



GRESHAM
SMITH AND
PARTNERS

Cost Benefit Analysis

For Culvert Replacement

Katie Nolan, P.E.
Gresham Smith

Background

ODOT Culvert Inventory

- 82,660 culverts and storm sewers (9/18/2015)
- Joint effort with the 12 ODOT Districts, Office of Structural Engineering and consultant teams

The image displays two versions of the ODOT Culvert Inventory Report form, CR-66 05-13 and CR-67 05-13. Both forms are titled 'STATE OF OHIO DEPARTMENT OF TRANSPORTATION CULVERT INSPECTION REPORT'. They contain various fields for data entry, including:

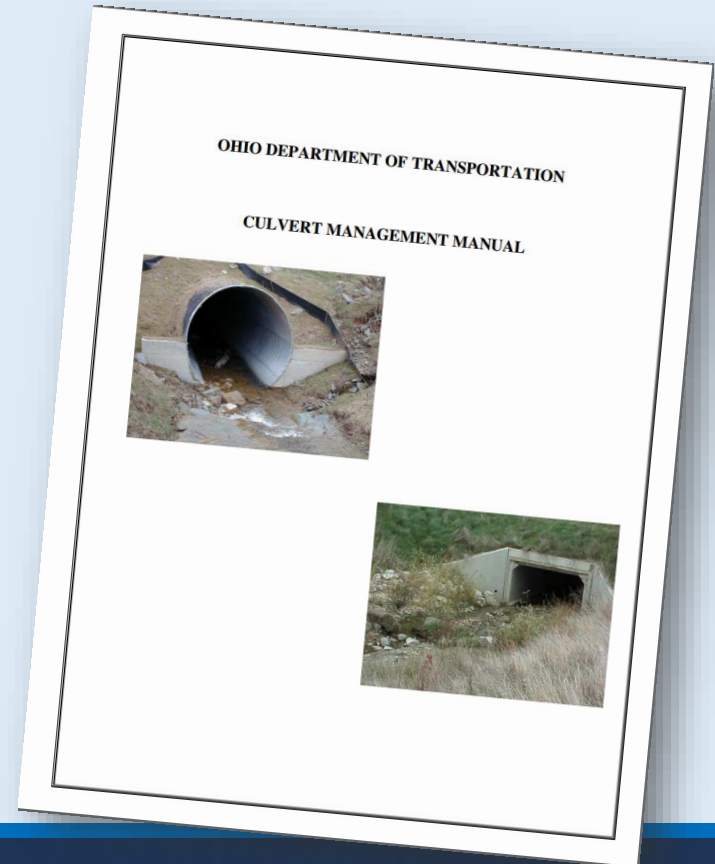
- CR-66 05-13:**
 - 1. Entry Class
 - 2. District
 - 3. County
 - 4. Route
 - 5. Straight Line Mileage
 - 6. Longitude
 - 7. Maintenance Responsibility
 - 8. Road ID
 - 9. Feature Intersection
 - 10. Year built
 - 11. Shape
 - 12. Span (m)
 - 13. Length (ft)
 - 14. Rise (m)
 - 15. Slope (m) / Wall Thickness (m)
 - 16. Inlet End Treatment
 - 17. Maximum Height of Cover (ft)
 - 18. Year Modified
 - 19. Modification Size (in.)
 - 20. Year Extended
 - 21. Material
 - 22. Extension Length (ft)
 - 23. Year Extended
 - 24. Material
 - 25. Extension Length (ft)
 - 26. Year Extended
 - 27. Material
 - 28. Extension Length (ft)
 - 29. Year Extended
 - 30. Material
 - 31. Shape
 - 32. Span (m)
 - 33. Rise (m)
 - 34. Slope (m) / Wall Thickness (m)
 - 35. Design Discharge (cfs)
 - 36. pH
 - 37. Channel Protection (Outlet)
- CR-67 05-13:**
 - 1. Entry Class
 - 2. District
 - 3. County
 - 4. Route
 - 5. Straight Line Mileage
 - 6. Longitude
 - 7. Maintenance Responsibility
 - 8. Road ID
 - 9. Feature Intersection
 - 10. Year built
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 - 27. Material
 - 28. Extension Length (ft)
 - 29. Year Extended
 - 30. Material
 - 31. Shape
 - 32. Span (m)
 - 33. Rise (m)
 - 34. Slope (m) / Wall Thickness (m)
 - 35. Design Discharge (cfs)
 - 36. pH
 - 37. Channel Protection (Outlet)

Both forms include a 'GENERAL APPRAISAL & OPERATIONAL STATUS' section with checkboxes for 'Good', 'Fair', 'Poor', and 'Very Poor'. They also have a 'COMMENTS' section for additional notes and a 'DATE' field for the inspection date.

Background

ODOT Culvert Inventory

- Culvert Management Manual provided guidelines for conducting the inventory
- Any structure with span < 10 feet
- Provides detailed information on:
 - Location
 - Length, Depth and Material
 - End Treatment Type
 - Condition Ratings



Background

ODOT Research

- When is it recommended to use the open cut or trenchless techniques?
- When do we hire a contractor and when do we use ODOT's work force?
- Becoming proactive instead of reactive!



Goals and Objectives

Cost Benefit Analysis (CBA)

- Develop an assessment tool to evaluate culverts with each method
- Recommend a preferred methodology for culvert replacement by culvert/by District
- Develop a recommendation as to whether ODOT should purchase equipment based on the CBA
- Provide a Fact Sheet to ODOT that clearly presents the results and recommendations

Cost Benefit Analysis - CBA

Cost Benefit Analysis Process

Step 1 – Fatal Flaw Analysis

Step 2 – Preferred Method Analysis

Step 3 – Results

Step 4 – Recommendations

Cost Benefit Analysis - CBA

Replacement methods limited to:

Open Cut

Pipe Bursting
(PB)

Horizontal Auger
Boring (HAB)

Step 1 – Fatal Flaw Analysis

ID and confirm criteria

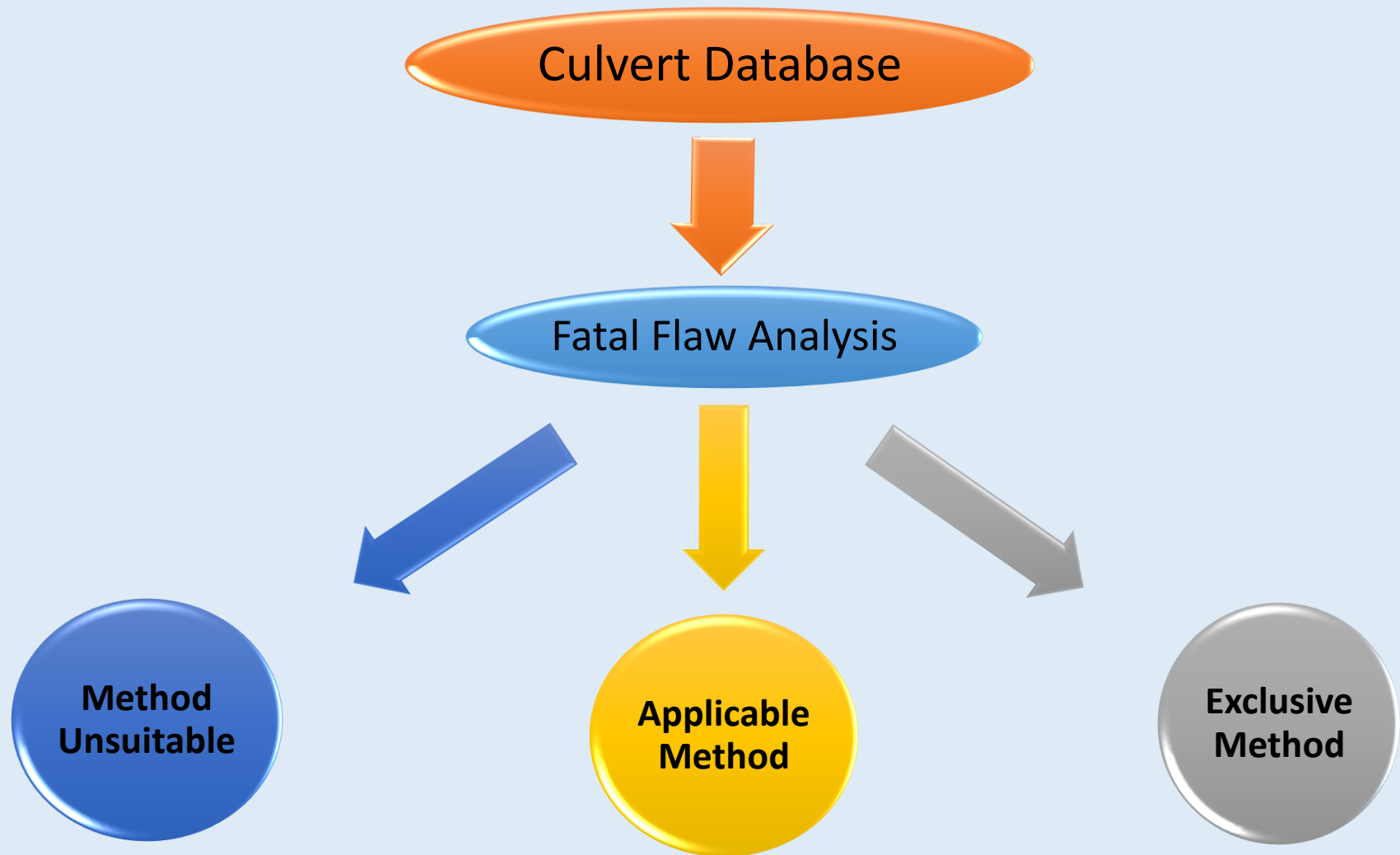
- Detailed investigation of the database items
- Determine items that would provide a potential comparison point
- Determine criteria to evaluate each item for the three replacement methods
- ID errors/missing information in the database

Step 1 – Fatal Flaw Analysis

Factors used in the analysis:

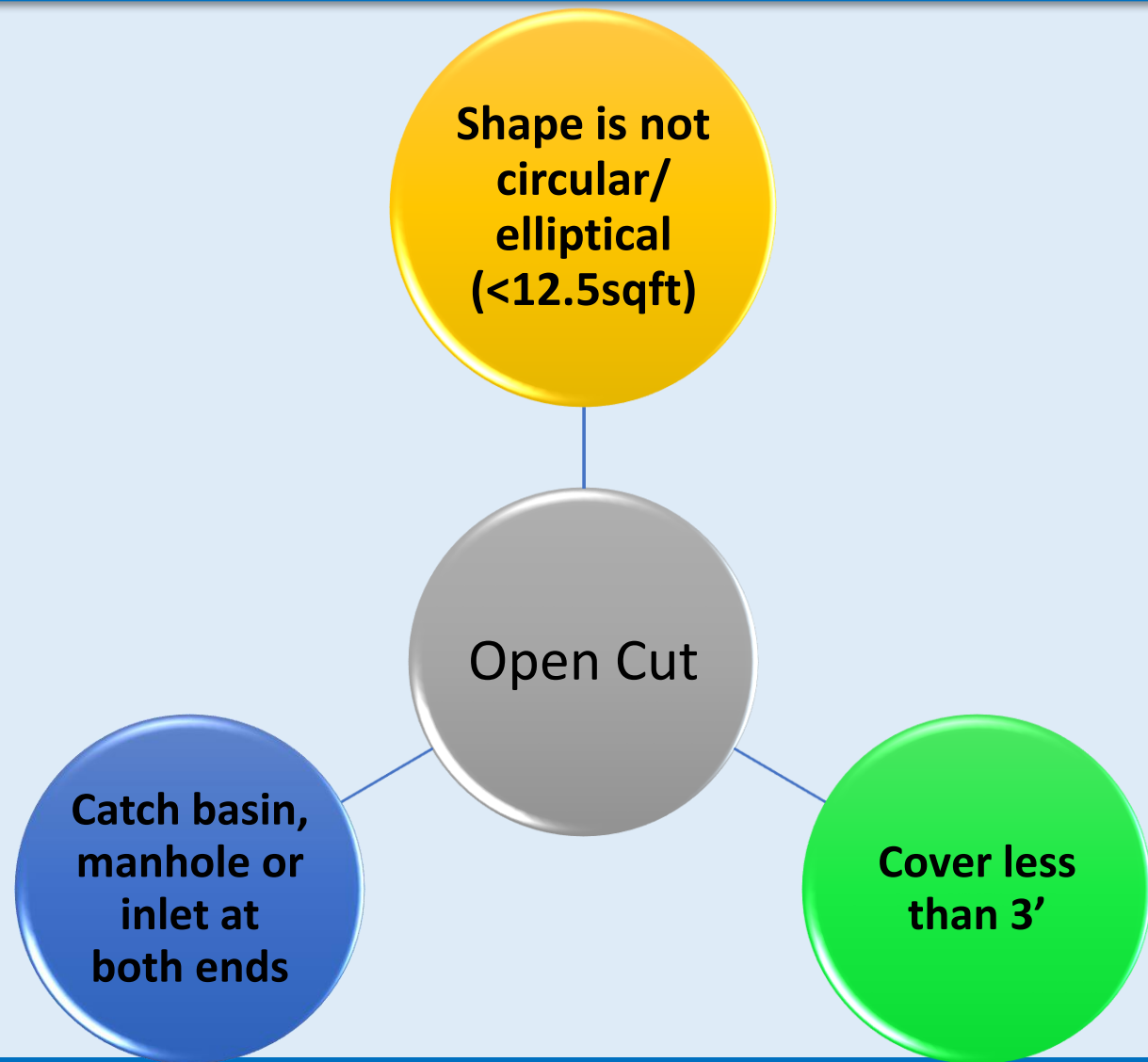
- Culvert shape
- Maximum height of cover
- Culvert size
- Length
- Culvert material
- Seams or joints
- Culvert alignment
- End treatment inlet and outlet
- Roadway classification

Fatal Flaw Analysis



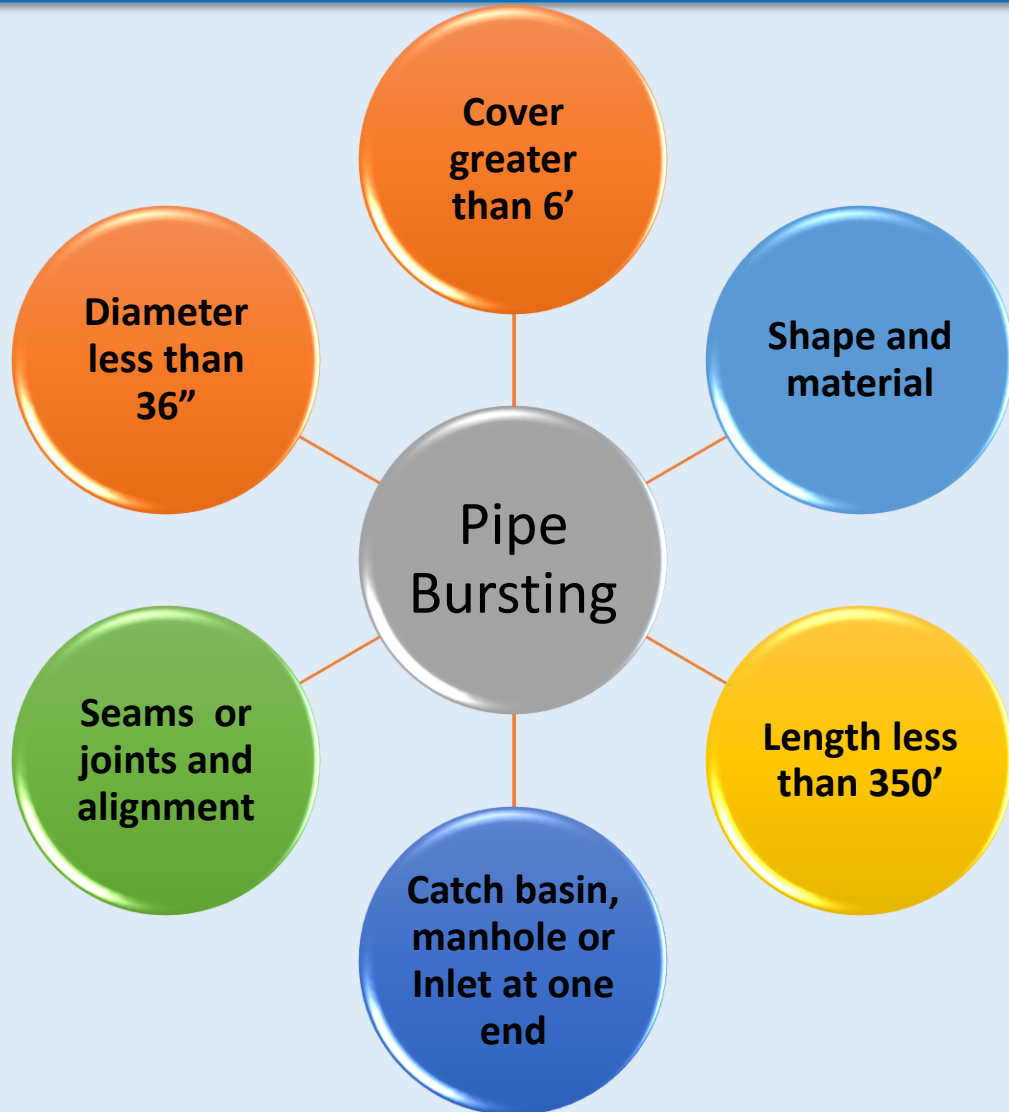
Fatal Flaw – Database Factors

Open Cut



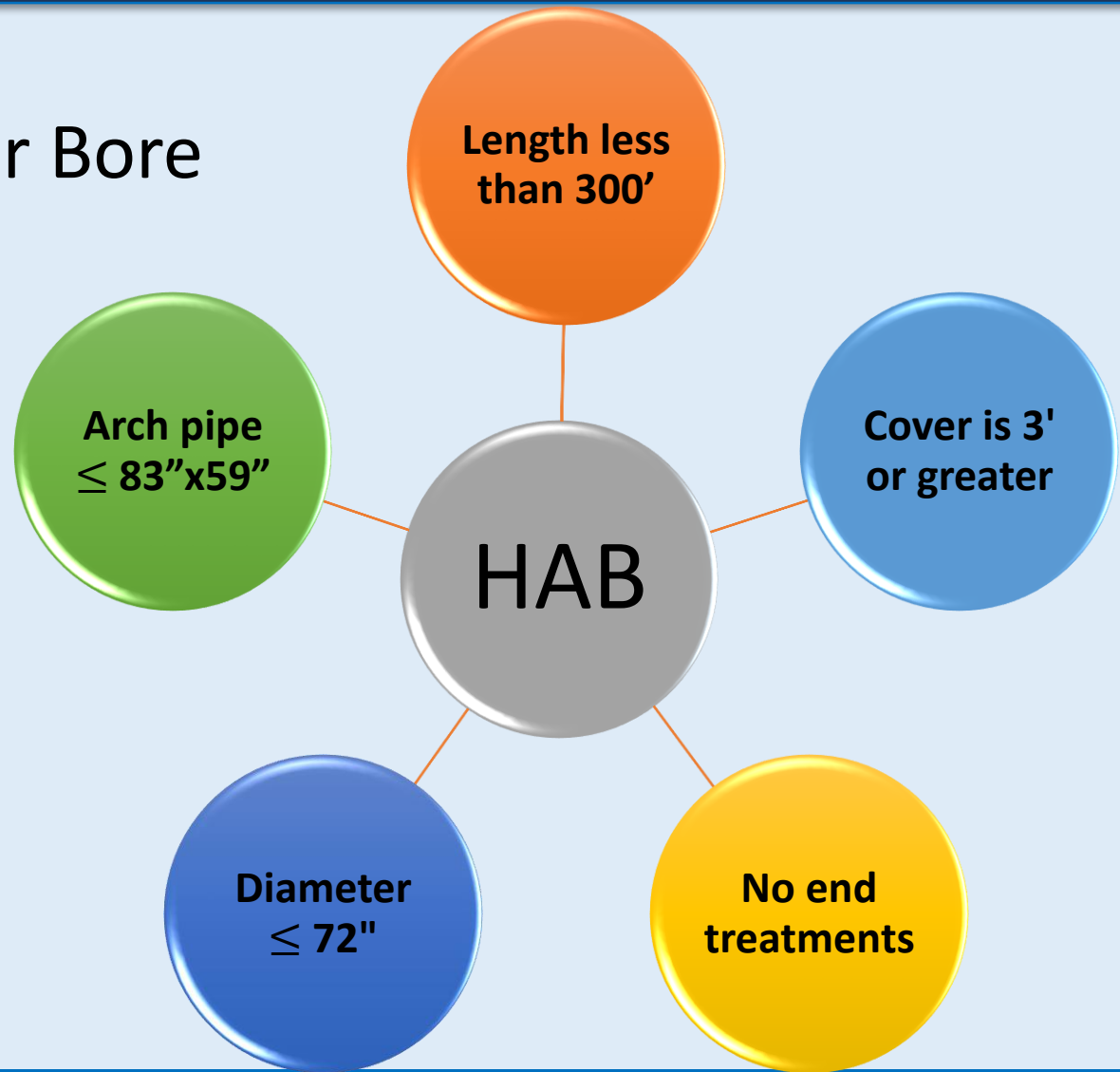
Fatal Flaw – Database Factors

Pipe Bursting



Fatal Flaw - Database Factors

Horizontal Auger Bore



Fatal Flaw Results

The Fatal Flaw analysis is intended to identify the culverts that are exclusive for one method.

The culverts that are exclusive to one method are removed from further consideration.

Exclusive Method

Open Cut

- 30,226
- 36.6%

Open Cut – Not Preferred (IR/US route)

- 13,859
- 16.7%

Pipe Bursting

- 1,006
- 1.2%

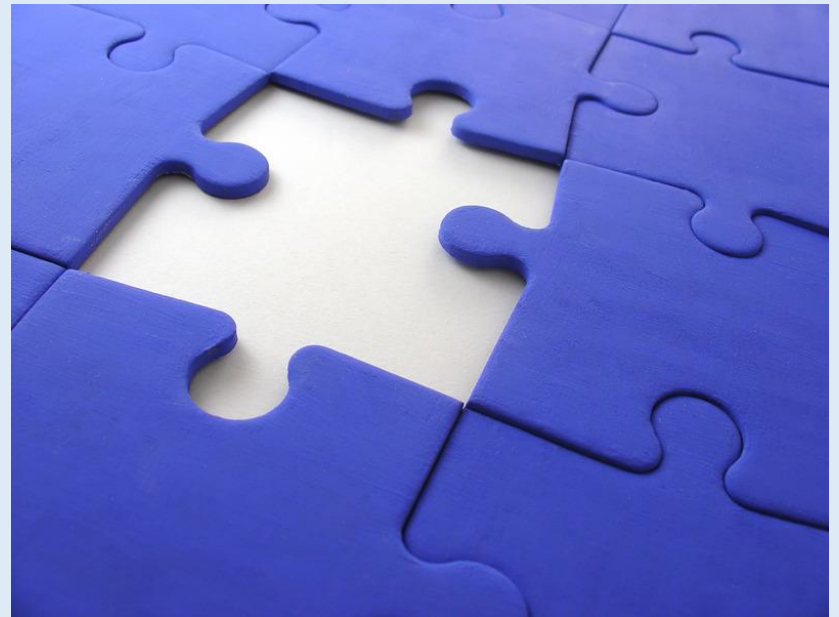
HAB

- 8,727
- 10.6%

Errors/Missing Data

A significant portion of the culvert attribute data was missing or had errors

- Shape – 798 missing (786 were assumed to be round if the span dimension was provided or the span = rise)
- Height of cover – 16,349
- Length – 3,029
- Material – 738
- Seams or joints – 13,714
- Culvert alignment – 11,210
- End treatments – 15,553



Step 2 – Preferred Method Analysis

Detailed comprehensive comparison of methods by using characteristics in culvert database:

- Seams or joints
- Channel alignment
- Culvert alignment
- Inlet end treatment
- Outlet end treatment

Step 2 – Preferred Method Analysis

Pair Wise Comparison

- Each criterion is compared individually with the other criteria

Value	Significance
9	Absolutely more important
7	Strongly more important
5	Moderately more important
3	Weakly more important
2	Slightly more important
1	Equally important
1/2	Slightly less important
1/3	Weakly less important
1/5	Moderately less important
1/7	Strongly less important
1/9	Absolutely less important

Pair Wise Comparison

	Seams or Joints	Channel Alignment	Culvert Alignment	Inlet and Outlet End Treatment	Geometric Mean	Normalized Weight
Seams or Joints	1	5	1	1/3	1.136	0.26
Channel Alignment	1/5	1	1/5	1	0.447	0.10
Culvert Alignment	1	5	1	1/3	1.136	0.26
Inlet and Outlet End Treatment	3	1	3	1	1.732	0.39
Sum					4.452	1.00

Pair Wise Comparison Results

Replacement Method

Open Cut
(OC)

- 407

Pipe
Bursting
(PB)

- 19

HAB

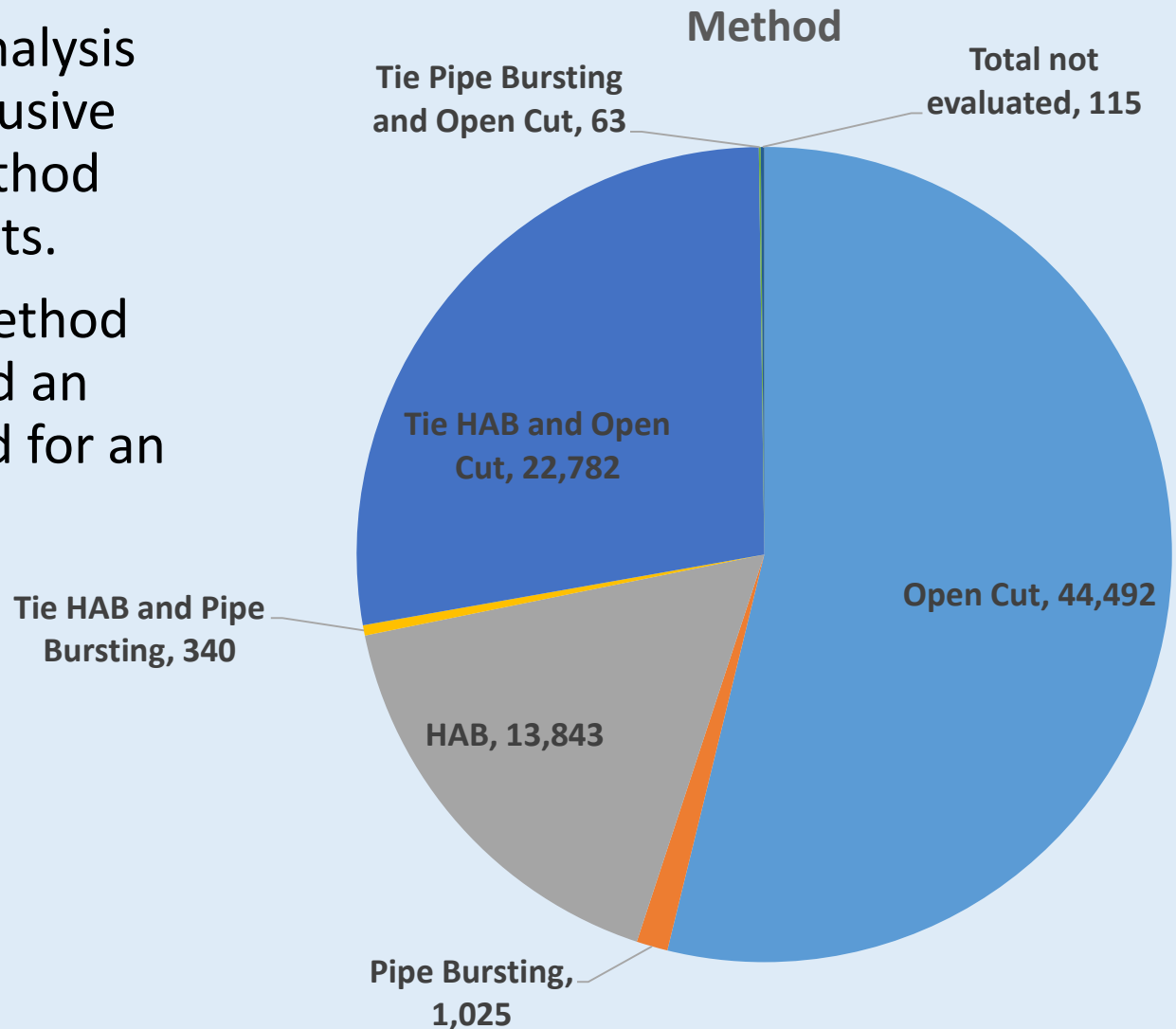
- 5,116

TOTAL

- 5,542

Step 3 – Results

- The Fatal Flaw analysis indicated an exclusive replacement method for 53,818 culverts.
- The Preferred Method analysis indicated an exclusive method for an additional 5,542 culverts.



Step 4 – Recommendations

ODOT District	# of Culverts Per Replacement Method					
	Horizontal Auger Boring	Pipe Bursting	Open Cut	Open Cut not preferred US/IR	Method Ties	Not Evaluated
District 1	929	136	2,679	1,462	1,121	0
District 2	419	22	2,970	1,514	681	0
District 3	1,517	128	1,780	729	2,412	9
District 4	875	181	2,309	1,671	1,686	26
District 5	1,628	156	2,725	859	2,977	27
District 6	903	71	1,399	1,903	1,461	15
District 7	1,191	78	3,450	1,719	1,356	2
District 8	1,825	43	2,209	1,001	1,569	17
District 9	1,868	83	3,500	1,242	3246	2
District 10	1,416	77	5,376	430	4,297	9
District 11	973	46	1,708	639	2,149	8
District 12	299	4	528	690	230	0
Total Number of Culverts	13,843	1,025	30,633	13,859	23,185	115

Transferability



Transferability

How Would Transferability Work?

- Do you have asset data?
- Do you know what to do with or how to use asset data?
- The concept/approach can be used on all asset data sets!

**Goal is to work with and maximize
existing asset data sets.**

Questions/Discussion

Katie_Nolan@gspnet.com

513.619.4631

Thank You!