequency of inspection; and whether an agency would be interested in participating in this pilot study.

The map shown in Figure 3-1 shows the status of local culvert inventories compiled from the survey responses. The data represents complete responses (whose who filled out the entire survey) where the respondent indicated they were interested in participating in the pilot. Some agencies (60 respondents) completed the survey but indicated they would not be able to participate in the pilot. While those agencies do not show up in Figure 3-1, the data they provided was helpful in laying the groundwork for the inventory and condition evaluation components of the pilot. The data is broken into two categories based on the type of agency responding to the survey: city/village/township, and county road agencies. Those responses are then broken into three subcategories: Tier 1, Tier 2, and Tier 3. Counties where the MDOT Culvert Mapping Project occurred on state highways are also indicated.

- Tier 1 - identifies agencies (39 respondents) that have not inventoried or condition evaluated culverts within their jurisdiction.
- Tier 2 - identifies agencies (33 respondents) that have a portion of their culverts inventoried, but none or very few have had their condition evaluated on a routine basis (at least once every 5 years).
- Tier 3 - identifies agencies (9 respondents) that have most of their culverts inventoried and condition evaluated on a routine basis (at least once every 5 years).

The map shown in Figure 3-1 was generated based on the respondent’s geographical information. If the respondent represents a county, that county is highlighted on the map. If they represent a city, village, or township, then a zip code was used and highlighted on the map. The regions identified on the map were generated using Excel’s 3D Map add-on. Cities with multiple zip codes were assigned one zip code for the purpose of generating the map: exact agency boundaries may not be represented. A full list of the participating agencies, the county/zip code of the agency, and agency’s tier is presented in Appendix C.

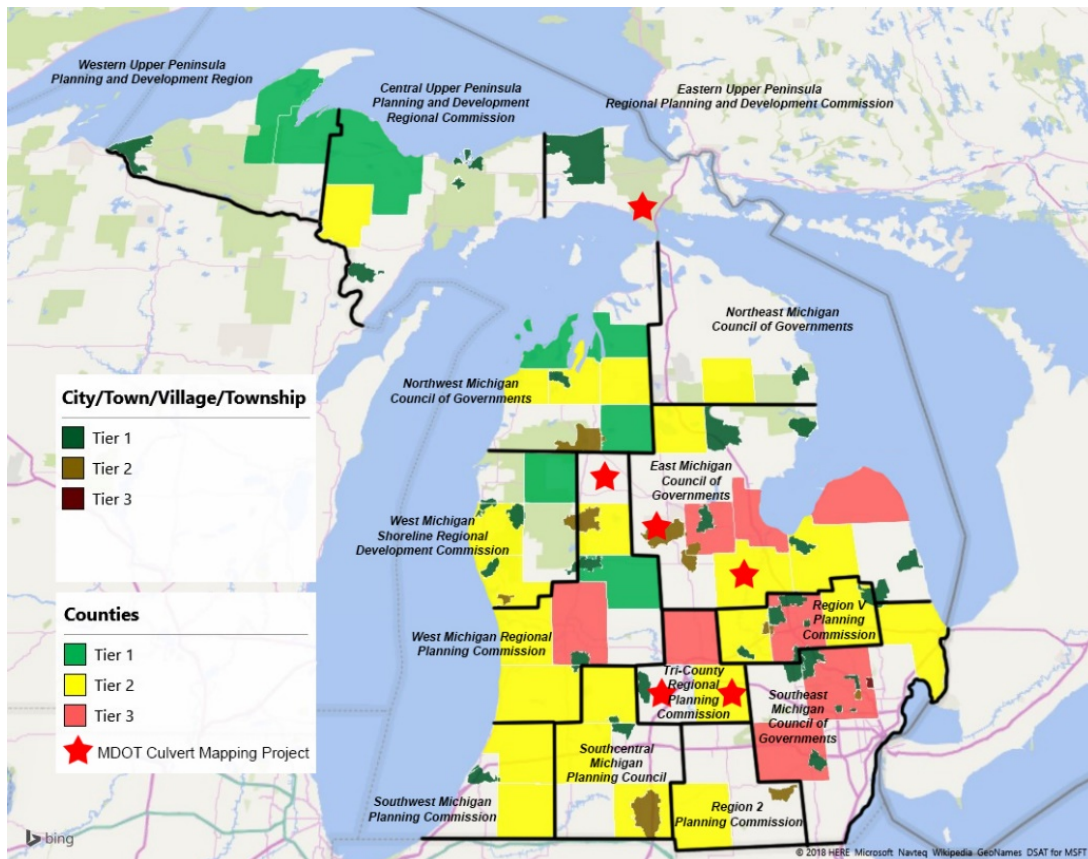


Figure 3-1: Willing pilot respondents & state of local inventories

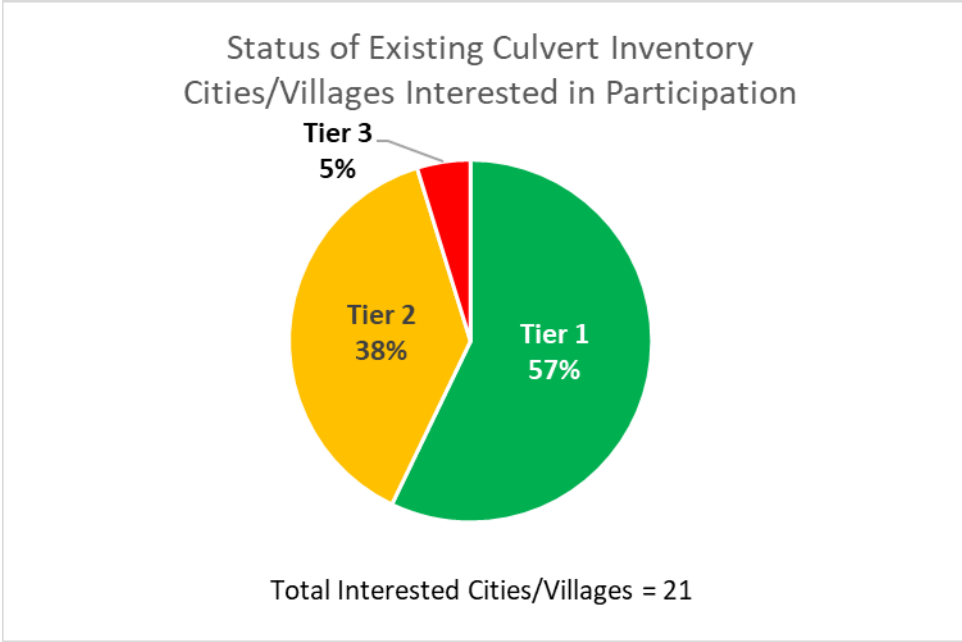


Figure 3-2: Willing pilot respondents by tier – city/village road agency

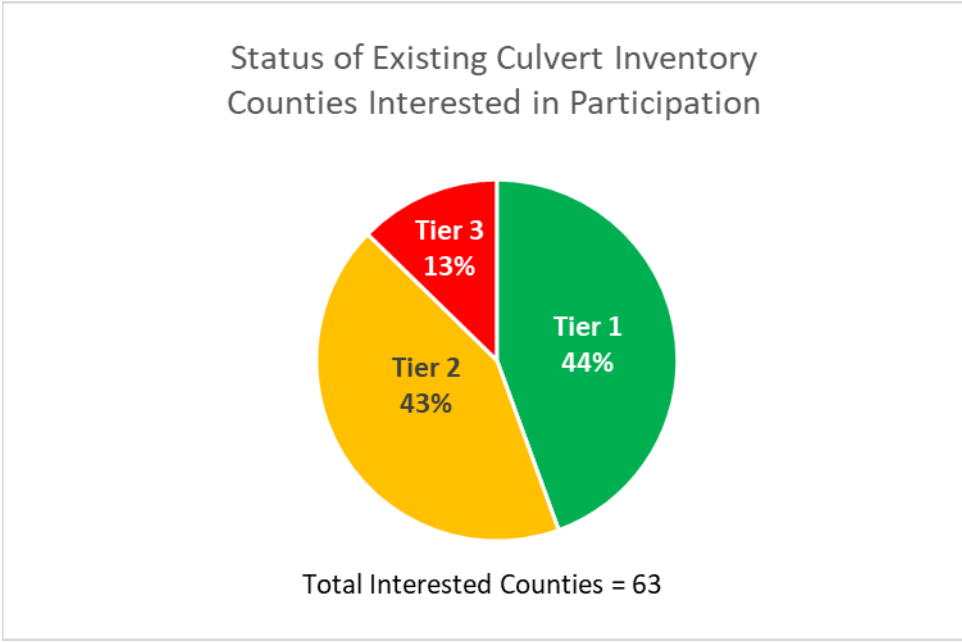


Figure 3-3: Willing pilot respondents by tier – county road agency

Table 3-2: Culvert pilot survey respondents

Tier	Round	RPO	Agency Type	Agency
2	1	WMRPC	County	Allegan County Road Commission
1	1	Networks Northwest	County	Antrim County Road Commission
1	2	WUPPDR	County	Baraga County Road Commission
2	2	SCMPC	County	Barry County Road Commission
3	1	EMCOG	County	Bay County Road Commission
2	1	Networks Northwest	County	Benzie County Road Commission
2	2	SCMPC	County	***Branch County Road Commission
2	2	SCMPC	County	Branch County Road Commission
2	2	SCMPC	County	Cass County Road Commission
1	2	SCMPC	City	City of Battle Creek
1	2	SWMPC	City	City of Benton Harbor
2	1	WMRPC	City	City of Big Rapids
2	2	SEMCOG	City	City of Bloomfield Hills
1	1	EMCOG	City	City of Brown City
1	2	GLS-Region V	City	City of Burton
2	1	Networks Northwest	City	City of Cadillac
1	2	GLS-Region V	City	City of Clio
2	2	SCMPC	City	City of Coldwater
1	1	EMCOG	City	City of East Tawas
1	2	SEMCOG	City	City of Farmington Hills
1	2	GLS-Region V	City	City of Fenton
1	2	WUPPDR	City	City of Ironwood
1	2	SEMCOG	City	City of Lake Angelus
2	2	SEMCOG	City	City of Marysville
2	1	EMCOG	City	City of Mt. Pleasant
1	2	CUPPAD	City	City of Munising
2	2	WMSRDC	City	City of Muskegon Heights
3	1	SEMCOG	City	City of Rochester Hills
1	2	SEMCOG	City	City of Southfield
2	1	EMCOG	City	***City of St. Louis
2	2	Region 2 PC	City	City of Tecumseh
1	1	EMCOG	City	City of West Branch
1	2	WMSRDC	City	City of Whitehall
3	1	TCRPC	County	Clinton County Road Commission
2	2	CUPPAD	County	Dickinson County Road Commission
3	1	GLS-Region V	County	***Genesee County Road Commission
2	1	Networks Northwest	County	Grand Traverse County Road Commission
2	2	Region 2 PC	County	Hillsdale County Road Commission
1	2	WUPPDR	County	Houghton County Road Commission

Tier	Round	RPO	Agency Type	Agency
3	1	EMCOG	County	Huron County Road Commission
2	2	TCRPC	County	Ingham County Road Department
2	1	Networks Northwest	County	Kalkaska County Road Commission
3	1	WMRPC	County	Kent County Road Commission
1	2	WMSRDC	County	Lake County Road Commission
2	2	GLS-Region V	County	Lapeer County Road Commission
1	1	Networks Northwest	County	Leelanau County Road Commission
1	2	CUPPAD	County	Marquette County Road Commission
2	1	WMRPC	County	Mecosta County Road Commission
3	1	EMCOG	County	Midland County Road Commission
1	1	Networks Northwest	County	Missaukee County Road Comm.
1	1	WMRPC	County	Montcalm County Road Commission
2	2	WMSRDC	County	Muskegon County Road Commission
2	2	WMSRDC	County	Oceana County Road Commission
2	2	NEMCOG	County	Oscoda County Road Commission
2	1	WMRPC	County	Ottawa County Road Commission
3	1	SEMCOG	County	Road Commission for Oakland County
2	2	SCMPC	County	Road Commission of Kalamazoo County
2	1	EMCOG	County	Roscommon County Road Commission
2	1	EMCOG	County	Saginaw County Road Commission
2	2	GLS-Region V	County	Shiawassee County Road Commission
2	2	SEMCOG	County	St Clair County Road Commission
2	1	EMCOG	County	Tuscola County Road Commission
2	2	SWMPC	County	Van Buren County Road Commission
1	1	EMCOG	City	Village of Carsonville
1	1	WMRPC	City	Village of Caledonia
1	2	CUPPAD	City	Village of Daggett
1	1	EMCOG	City	Village of Fairgrove
1	2	SEMCOG	City	Village of Holly
1	1	WMRPC	City	Village of Howard City
2	2	GLS-Region V	City	Village of Lennon
1	2	NEMCOG	City	Village of Lincoln
1	2	GLS-Region V	City	Village of Morrice
1	2	EUPPRDC	City	Village of Newberry
1	2	WMSRDC	City	Village of Pentwater
1	1	EMCOG	City	Village of Sanford
1	2	TCRPC	City	Village of Vermontville
1	2	WMSRDC	City	Village of Walkerville
3	1	SEMCOG	County	Washtenaw County Road Commission

Agencies marked with \*\*\* initially committed to participate in the culvert pilot but had to withdraw once the pilot started due to various reasons.



**Note:** In Table 3-2, the colored cells represent agencies willing to participate as depicted similarly on the map in Figure 3-1. Table cells without a background color represent agencies that responded to the survey but were unwilling or unable to participate.

As shown in Figure 3-2 and Figure 3-3, it is evident that many of the agencies fall in either Tier 1 or Tier 2, with a much smaller number of agencies falling under Tier 3. Therefore, the need for such a pilot study is apparent; most Michigan local agencies are currently not collecting culvert inventories and condition evaluations or are doing so infrequently.

Respondents were asked about the culvert attributes (items) for which they collect data as part of their inventory and condition evaluations. The number of respondents collecting each of the items identified in the survey is presented in Figure 3-4. All responses to the survey were used to create this chart, not just those indicating an interest in participating in the pilot. The top four inventory items were; material type, shape, length, and height/diameter. Some inventory items recorded that were not included on this chart include footing type and railing information, which were recorded by only one agency. Many Tier 2 responses indicated that data was; often collected during maintenance operations, was based on existing drawings, and/or was basic and incomplete. Guidance and common statewide inventory and condition evaluation practices would help to standardize the data collected by local agencies.

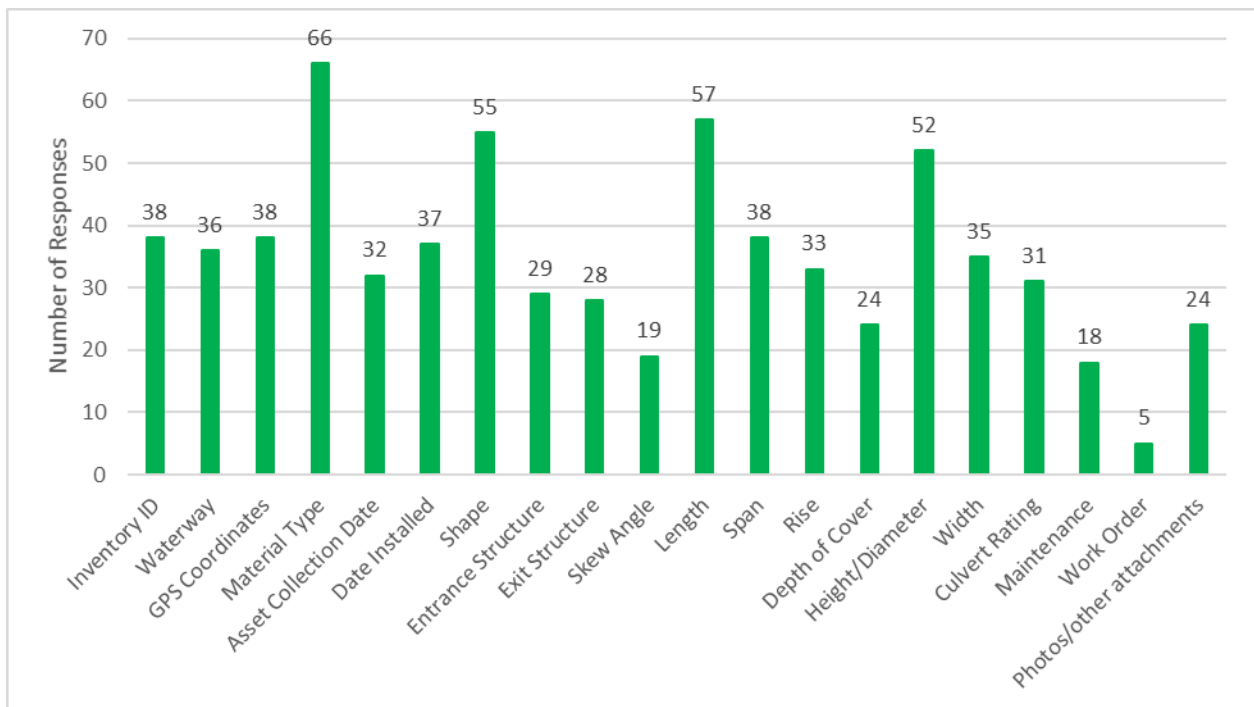


Figure 3-4: Inventory data collected by agencies surveyed

### 3.2.1. Data Storage

Of the survey respondents, there were many variations in how inventory data was organized and stored. Common data storage methods included Roadsoft, paper files, spreadsheets, Geographical Information System (GIS) databases, or other asset management software such as MiBridge or Lucity. Many agencies indicated that they currently store inventories on paper or spreadsheets but are moving towards incorporating the data into an asset management software program or GIS database. Figure 3-5 shows a breakdown of data storage methods used by participating agencies.

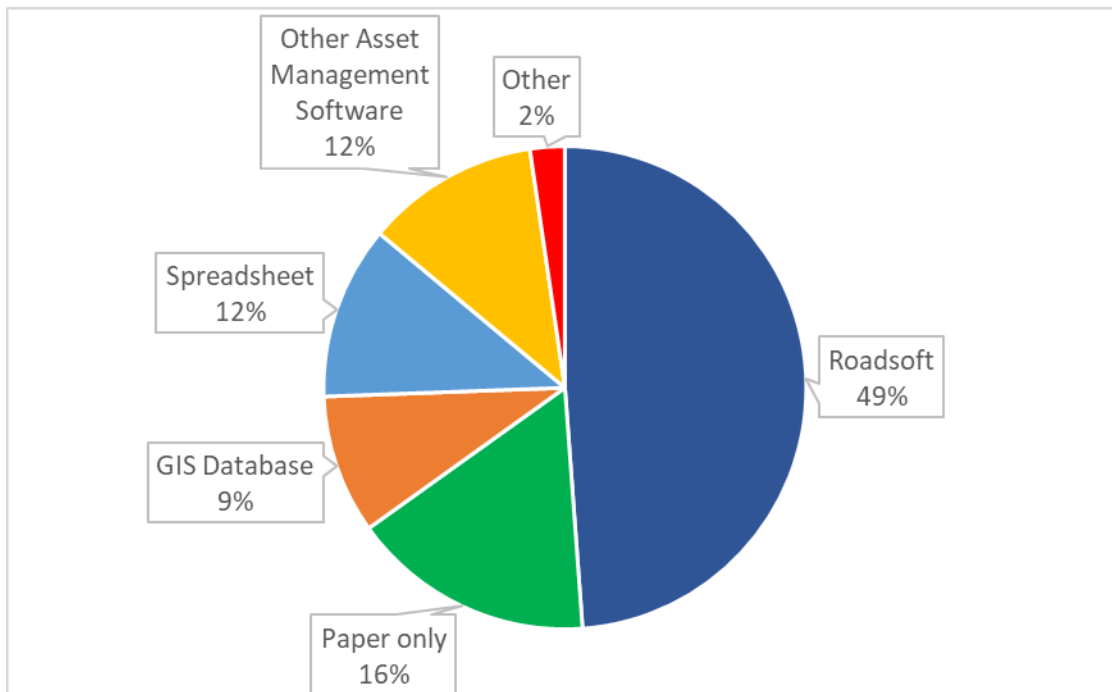


Figure 3-5. Breakdown of data storage methods from participating agencies

### 3.2.2. Culvert Sizes

Most responding agencies did not indicate they subdivide their culverts for the purpose of inventory and condition evaluation, either by a lack of response or by directly indicating so. However, of the participating agencies that do subdivide their culverts, there were several different methods of subdivision, mainly by size, material type, and need for maintenance. Some county road agencies were found to separate culverts by size into categories 2 to 5 feet and below, and 5 to 20 feet. Tuscola County Road Commission (CRC) indicated this was due to different funding sources for maintaining different sized culverts, and Kent CRC indicated this was for inspection frequency: giving priority to the larger culverts. Bay CRC separated culverts into less than 10 feet and 10 to 20 feet. Branch CRC separated culverts into 3 feet and below, 3 to 6 feet, 6 to 10 feet, and 10 to 20 feet. MDOT separated culverts into categories of 1 to <10 feet and 10 to <20 feet.

Subdivision of culverts by size was primarily due to establishing maintenance priorities linked to the condition rating of the culvert for the purpose of asset management practices. Agencies also subdivided culverts by material type to assist with evaluating culvert deterioration and to effectively plan maintenance projects.

### **3.2.3. Condition Rating**

Several different condition rating systems are used by agencies that evaluate the condition of their culverts. Many agencies use the previously described FHWA system presented in the 1986 *Culvert Inspection Manual*, which is the system used by Roadsoft. Other common rating systems indicated by local agencies were a good/fair/poor system, and a simple visual inspection system with no rating scale. Bay CRC uses the National Bridge Inventory (NBI) inspection criteria to rate culverts spanning 10 to 20 feet in accordance with the MDOT pilot proposal (MDOT 2016). It appears that most agencies store the condition evaluation data in the same location as their inventory data.

### **3.2.4. Inspection Frequency**

The level of inspection varied greatly between agencies. Some agencies rated the condition of the pipe and structural components, while others also rated: the flow conditions, erosion around the culvert, amount of sediment obstructing the culvert, entrance/exit structure conditions, pavement condition, and guardrail condition, among other ratings. There was little consistency in what should be rated to meet the needs of the local agencies.

Inspection frequency varied greatly among Tier 3 agencies. Inspections occur once every three to five years depending on the agency, with some variation based on culvert size and condition. Many agencies responded that inspection frequency varies by culvert size with more frequent inspection performed on larger culverts rather than smaller culverts. Some agencies indicated they do not evaluate the condition of their smaller culverts at all. Some agencies perform inspections based on the last recorded culvert condition: the worse the culvert condition, the more frequent the inspection.

### **3.2.5. Equipment**

Equipment used to perform these inspections also varied between agencies, although there are similarities. Most agencies provided waders, tape measures, pick hammers, and flashlights to their inspectors. Other common inspection equipment included a GPS, cameras, laptops with asset management software, probe rods, and shovels.