JOINT TRANSPORTATION RESEARCH PROGRAM

INDIANA DEPARTMENT OF TRANSPORTATION
AND PURDUE UNIVERSITY

Processes of Small Culvert Inspection and Asset Management

Justin D. Bowers, Samuel R. Magers, Jennifer Pyrz, Darcy M. Bullock

SPR-3859 • Report Number: FHWA/IN/JTRP-2014/08 • DOI: 10.5703/1288284315502

RECOMMENDED CITATION

Bowers, J. D., Magers, S. R., Pyrz, J., & Bullock, D. M. (2014). *Processes of small culvert inspection and asset management* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2014/08). West Lafayette, IN: Purdue University. http://dx.doi.org/10.5703/1288284315502

AUTHORS

Justin D. Bowers
Graduate Research Assistant
Lyles School of Civil Engineering
Purdue University

Samuel R. Magers
Graduate Research Assistant
Lyles School of Civil Engineering
Purdue University

Jennifer Pyrz, PE
JTRP Implementation Engineer
Purdue University

Darcy M. Bullock, PhD, PE
Professor of Civil Engineering
Lyles School of Civil Engineering
Purdue University
(765) 464-2226
darcy@purdue.edu
Corresponding Author

JOINT TRANSPORTATION RESEARCH PROGRAM

The Joint Transportation Research Program serves as a vehicle for INDOT collaboration with higher education institutions and industry in Indiana to facilitate innovation that results in continuous improvement in the planning, design, construction, operation, management and economic efficiency of the Indiana transportation infrastructure. https://engineering.purdue.edu/JTRP/index_html

Published reports of the Joint Transportation Research Program are available at: http://docs.lib.purdue.edu/jtrp/

NOTICE

COPYRIGHT

Print ISBN: 978-1-62260-300-8
ePUB ISBN: 978-1-62260-301-5

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/IN/JTRP-2014/08		

4. Title and Subtitle	5. Report Date
Processes of Small Culvert Inspection and Asset Management	August 2014
	6. Performing Organization Code
7. Author(s)	**8. Performing Organization Report No.**
Justin D. Bowers, Samuel R. Magers, Jennifer Pyrz, Darcy M. Bullock	FHWA/IN/JTRP-2014/08
9. Performing Organization Name and Address Joint Transportation Research Program Purdue University 550 Stadium Mall Drive West Lafayette, IN 47907-2051	**10. Work Unit No.**
	11. Contract or Grant No. SPR-3859
12. Sponsoring Agency Name and Address Indiana Department of Transportation State Office Building 100 North Senate Avenue Indianapolis, IN 46204	**13. Type of Report and Period Covered** Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the Indiana Department of Transportation and Federal Highway Administration.

16. Abstract

Proper drainage is essential for pavement to maximize life expectancy and minimize maintenance. Culverts are a critical asset to facilitate drainage. As with many assets, culverts deteriorate with age and require regular inspection. It is important to have a formalized process of inventory and inspection that is efficient and can effectively support culvert asset management. The current culvert inspection and asset management processes for the Indiana Department of Transportation (INDOT) have been modeled over the years on the bridge inspection process and were recently evaluated. A study was undertaken to further evaluate the current culvert asset management practices. Approximately 700 small culverts and catch basins were visited and evaluated using both the traditional culvert inspection practices and a revised asset management evaluation scale. The paper summarizes the findings of this evaluation and concludes by making recommendations for process improvements. These recommendations include the addition of photos to the culvert database, a revised rating scale, advanced planning of inspection schedules, a formalized process for culvert reassessments, the creation of a separate catch basin inlet inventory, various improvements to the inventory process, and a dedicated staff to complete inspections efficiently. It is also noted that building a reliable database will show historical trends and can eventually lead to a study of small culvert inspections and culvert longevity, which will lead to improved asset management.

17. Key Words	18. Distribution Statement
culvert, inspect, asset management, highway maintenance	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	19	

Form DOT F 1700.7 (8-69)

ABSTRACT

PROCESSES OF SMALL CULVERT INSPECTION AND ASSET MANAGEMENT

Proper drainage is essential for pavement to maximize life expectancy and minimize maintenance. Culverts are a critical asset to facilitate drainage. As with many assets, culverts deteriorate with age and require regular inspection. It is important to have a formalized process of inventory and inspection that is efficient and can effectively support culvert asset management.

The current culvert inspection and asset management processes for the Indiana Department of Transportation (INDOT) have been modeled over the years on the bridge inspection process and were recently evaluated. A study was undertaken to further evaluate the current culvert asset management practices. Approximately 700 small culverts and catch basins were visited and evaluated using both the traditional culvert inspection practices and a revised asset management evaluation scale. The paper summarizes the findings of this evaluation and concludes by making recommendations for process improvements. These recommendations include the addition of photos to the culvert database, a revised rating scale, advanced planning of inspection schedules, a formalized process for culvert reassessments, the creation of a separate catch basin inlet inventory, various improvements to the inventory process, and a dedicated staff to complete inspections efficiently. It is also noted that building a reliable database will show historical trends and can eventually lead to a study of small culvert inspections and culvert longevity, which will lead to improved asset management.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Literature Review

Proper drainage is essential for pavement to maximize life expectancy and minimize maintenance. Culverts are a critical asset to facilitate drainage and provide structured paths for water to flow under road beds. Their purposes are to prevent roadway flooding, reduce erosion, and prevent roadway maintenance problems (Environmental Protection Agency, 2000). Indiana defines catch basins and culverts with a span less than 48 inches as "small culverts" (Indiana Department of Transportation, 2013). It is estimated that 90,000 small culverts are located under Indiana state highways (Indiana Department of Transportation, 2012).

More importance is generally given to more visible infrastructure such as pavement, bridges, and guardrails (Bhattachar, 2007). However, smaller assets such as culverts are important assets to track due to their impact on pavement performance and the opportunities to realize efficiencies by programming culvert maintenance with pavement re-surfacing and re-construction activities. If these underground assets are not monitored, usage over time and environmental factors begin to wear on the structures or there may be initial construction defects. This increases the likelihood of failure (Bhattachar, 2007). To proactively identify emerging maintenance issues, agencies conduct periodic culvert inspections (Arnoult, 1986).

1.2 Motivation for Research

Culverts can fail over time in a variety of ways (Figure 1.1), and they require regular inspection. The motivation of this paper is to provide recommendations for enhancement and efficiency of INDOT's the small culvert inspection process. Each year, INDOT conducts inspections of 20–25% of their small culvert inventory so that the entire inventory can be inspected once every 4–5 years. Although the 4–5 year inspection interval may be an appropriate time period based on the life of a small culvert, various users of the information contained in the current inventory system find it unreliable. The inventory and inspection processes carried out by INDOT can be improved, ultimately saving time, effort, and money for the agency. This paper reports on the current inspection and inventory processes of Indiana's Crawfordsville District and concludes with recommended strategies to improve these processes.

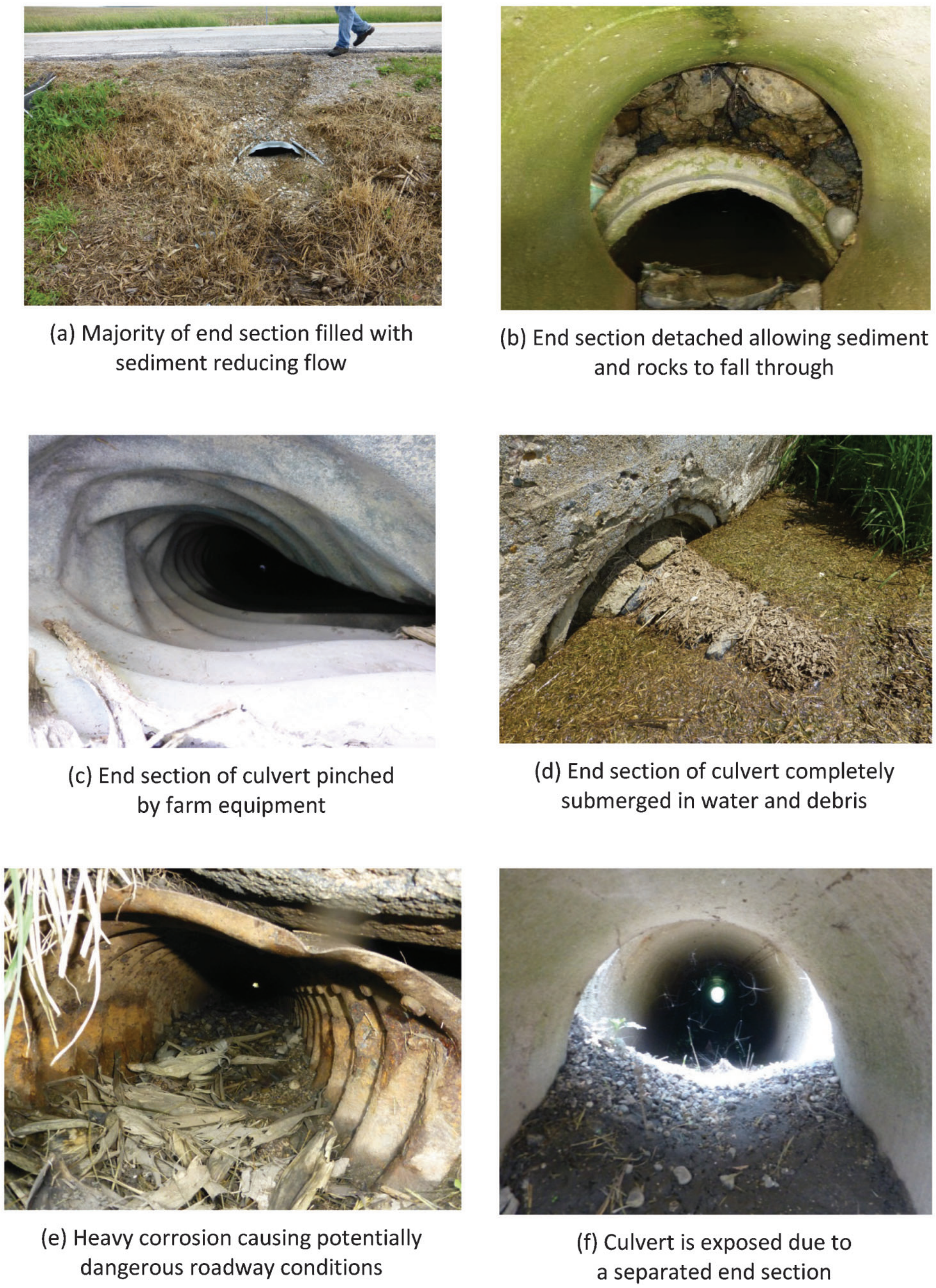


Figure 1.1 Motivation for optimizing culvert inspections.

2. FIELD DATA COLLECTION

Sites were visited with a van equipped with strobe lights and inspection equipment, a digital camera, personal protective equipment (PPE), a measuring tape, a measuring wheel, flashlights, and a shovel. The participants of this research simulated INDOT's method of small culvert inspection over a two month period.

3. METHODS

3.1 Small Culvert Inspection Method

The Indiana Department of Transportation Work Performance Standard for small culvert inspection (Activity 2320) establishes that inexperienced personnel must be trained prior to inspecting structures (Indiana Department of Transportation, 2013). During training of the researchers, a slide show was shown that describes the inspection form, what to look for while inspecting, and how to give an accurate rating based on Indiana's standards. Researchers then participated in field training with an experienced inspector, where they performed actual inspections. The following is a step-by-step example of small culvert inspections that an INDOT inspection team may follow.

A section of road is selected for inspection by two workers. One serves as a driver and the other as the inspector. The odometer is reset each time a reference post is passed. Once a culvert is identified, the vehicle is parked on the side of the road next to or shortly ahead of the culvert. The driver reads off the mile marker to the inspector. The inspector records the mile marker, GPS coordinates, county, and side of road in a database inventory tool and on a hard copy form (Figure 3.1). The vehicle is then moved to the safest area available and both personnel exit the vehicle. The driver measures the horizontal span of the culvert with a tape and its length with the measuring wheel. Meanwhile, the inspector conducts a visual inspection of the embankments, end sections, flow lines, inside culvert condition, and road condition. If a defect is noticed, the inspector points it out and it is discussed.

After the personnel return to the vehicle, the inspector records the type, shape, length, and size of the culvert. The inspector considers and records ratings for the

- embankments,
- end sections,
- flow lines,
- culvert, and
- general conditions.

Comments on these ratings might also be recorded. The driver then drives to the next culvert site, and the process is repeated. According to the Work Performance Standard, workers should average 20 such inspections per day (Indiana Department of Transportation, 2013).

During this study, the culvert inspection process was executed over a sample of road segments within INDOT's Crawfordsville District. The process was modified slightly throughout the study for optimization purposes, but the inspections themselves remained consistent with INDOT's expectations and standards. The average daily number of inspections, however, was near 50 rather than the required 20. To add to the information collected in the inspections, at least four geocoded photos were taken at every culvert for reference purposes. The inspection process has been documented in Figure 3.2. The data collected included small culverts on various roads maintained by INDOT in the Fowler, Frankfort, and Crawfordsville sub-districts. These segments were selected based on proximity to Purdue University as well as on the Crawfordsville District's inspection needs. The area of inspection is shown in Figure 3.3 and Figure 3.4.

3.2 Catch Basin Inspection Method

Though the pipes immediately under inlets and catch basins are the town or city's responsibility, the inlets and catch basins themselves are maintained by INDOT. Therefore, these structures are to be inspected by INDOT crews at the same time as the culvert inspections. The catch basin and culvert inspections do not vary according to the current performance standard, but in practice, the processes differ. Following INDOT's current inspection process, the inspection crew will drive slowly through a town, again synchronizing the odometer with a mile marker. Once a catch basin is found, the driver will temporarily park near or over the top of the structure and visually inspect it. The same database inventory tool and inspection forms are used as for culverts, and the appropriate ratings for each data field are entered.

Throughout the data collection portion of this research, catch basins were inspected slightly differently than INDOT's method. Rather than driving and stopping at each catch basin, the vehicle was parked in a nearby parking lot and the inlets were inspected on foot. This was done for multiple reasons. First, the vehicle used for this project was not equipped for stopping in traffic. Although a flashing light was provided for the top of the vehicle, it lacked certain capabilities and tools that INDOT vehicles are equipped with, such as caution signs and built-in flashers. Second, a geocoded photo was taken of each catch basin for reference purposes. In contrast to the culvert inspections, a condition rating was only given for "End Section (In)" of catch basins as it is essentially the only data field maintained by the state for catch basins.

Used with Activity 2320

Small Culvert Inspection Field Form

ROAD: ______________________

UNIT: ______________________

DATE: ______________________

INSPECTOR(S): ______________________

DIRECTION OF TRAVEL: Both (All) Inc (N/E) Dec (S/W)

Page _____ of ______

SIDE OF ROAD KEY

R - Right Side
L - Left Side
M - Median
H - Highway

TYPE KEY

BC - Box Culvert
C - Concrete Pipe
CB - Catch Basin
FT - Farm Tile
I - Inlet
MH - Man Hole
MP - Metal Pipe
MPP - Multi-Plate
PL - Plastic Liner
PP - Plastic Pipe
SD - Slotted Drain
ST - Slab Top
VC - Vitrified Clay
W - Weir
O - Other

SHAPE KEY

A - Arched Pipe
C - Circular Pipe
E - Elliptical
CB/I - Catch Basin/Inlet

CONDITION KEY

9 - No Repairs Needed
8 - No Repairs Needed, list specific items for special inspection during next regular inspection
7 - No Immediate Plan for Repair; examine possiblity of increased level of inspection
6 - By End of Next Season; add to work schedule
5 - Place in Current Schedule/Current Season/First Reasonable Opportunity
4 - Priority, Current Season; review work plan for relative priority, adjust schedule if possible
3 - High Priority; current season as soon as can be scheduled
2 - Highest Priority; discontinue other work if required, emergency basis
1 - Emergency Action Required; re-route traffic and close

GENERAL NOTES

1. All mile marker references should be entered to the nearest thousandth (0.001) of a mile by DMI.

2. Please make sure all coordinate data is collected using the WGS84 datum and in decimal degree

MILE MARKER (00.000)	COUNTY	SIDE OF ROAD	TYPE	X COORDINATE (Longitude) (00.00000)	Y COORDINATE (Latitude) (00.00000)	LENGTH (ft)	SHAPE	SIZE (in)	EMBANKMENT		END SECTION		FLOWLINE		CULVERT CONDITION	GENERAL CONDITION	COMMENTS
									IN	OUT	IN	OUT	IN	OUT			

Form: 2320-F *(Rev. 3-2014)*

Figure 3.1 Existing small culvert inspection form.

(a) Taking overview photo

(b) Taking inside view photo

(c) Measuring span of culvert

(d) Measuring the length of the culvert with a wheel

(e) Inspecting inside culvert with flashlight

Figure 3.2 Culvert inspection process.

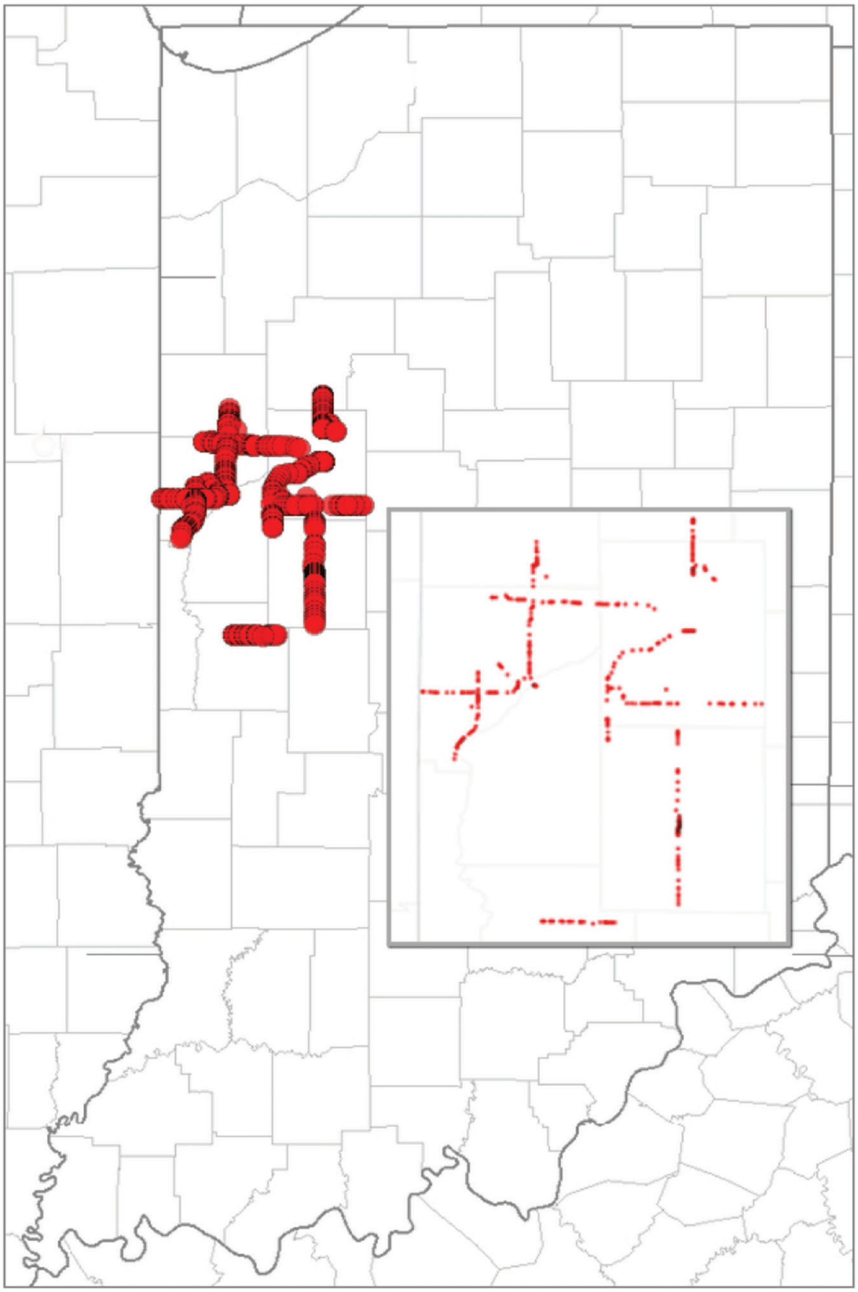


Figure 3.3 Indiana map of all road sections inspected.

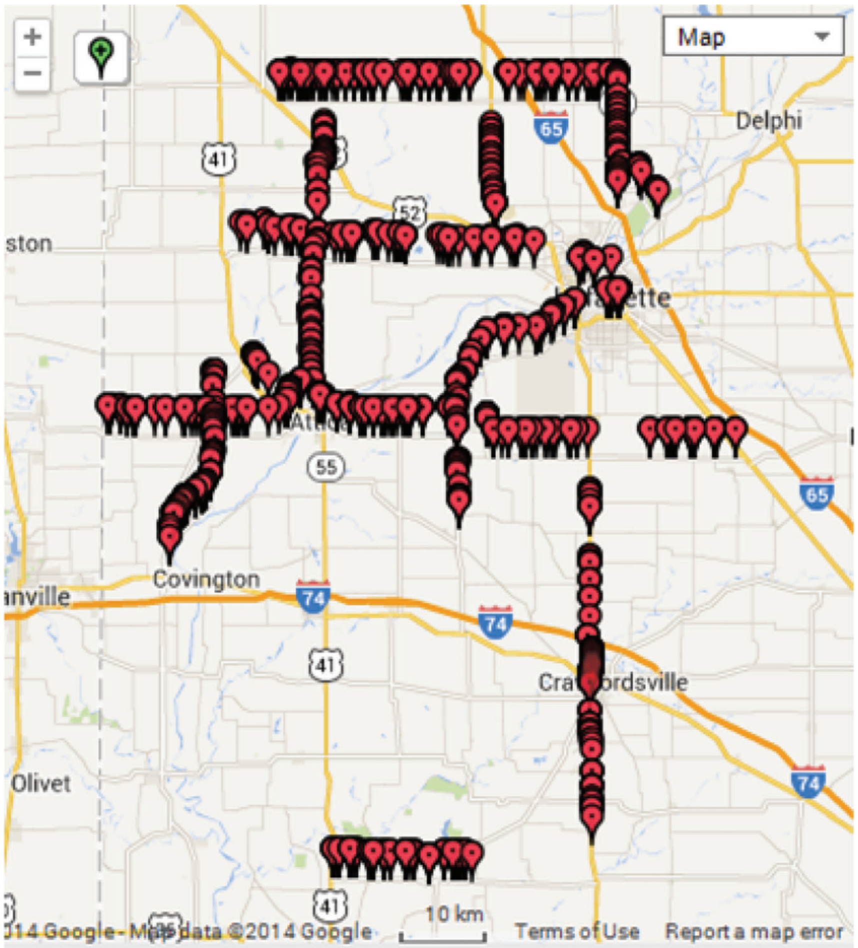


Figure 3.4 Detailed map of all road sections inspected.

4. DATA

4.1 Rating of Culverts

The following information was recorded for each small culvert: mile marker, county, side of road, culvert type, longitude, latitude, culvert length, shape, horizontal span, and comments. Additionally, multiple ratings were assigned to each structure. Ratings were applied to the structure's embankments (both in and out), end sections (both in and out), flow lines (in and out), and condition. A rating for "general condition" was also applied to denote the overall condition of the culvert, taking into consideration each of these elements. "In" denotes the end of the culvert in which water is expected to flow into the pipe. "Out" denotes the end of the culvert in which water is expected to flow out of the pipe. The definitions for each aspect inspected are as follows.

- **Embankment:** The area between the top of culvert and the pavement.
- **End Section:** The headwall, wing walls, and the section of the culvert that is visible without looking inside of it
- **Flow Line:** The quality of the culvert's pathway for water to flow towards a ditch, stream, river, etc.

The original ratings for all road sections were compiled and are shown in Figure 4.1. The ratings given for each of these features were initially based on the FHWA culvert inspection scale which is used by INDOT and can be viewed in Table 4.1.

4.2 Rating of Catch Basins

The only data field in the current inventory worksheet that is relevant for catch basins is the "end section in" because it is the only part of the structure INDOT is required to maintain. The ratings were found to be uniformly positive and there were often no defects within the outside structure.

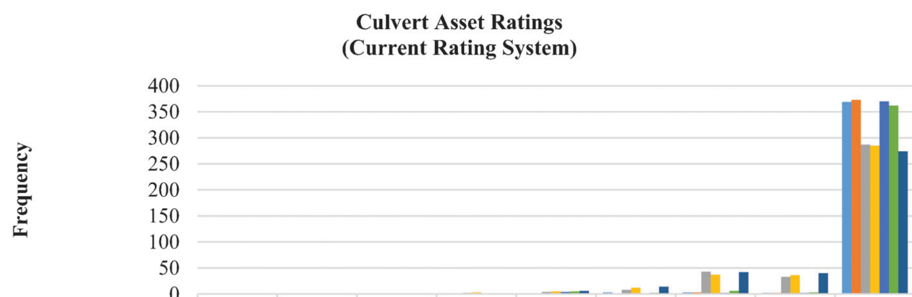
Note that the ratings given for catch basins and small culverts are heavily positive. They were both empirically rated using INDOT's current scale (Table 4.1), which provides little differentiation at the uppermost end of the ratings. Because of the way the scale is currently defined, a large majority of the culverts are being rated as "9," even when minor problems are observed. It is believed that these rankings do not represent the true condition of the culverts. The results of the catch basin ratings can be seen in Figure 4.2.

4.3 Rerating of Culverts

As part of this project, a new rating scale was developed and all previously inspected small culverts were rerated as a means of better portraying the true condition of the culverts. The revised scale is shown in Table 4.2. The new scale was developed to provide clear differentiation between, and to produce a more linear alignment of, culvert conditions. The numbers that were assigned to each rating category still span from 1 to 9, but with fewer categories in between. These numbers were selected to align with the current rating scale in order to facilitate INDOT's prioritization and programming activities. The results of the reassessment can be seen in Figure 4.3.

The charts presented in Figure 4.1b (current rating scale) and Figure 4.3b (proposed rating scale) represent the lowest rating given for each culvert (i.e., if the "flowline in" had a rating of "3" while the other ratings given were higher than "3," the "flowline in" rating of "3" was recorded in the chart). The current rating scale data shows a much larger skew towards higher ratings than that of the proposed rating scale data. Note that if a culvert had multiple attributes with the lowest rating, both were included in the lowest rating charts.

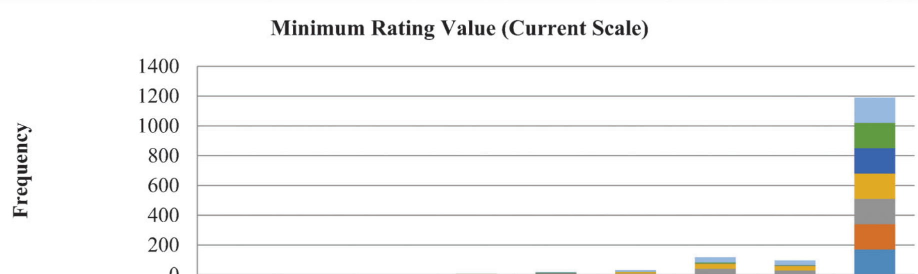
Comparing the revised ratings with the original ratings suggests that the current scale is not providing sufficient information about the condition of the culvert inventory. Under the revised ratings, culverts can more clearly be differentiated between those that are actually in near-perfect condition and those that require some sort of maintenance or increased level of assessment. Without this differentiation between the culvert ratings, INDOT is not collecting the information needed to make informed decisions about culvert maintenance priorities.



	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
Embankment In	0	0	0	1	0	3	3	2	369
Embankment Out	0	0	0	0	0	1	3	2	373
End Section In	0	0	0	2	4	8	43	33	287
End Section Out	0	0	0	3	5	12	37	36	285
Flowline In	0	0	0	0	4	0	2	2	370
Flowline Out	0	0	0	0	5	2	6	3	362
Culvert Condition	0	0	0	1	6	14	42	40	274

Rating

(a) Histogram of culvert ratings given (INDOT's current scale)



	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
Culvert Condition	0	0	0	1	4	12	35	31	170
Flowline Out	0	0	0	0	4	2	6	3	170
Flowline In	0	0	0	0	3	0	2	2	170
End Section out	0	0	0	3	4	10	35	31	170
End Secton In	0	0	0	2	4	6	35	25	170
Embankment Out	0	0	0	0	0	1	2	2	170
Embankment In	0	0	0	1	0	1	3	2	170

Rating

(b) Histogram of lowest rating given per culvert (INDOT's current scale)

Figure 4.1 Histograms of sample culvert data rated by current scale.

TABLE 4.1
Current Rating Scale

9	No repairs needed
8	No repairs needed; list specific items for special inspection during next regular inspection
7	No immediate plan for repair; examine possibility of increased level of inspection
6	By end of next season; add to work schedule
5	Place in current schedule/current season/first reasonable opportunity
4	Priority, current season; review work plan for relative priority, adjust schedule if possible
3	High priority; current season as soon as can be scheduled
2	Highest priority; discontinue other work if required, emergency basis
1	Emergency action required; re-route traffic and close.

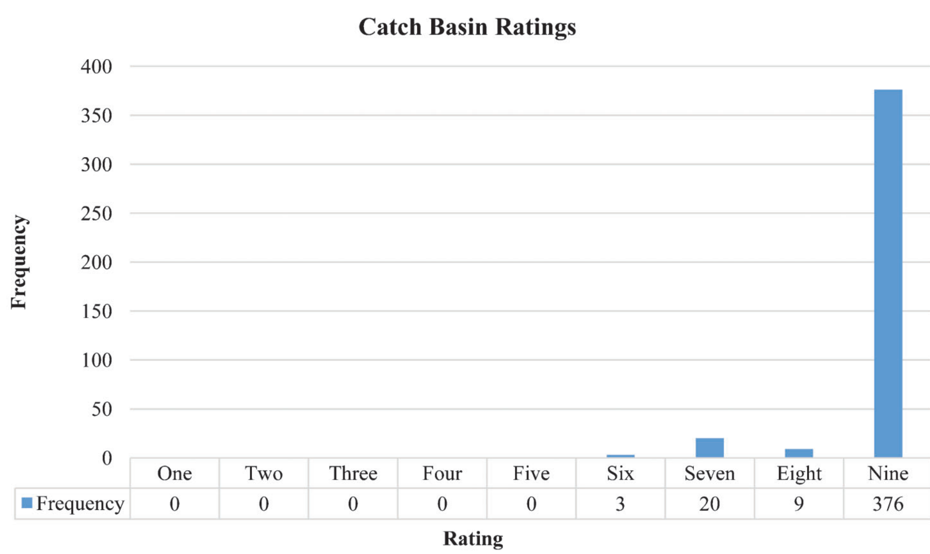
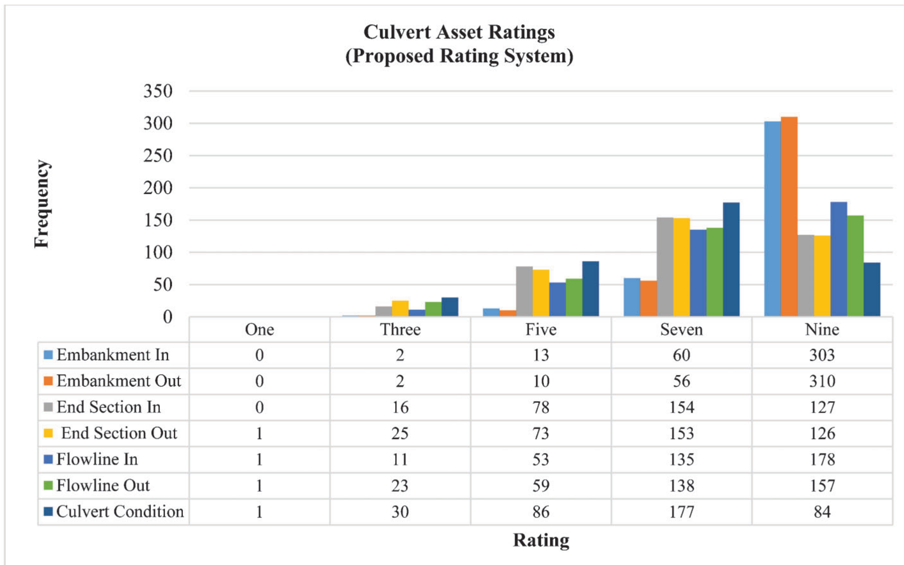


Figure 4.2 Histogram of catch basin data.

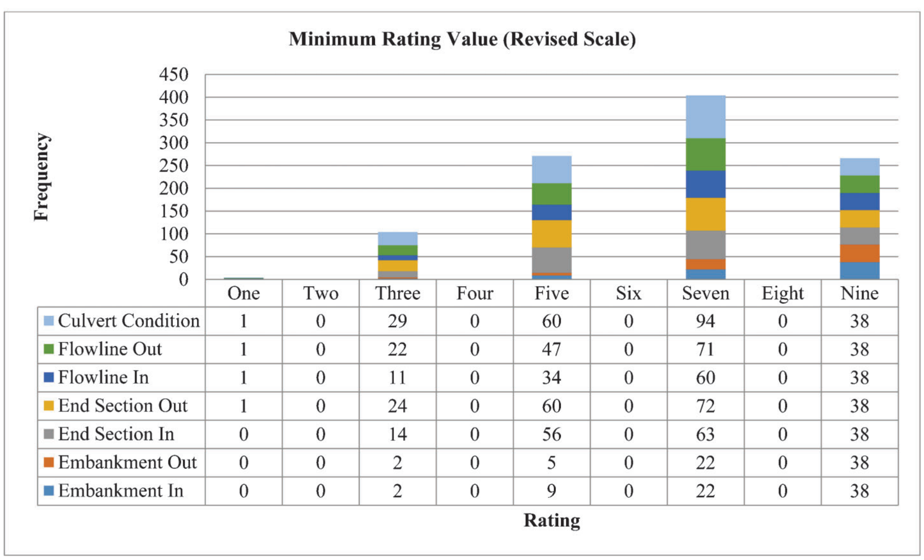
TABLE 4.2
Proposed Rating Scale

Proposed Rating Scale		Re-inspection Frequency
9	**Excellent**: Perfect condition, recently installed or repaired	6 years
7	**Good**: No repairs needed, list specific items to consider for next inspection	4 years
5	**Fair**: Acceptable condition, increase inspection frequency	2 years
3	**Poor**: n danger of failing, needs repair	<1 year
1	**Critical**: Culvert is failing; immediate action needed	Repair plan needed this season
N	**Unknown/Not Found**	Locate culvert or remove from inventory this season



	One	Three	Five	Seven	Nine
Embankment In	0	2	13	60	303
Embankment Out	0	2	10	56	310
End Section In	0	16	78	154	127
End Section Out	1	25	73	153	126
Flowline In	1	11	53	135	178
Flowline Out	1	23	59	138	157
Culvert Condition	1	30	86	177	84

(a) Histogram of culvert ratings given (proposed scale)



	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
Culvert Condition	1	0	29	0	60	0	94	0	38
Flowline Out	1	0	22	0	47	0	71	0	38
Flowline In	1	0	11	0	34	0	60	0	38
End Section Out	1	0	24	0	60	0	72	0	38
End Section In	0	0	14	0	56	0	63	0	38
Embankment Out	0	0	2	0	5	0	22	0	38
Embankment In	0	0	2	0	9	0	22	0	38

(b) Histogram of lowest rating given per culvert (revised scale)

Figure 4.3 Histograms of sample culvert data rated by proposed scale.

5. RECOMMENDATIONS

5.1 Photography Implementation

Although INDOT's current rating system includes detailed descriptions of what each rating means, applying these ratings is still inherently a subjective exercise. This is an issue that is nearly impossible to avoid, as each inspector will have varying opinions of appropriate ratings.

Through the research conducted, it was found that the use of photography to document field conditions can be helpful in reconciling discrepancies. Acquiring photos at the time of field inspection is an easy and useful way to evaluate an asset or to document changes over time (United States Department of Energy, 2003). A minimum of four photos were taken of every small culvert inspected and at least one photo was taken of every catch basin inspected. The addition of these photos to the inspection process requires a minimal amount of additional time per culvert while providing a wealth of information to the inventory database. It is important to note the process for taking these photos, which can be seen in Figure 3.2.

- A wide angle overview photo was taken on each end of the culvert (Figure 3.2a) to note various conditions including the end sections, flow lines, embankments, and cover.
- An inside view photo was taken (Figure 3.2b) to note the condition of the culvert. This photo angle should also be taken on both sides of the culvert.
- Additional photos should be taken of irregular or concerning conditions such as cracks in the pavement above a culvert or signs of flooding, erosion, etc.

One factor considered in determining the appropriate level of photo documentation was the Department of Natural Resources' requirement for including photos when applying for permits. Although it could be useful to take these photos at the time of the culvert inspection, it was determined that it would not be an efficient use of time and resources to do so. The photos required for environmental permits (eight in total) are intended to document features of the broader site surrounding the culvert instead of the culvert itself. The types of photos required for each purpose do not overlap and the additional photos would take up valuable time and data storage without a correspondingly positive benefit.

5.2 Changes to Rating Scale

The current "1–9" rating scale was originally developed to align with inspection rating scales for bridges and large culverts, and the numbers associated with each category are being used for scoring and ranking of projects in capital programming. However, in the case of small culverts, the number of categories and the fact that the scale is nonlinear (Table 4.1) result in inspection information that can be misleading and ratings that do not adequately communicate the severity of the condition they represent. For example, it is difficult to distinguish the difference between a culvert that is rated an "8" and a culvert that is rated a "9" as their descriptions are very similar. Additionally, a culvert with a rating of "5" calls for a repair or replacement in the "current work season at the first reasonable opportunity." However, somebody reviewing the culvert ratings may view a rating of "5" as relatively reassuring as it is located in the middle of the scale. Further, basing the ratings on work schedules is difficult because the budget for culvert maintenance is limited and the ratings may call for unrealistic actions. It is recommended that the current rating scale be replaced with a five-category rating scale that is more straightforward and effective. Because INDOT tends to rely on "1–9" scales for inspections of other assets (including large culverts and bridges), it is recommended that the five-category scale be inflated across "1–9" ratings (Table 4.2) in the interest of uniformity.

The proposed rating scale was used for the reassessment and rating of all previously inspected culverts as shown in Figure 4.3. The intended result of this exercise was reduced biases during the inspection process and a more linear rating system that properly conveys actual asset condition.

5.3 Changes to Small Culvert Inspection Required Fields

Based on the findings of this research, it is recommended that several changes be made to the culvert inspection form to enhance the quality of the information being provided. First, the "general condition" column is not providing useful information for programming and should be omitted from the form. Persons responsible for culvert maintenance will find the element-specific ratings for embankments, flowlines, etc., to be of more value. Second, a recurring issue encountered during data collection was the inability to complete an inspection because of submersion in water or other field conditions that prohibited complete visual inspection. It is therefore recommended that a data field be added to the inspection report to indicate that an inspection was not conducted or is incomplete. This information should then also be transferred into the Work Management System (WMS) to alert database users of the need to revisit and re-inspect that culvert (ideally that same year, after a period of time when conditions are expected to be improved).

5.4 Changes to the Catch Basin Inspection Process and Inventory

Catch basins found within city or town limits on Indiana state roads are to be inspected and maintained by the state, but the pipes found underneath the inlets are to be maintained by the city or town. An INDOT inspector is required to look only at the visible aspects of a catch basin to inspect it. Therefore, only the "end section in" needs recorded, and no measurements need to be taken. This process is much faster than the process needed to inspect small culverts. Moreover, the catch basins are often near each other, traffic in towns and cities can be heavy, and there is often a sidewalk along the highway in these areas. It was found to be more efficient to park the vehicle and walk alongside the highway to conduct these inspections.

The differences between the catch basin and small culvert inspection processes call for each activity being a separate task with a separate inspection form and WMS database. The form (Figure 5.1) is a simplified version of the current small culvert inspection form. Implementing the new, simpler form would create less confusion for inspectors and make the process more efficient. Furthermore, the separate inventory database would allow for easier filtration of the small culvert database.

5.5 Changes to Inspection Frequency

INDOT currently operates under a goal of inspecting each small culvert every four or five years no matter the condition. However, there is currently no formal or systematic process for scheduling the inspections or for entering inspection data into the Work Management System (WMS). Throughout this study it was found that meeting the inspection frequency interval did not seem to be a problem. Rather, there were challenges with systematically integrating the data into business processes and decision making for program culvert repair and replacement.

Proposed Catch Basin Inspection Form

Page_____ of _____

Road:	
Unit:	
Date:	
Inspected By:	
Direction of Travel: Both (All) Inc (N/E) Dec (S/W)	

Condition Key	
9	Excellent - Perfect condition, recently installed or repaired
7	Good - No repairs needed, list specific items for next inspection
5	Fair - Acceptable Condition, Increase Inspection Frequency
3	Poor - Reinspect Next Year, Needs Repair
1	Critical - Culvert is failing; Needs Attention This Year
0	Unknown/Not Found

Shape Key
C - Circular
R - Rectangular

Side of Road Key
R - Right Side
L - Left Side
M - Median

Location Key
R - On Road
C - On Curb
OR - Off Road

X Coordinate (Longitude) 00.00000	Y Coordinate (Latitude) 00.00000	Side Of Road	Location	Shape	Structure Condition	Comments

Figure 5.1 Proposed catch basin inspection form.

A formal process for re-inspecting small culverts on a more frequent basis should be implemented for culverts that do not require immediate action, but display conditions that are expected to become critical within four years. For example, under the proposed rating scale, it is recommended that all culverts with a condition rating of "5" be re-inspected again in two years instead of four (Table 4.2). This could easily be implemented with reports generated from past year's inspection reports. Note that the suggested frequency for re-inspection should be adjusted to fit INDOT's target of inspecting 20–25% of the small culvert inventory per year. The frequency intervals should be reviewed periodically and modified as necessary.

Another factor to consider is that staff time could be optimized by loosely coordinating inspection activities around vegetation management activity (i.e., mowing, herbicide, brush clearing) schedules. Identifying and accessing culverts is much easier when vegetation management activities have been recently performed on roadsides and ditches and will greatly reduce the risk of overlooking hidden culverts. It is also important to consider road construction activities as they may restrict inspections from being completed.

5.6 Changes to Inventory Database

A key to improving and optimizing the culvert inspection process is to capture data and produce information that will facilitate management-level decisions regarding maintenance. The process begins with the field inventory and assessment and concludes when that data is entered into WMS. At present, the information in WMS is often perceived to be unreliable and incomplete. Maintenance and capital programming decisions therefore do not appear to be informed by the field data that is being collected.

In order to facilitate transfer of field data to WMS, several modifications are recommended to the process. It is important to keep up to date records of all small culverts to minimize dangerous failure scenarios as well as to reduce the cost of replacing culverts that could have been repaired at a much lower cost.

As observed throughout the study, the current method for entering the inspections into the WMS database is not a simple one step process. Although reformatting the WMS database is outside the scope of this research, the following future changes to the development of a reliable inventory are recommended.

- It is essential for every small culvert in the state to have a unique identifier code. Physically etched identifiers or electronic identifiers for each small culvert could eliminate confusion and help in the organization of the inventory. This would also reduce the number of culverts that become buried and lost in the field.
- Not all fields of the inspection form should be required for each inspection. Keeping the identifying fields static (for example, size, type, length will not change) and changing only the condition ratings themselves will greatly reduce the time required for each inspection. It is important to note that this cannot be done within the current WMS system. To update the current inventory, the previous entry for a culvert must be deleted and replaced, and only limited users at INDOT have these permissions to take this action. With the technology that is readily available today, this process can be improved upon.
- The use of offline tablets for field inventory applications would streamline the overall culvert inspection process. Numerous database tablet applications exist that could allow an inspector to update the culvert database directly from the field in real time. Most tablets have GPS capabilities, built-in cameras, and the ability to connect to the internet through cellular networks or Wi-Fi. It is believed that moving away from the current Access database and handwritten sheets will provide a more accurate database as well as a significant increase in productivity. Tablets have the potential to tie in seamlessly with a GIS database, which also tends to be a very powerful tool for asset management.

5.7 Proposed Dedicated Staff

Finally, it is recommended that dedicated and trained staff be assigned to conduct culvert inspections. Currently the job is spread among many people, not all of whom have consistent training in field inspection practice. Personnel that are trained and experienced in the completion of small culvert inventory and inspection will be able to work quickly and efficiently with few distractions. It would be beneficial to have all culvert inspection personnel undergo the same formal training. This would further reduce subjectivity and variation in the rankings. Hiring summer interns for this task may be a cost effective alternative to having INDOT employees conduct the inspections. This would free INDOT maintenance employees to conduct more urgent jobs and tasks without interruption. One team of two inspectors could accomplish approximately 40 inspections per day or approximately 2,000 inspections over a 10-week internship. The production of training videos may be a useful tool for INDOT as the use of interns would require an annual training session.

6. CONCLUSION

Small culverts are important assets that are not always given sufficient priority in the scheduling of inspection and maintenance activities. By implementing any of the above recommendations, INDOT can reduce the risk of culvert failure while saving time, effort, and revenue. All recommendations are intended to facilitate decision making at the management level, providing better information and more informed maintenance programs.

Once a more reliable database is formed and maintained, previous records can be used to track changes in individual culvert quality, and further research can be conducted regarding small culvert maintenance in Indiana including lifespans of culvert materials, problematic locations, and inspection frequency (New York State Department of Transportation, 2006).

REFERENCES

Arnoult, J. D. (1986). *Culvert inspection manual* (Publication No. IP-86-2). Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

Bhattachar, D. V. (2007). Development of an asset management model for culvert inventory and inspection. East Lansing: Michigan State University.

Environmental Protection Agency. (2000). Culverts. In *A guideline for maintenance and service of unpaved roads*. Washington, DC: Author.

Indiana Department of Transportation. (2012). *Preservation initiative policy statement*. Indianapolis, IN: Author.

Indiana Department of Transportation. (2013). *Work performance standard: 2320*. Indianapolis, IN: Author.

New York State Department of Transportation. (2006). *Culvert inventory and inspection manual*. Albany, NY: Author.

United States Department of Energy. (2003). *A case study of selected photographic inspection techniques for a transparency regime*. Richland, WA: Pacific Northwest National Laboratory.

About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,500 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at: http://docs.lib.purdue.edu/jtrp

Further information about JTRP and its current research program is available at: http://www.purdue.edu/jtrp

About This Report

An open access version of this publication is available online. This can be most easily located using the Digital Object Identifier (doi) listed below. Pre-2011 publications that include color illustrations are available online in color but are printed only in grayscale.

The recommended citation for this publication is:

Bowers, J. D., Magers, S. R., Pyrz, J., & Bullock, D. M. (2014). *Processes of small culvert inspection and asset management* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2014/08). West Lafayette, IN: Purdue University. http://dx.doi.org/10.5703/1288284315502