Making it Last

Additional Considerations for Large Drainage Structures

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Two Roadway Drainage Engineers Responsible for:

- Chapter 13 of the FDM.
- CMM, Standard Detail and Standard Specifications Revisions Related to Culverts and Storm Sewer Items
- Technical Assistance for Projects
  - SDD's, FDM, CMM, STSP's, SPV's and CD Creation and Questions
  - Design Reviews when Requested
  - Existing Drainage Issues
  - Special Projects – Liners, Trenchless Technologies
  - Aquatic Organism Passage
- Training
- Represent Department in Interagency Permit Issuance

Environmental Services Section Responsible for:

- FDM Chapters 10,21,22 and 24
- Technical Assistance for Projects
  - Wetland Impacts, Mitigation and Banking
  - Endangered Species, Species of Concern
  - Hazardous Materials
  - Aquatic Organism Passage
  - Erosion Control and Stormwater Quality
- Training
- Represent Department in Interagency Permit Issuance
- Interagency Agreements

WisDOT Full AOP Accommodation

- Focus on High Quality Waterways
  - Outstanding and Exceptional Water Resources (ORW/ERW)
  - Areas of Special Natural Resource Interest (ASNRI)
  - Priority Navigable Waters (PNW)
  - Presence of aquatic threatened or endangered species
  - Significant trout stream/fishery water
  - Particular, site-specific conditions, not listed above, but identified by WDNR with written justification

Upsizing Drainage Structures for Stream Connectivity and Resiliency Can Be Costly

Make the Investment Last by Considering:

- Appropriate Hydrology and Hydraulics
- Scour
- Soil and Water Chemistry
- Stream Stability/Abrasion
- Materials/Protective Coatings
- Installation Practices
- Experienced Design Professionals

AOP COMPARISON

Table 1. Comparison of AOP Culvert Sizing Methods and Costs

Highway	Water Body	Existing Culvert Size	Standard HDS 5 Design Size	HDS 5 Size Increase -vs- Existing	HDS 5 Project Cost[1]	HEC 26 Size	HEC 26 Size Increase -vs- HDS 5	HEC 26 Project Cost[1]	HEC 26 Cost Increase -vs- HDS 5	Stream Simulation Size	Stream Simulation Size Increase -vs- HDS 5	Stream Simulation Project Cost	Stream Simulation Increase -vs- HDS 5
STH 13	Saxine Creek	Circular 8.0' dia.	Circular 8.5' dia.	13%	$212,200	Circular 12' dia.	99%	$303,400	$91,200 (43%)	Circular 16' dia.	254%	$489,100[2]	$276,900 (131%)
STH 21	White River	Circular 6.0' dia.	Circular 6.5' dia.	17%	$549,100	Box 12'X7'	153%	$685,700	$136,600 (25%)[5]	26.5 ft long bridge[4]	672%	$910,400[2]	$361,300 (66%)[5]
STH 67	Unnamed Trib. to Long Lake	Circular 1- 3' dia. 1- 2' dia.	Circular 4' dia.	23%	$148,700	Arch 8.59' x 5.92'	218%	$182,700	$34,000 (19%)	Box 11'x7.5'	557%	$287,000[3]	$138,300[3] (48%)

Notes:
1. Estimated Cost based on bid results at the time of letting adjusted to 2018 dollars.
2. Based on actual WisDOT construction costs for USFS sized culvert adjusted to 2018 dollars.
3. Based on actual WisDOT project bid results from May 2017 letting.
4. Included accommodations for terrestrial organism passage
5. Percent increase is lowered by substantial cost of traffic accommodation for all options and water diversion for culverts

- Structure size increased 200% to 600% and cost increased 48% to 131% for large AOP structures when compared to traditional culvert design.

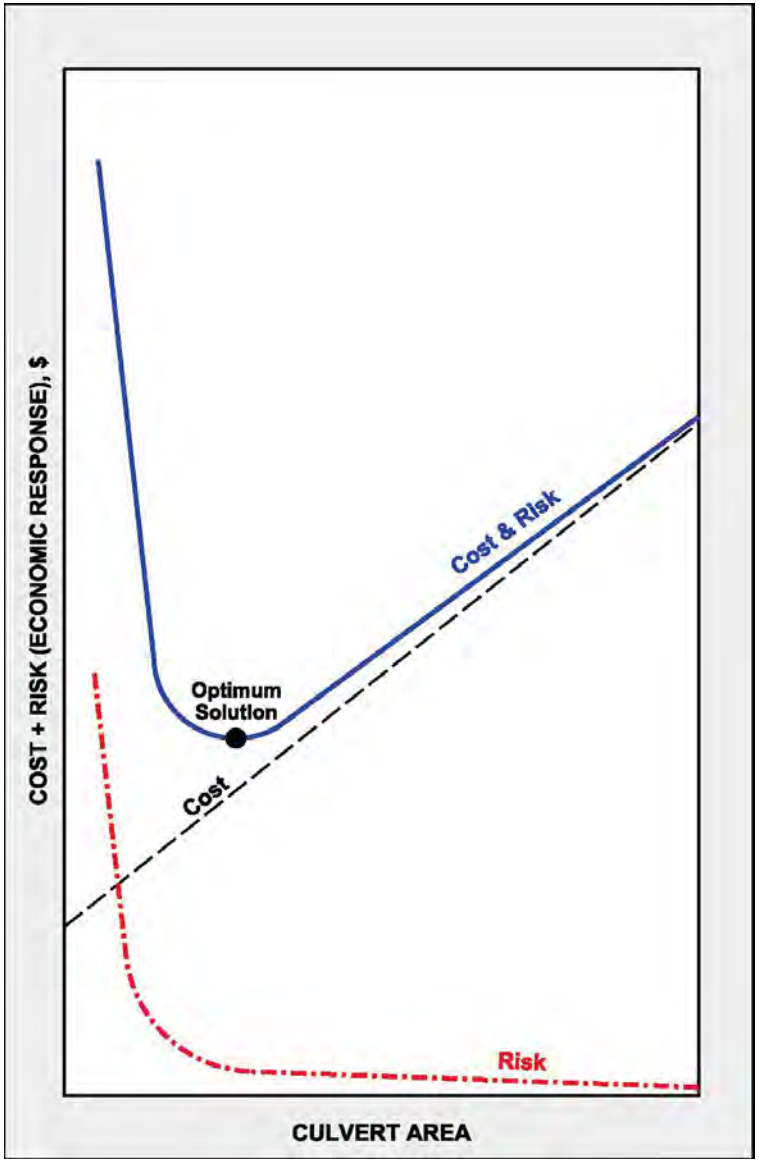
Hydrology and Hydraulics

Sizing a Culvert using full bank width, HEC 26 or other stream simulation methods does not absolve the designer or owner from meeting other Federal, State or local standards for sizing. Some additional considerations include:

- Hydrologic Methodology
- Design Event(s) Selection
- Risk and Resilience
- Floodplain Concerns
- Drainage Districts
- Scour

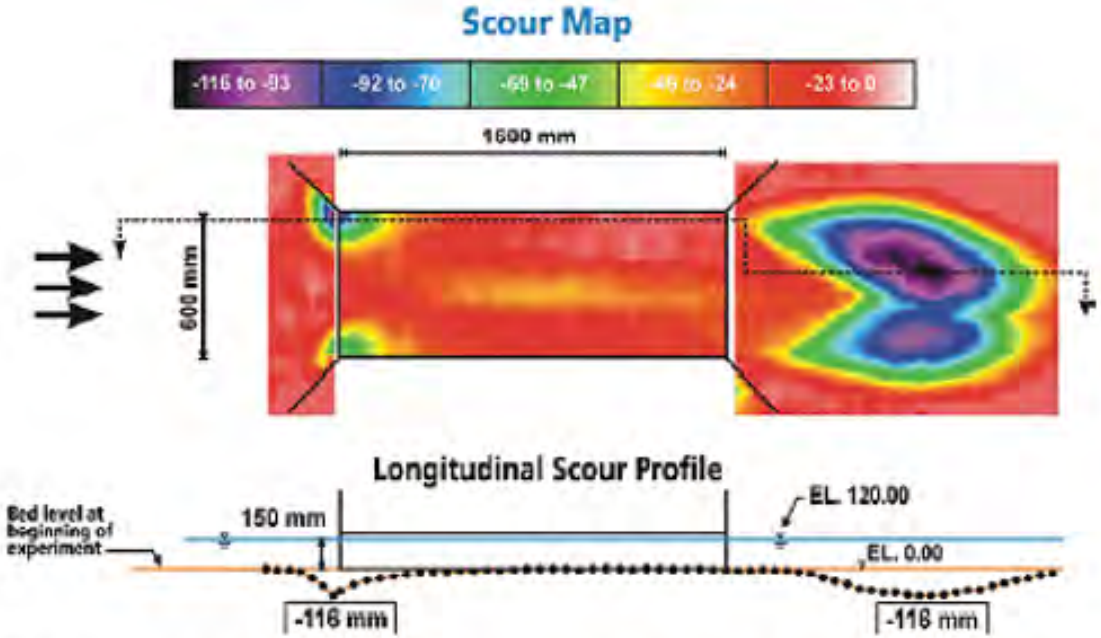
Hydrology and Hydraulics

- For large structures FHWA advises a risk analysis process. FHWA's HEC 17 *Highways in the River Environment-Floodplains, Extreme Events, Risk, and Resilience* was revised in 2016 and is a resource.



Scour

- Don’t Ignore Scour with Three Sided Structures



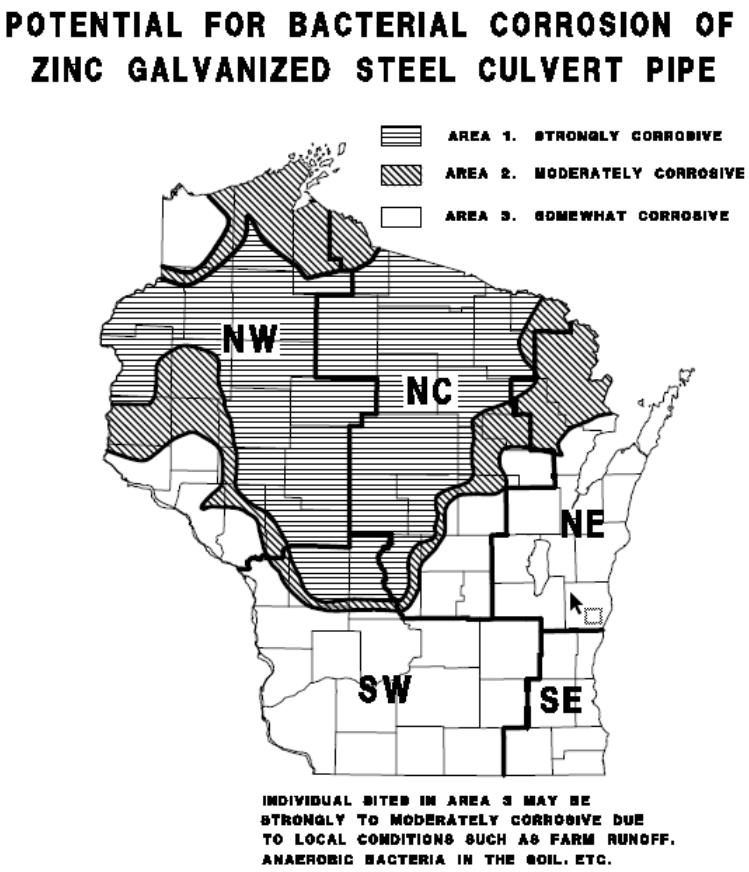
This scour map and profile for a bottomless culvert with wing walls show that the deepest scour (darkest shading) was observed at the upstream corners and downstream of the culvert outlet. *Source: FHWA*.

Scour

- WisDOT does allow three-side box culverts but the design must follow WisDOT's Bridge Manual and consider:
  - H&H
  - Scour Risk
    - HEC 18
    - NCHRP Scour Methodology
  - Foundation Design
    - Driven Piles
    - Sheet Pile Scour Protection
    - Spread-Footings
  - Cost/Geometry/Safety

Source: Gibson Associates

Soil and Water Chemistry



Soil and Water Chemistry

Metal Pipe Considerations

- pH = 5 to 10
- Resistivity ≥ 3000 ohm-cm for steel, ≥ 1500 ohm-cm for aluminum
- Chlorides ≤ 100ppm
- Don’t forget water chemistry can change (stagnant/ standing water, agricultural practices

Stream Stability / Abrasion

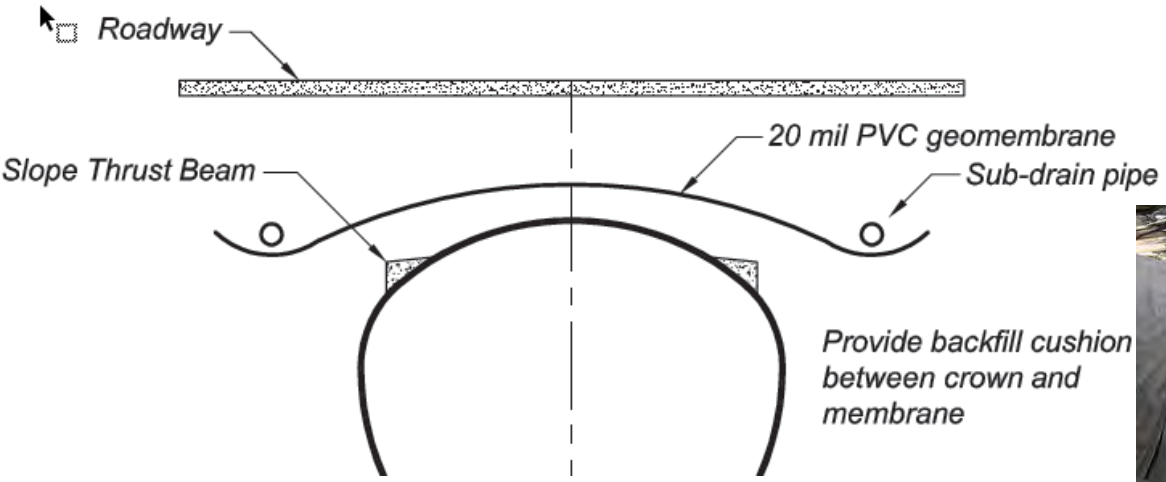
- Considering stream stability is important for determining foundation design, scour, headcutting, perching, and abrasion potential.

Source:TRB

Source:NHDOT

Materials to Enhance Service Life

- Consider protective membranes for road salts, especially for aluminum structures



Source:Contech

Source:AIL

Materials to Enhance Service Life

- Polymer Coating - WisDOT Standard Specification 521

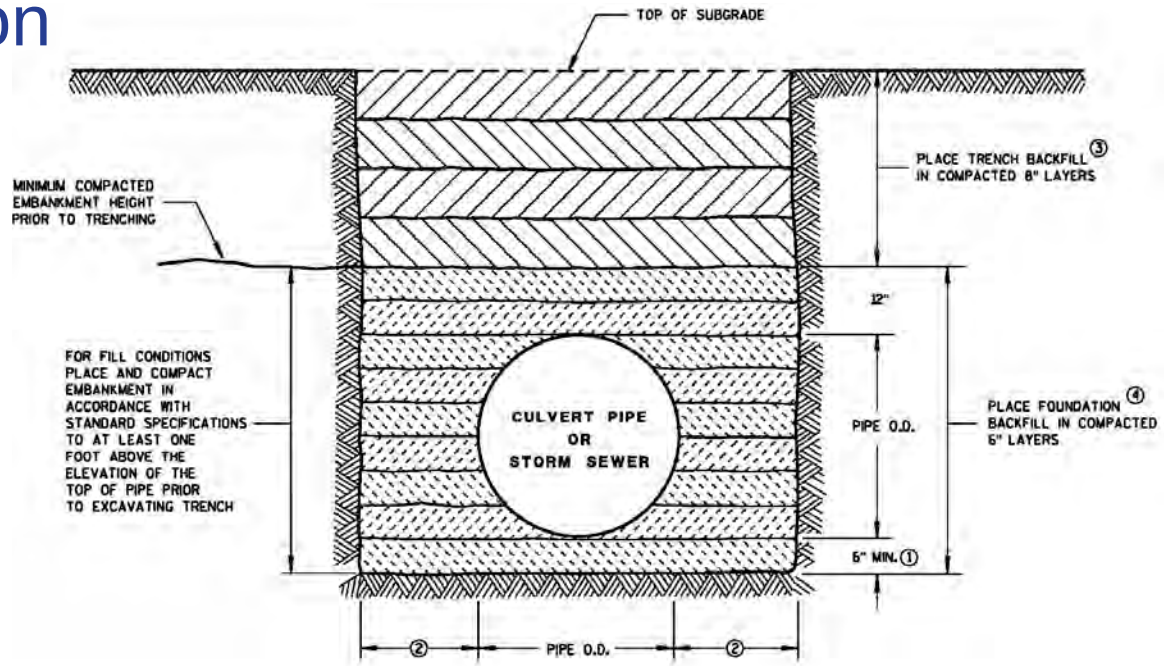
Materials to Enhance Service Life

- New Materials – Steel Reinforced Polyethylene

Photos Courtesy of Contech

Quality of Installation

- Site Soils and Groundwater Characteristics
- Proper Backfill
  - Onsite Backfill Versus Import
- Proper Compaction



Quality of Installation

Conclusion

- Culverts Designed for Stream Connectivity and Resiliency are a Significant Investment
- Durability of Materials will Impact Service Life
- Design Considerations, Quality of Installation and Maintenance Have an Even Greater Impact
- The Owner has a Significant Role in Service Life

Thank You