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Road-Stream Crossing Design Manual Training

March 2022

Source: Massachusetts EOEEA

Rhode Island Stream Crossings

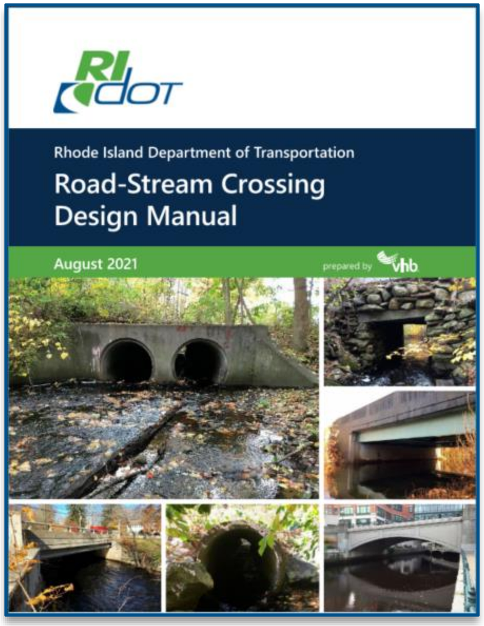
- Approximately 3,578 miles of riverine ecosystems in Rhode Island
  - Currently an estimated 4,300+ road and railroad crossings affecting Rhode Island streams.
  - Many crossings do not allow for the natural movement of water, sediment, and migratory species due to poor hydraulic and ecological design.
- Common problems at existing crossings
  - Clogging, high or low velocities, perched crossings, ponding or flooding, scour, undersized and unnatural or no bed material.


Example of perched crossing


Example of undersized crossing

Purpose of the Manual

- Provide specific standards for Rhode Island streams
- Required for all RIDOT-owned road-stream crossings
    - Strongly encouraged for other RI state agencies, municipalities, regulators, and stream crossing designers
- Avoid "in-kind" replacement with more holistic approach
    - Enhance aquatic organism passage ("AOP") and stream continuity
    - Provide safer, cost-effective, low maintenance, and resilient stream crossings



Development of the Manual

- Literature Review
  - VHB team reviewed 30+ documents on industry standards, state guidance, and the most recently available research.
- Stakeholder Meetings
  - Members from EPA, National Marine Fisheries Service, National Park Service, RI Coastal Resources Management Council, RI Department of Environmental Management, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service.

When are you expected to use the Manual?

- **Now!** Effective <u>10/15/21</u>
  - The Manual must be used to design all RIDOT-owned stream crossings (new, replacement, or retrofit)
- Replacement/Retrofit Process:
  - 1. RIDOT 2019 Stream Assessment Handbook (not required but highly encouraged)
  - 2. Design using the new Manual
  - 3. Re-Assess with RIDOT 2019 Assessment Handbook
- Emergency replacement projects
  - Use the Manual when feasible with RIDOT approval

Key Methods

Design Manual

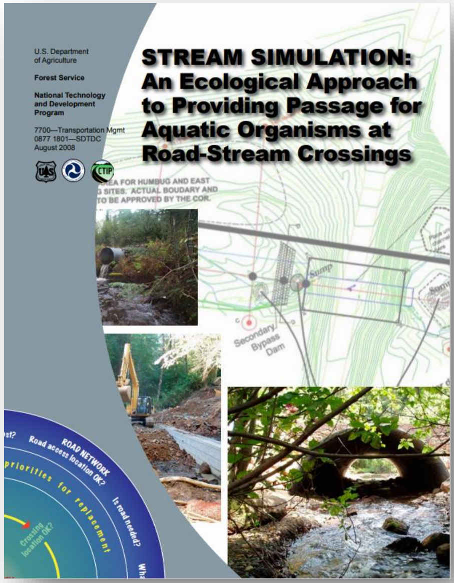
- 01 Build Upon RIDOT Assessment Handbook
- 02 Design Framework from Regional Stream Crossing Manuals
- 03 Structural and Environmental Considerations
- 04 Base Requirements upon the RIDOT Highway Functional Classification
- 05 Retrofit Guidance

What this Manual is Not:

- A design guide for stormwater and other drainage pipes
- A replacement for the RIDOT Bridge Inspection Manual, the RIDOT Linear Stormwater Manual, or the Rhode Island Stormwater Design and Installation Standards Manual
- A guide for structural or geotechnical design and analysis of bridges, arches, or culverts
- An assessment guide for prioritizing stream crossing replacement
- A stream crossing permitting guidebook – RIDEM will evaluate each crossing on a case-by-case basis and there may be additional requirements
- A guide for floodplain management or analysis

The Design Standards

- Two levels of Design Standards for each Design Criteria:
  - New or replacement crossings should always aim to meet the **Optimal Standard** for each Design Criteria.
  - ***With RIDOT approval*:** A crossing may meet the Optimal Standard for some Design Criteria and only meet the **Base Standard** for other Design Criteria.
- Focus on "Stream Simulation" Design
  - Approach from USFS *Stream Simulation* document (2008)
  - Goal to create a stream crossing that mimics the characteristics of the natural channel in as many facets as possible.



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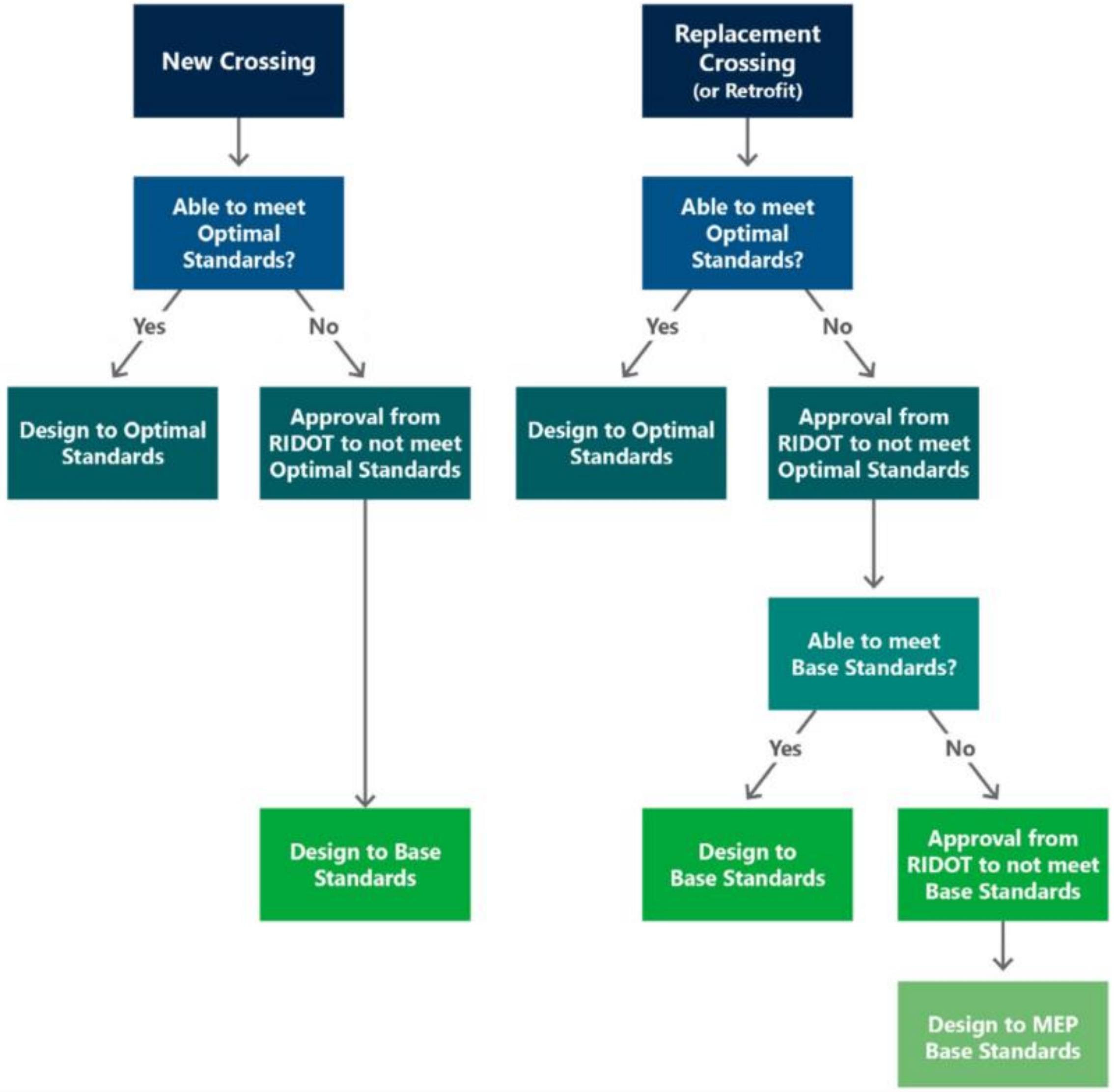
The Design Standards



The Design Criteria

1. Design Approach
2. Structure Type
3. Channel Velocity
4. Climate Change
5. Crossing Profile
6. Embedment & Substrate
7. Hydraulic Modeling
8. Openness Ratio
9. Stream Crossing Span
10. Structural Stability
11. Tidal/Coastal Modeling
12. Reporting Requirements

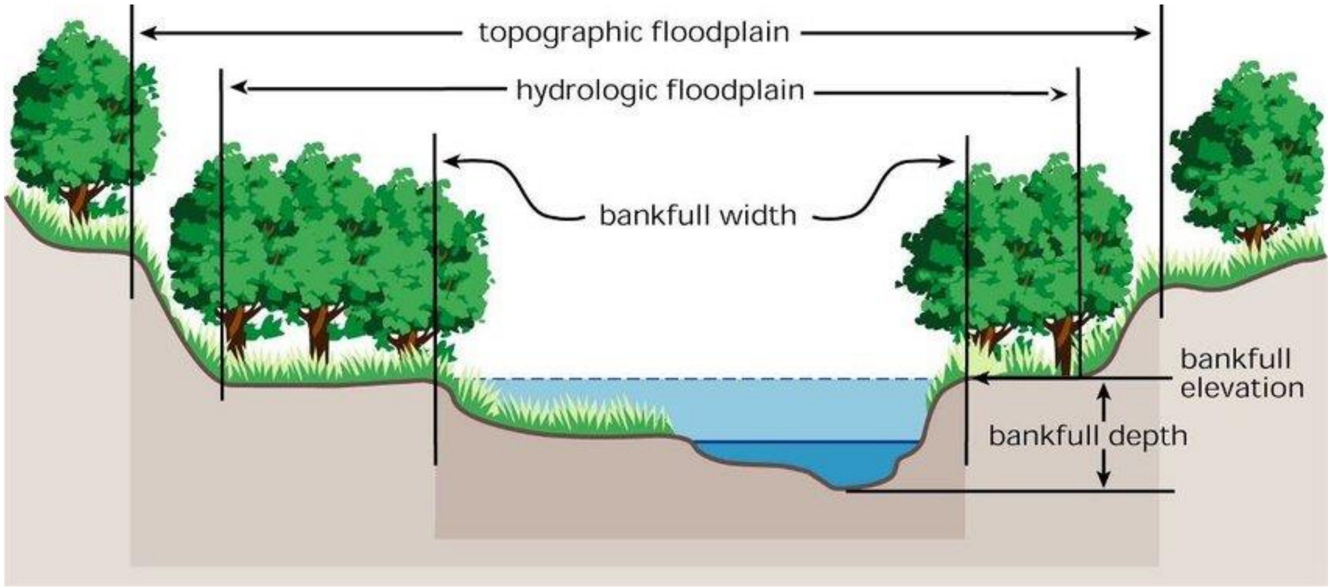
Design Criteria – 1. Design Approach

Optimal Standard

- USFS Stream Simulation

Base Standard *RIDOT Approval Required*

- AOP Design
- Modified Hydraulic Design



Source: FISRWG, 1998

Design Criteria – 2. Structure Type

Optimal Standard	Base Standard *RIDOT Approval Required*
• Bridge, 3-sided box culverts, open-bottom/arch culverts	• Pipe culvert or box culvert with embedment

Bridge

3-Sided Box Culvert

Pipe Culvert

Design Criteria – 3. Channel Velocities

Optimal Standard	Base Standard *RIDOT Approval Required*
• Velocity within the swimmable range of (AOP) target species (or comparable to a reference reach) at bankfull flow and range of base flows (if no target species). • Include AOP study for target species (when applicable).	• Velocity comparable to natural channel at bankfull flow.

Juvenile brook trout (Source: RIDEM)

Design Criteria – 4. Climate Change

Requires the proposed design to pass the future Design Storm according based upon span & the highway functional classificatio n of the roadway.

Highway Functional Classification[6]	Flood Frequency Requirements[7]	Design Storm Freeboard Requirements	Climate Change Projection Horizon[8,9,10]
		Span Less than 10 feet	
All Classes	• Design Storm: 10% AEP • Design Scour: 4% AEP • Check Scour: 2% AEP • Climate Check: 4% AEP	No freeboard required	Pass the design storm for the projections of the end of the service life: 75-year Horizon (unless crossing is atypical)
	1	*Span 10 to 20 feet*	
Rural Minor Collector *Rural Local* 2 *Urban Collector/Local Bike or Walking Path*	• Design Storm: 10% AEP • Design Scour: 4% AEP • Check Scour: 2% AEP • Climate Check: 4% AEP	1-foot 3a ***This (if available)***	Pass the design storm for the projections of the end of the service life
Rural Major Collector *Urban Minor Arterial*	• Design Storm: 4% AEP ***For projections at end of service life*** • Design Scour: 2% AEP 3b ***Or this (if not available)*** • Check Scour: 1% AEP • Climate Check: 2% AEP	2-feet	Pass the design storm for the projections of the end of the service life *If Available*
Rural Principal Arterial *Rural Minor Arterial* *Urban Principal Arterial* *Or Any Structure on the NHS*	• Design Storm: 2% AEP • Design Scour: 1% AEP • Check Scour: 0.5% AEP • Climate Check: 1% AEP	2-feet ...	Pass the design storm for the projections of the end of the service life
		Span 20 feet or Greater	

Example: If the crossing is a 15-foot span Rural Major Collector with a planned construction year of 2025 and a service life of 75-years, then the Climate Change Projection Horizon is 75-years, and the designer must find the most applicable and up-to-date sea level rise and precipitation projections for the year 2100 and design the crossing to pass the 2100 4% AEP tidal event (if tidally influenced) and the 2100 4% AEP precipitation event. *<u>If 2100 projections are not available, the Climate Check Event is utilized</u>*, the project must pass the Current Day 2% AEP Check flood.

Recommended Projection Sources: RI CRMC, RI Climate Change Office, IPCC, NOAA, NECASC

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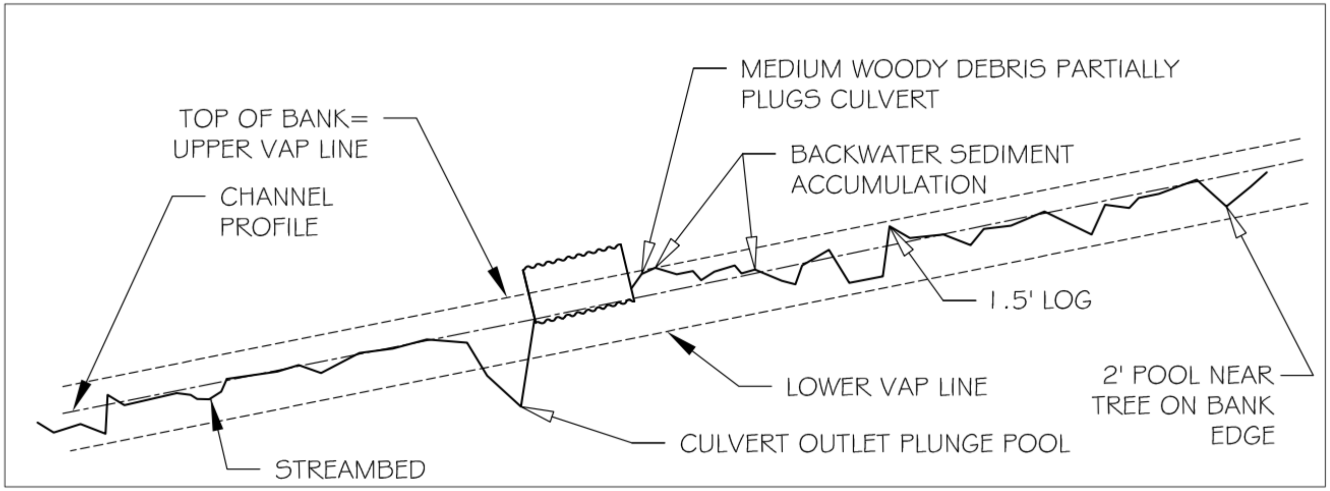
Design Criteria – 5. Crossing Profile

Optimal Standard	**Base Standard** *RIDOT Approval Required*
Crossing profile to match existing natural stream using reference reach and vertical adjustment potential (VAP).	Crossing profile to match existing natural stream grade upstream and/or downstream of the crossing location.



Source: FSSWG, 2008

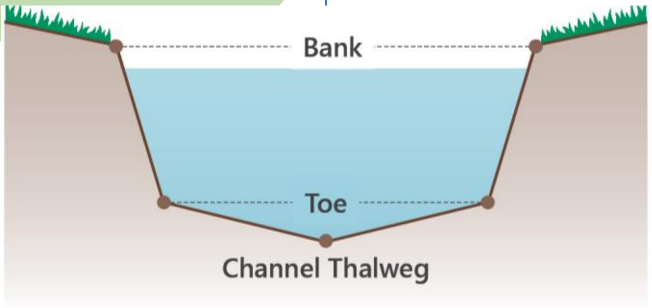
Design Criteria – 6. Embedment, Substrate, and Channel Stability

Optimal Standard

- Open-bottom structures have ≥ 1 foot of natural substrate material above any required scour protection material.
- Include scour stability analysis and grain size analysis
- Channel cross section within the crossing designed to mimic low flow depths of natural channel.

Base Standard *RIDOT Approval Required*

- Closed-bottom crossings ≥ 8 feet in span must have min. embedment of 2 feet. Crossings < 8 feet in span must have a min. embedment of 25% of the opening height
- Channel cross section designed within the crossing to mimic low flow depths of natural channel.

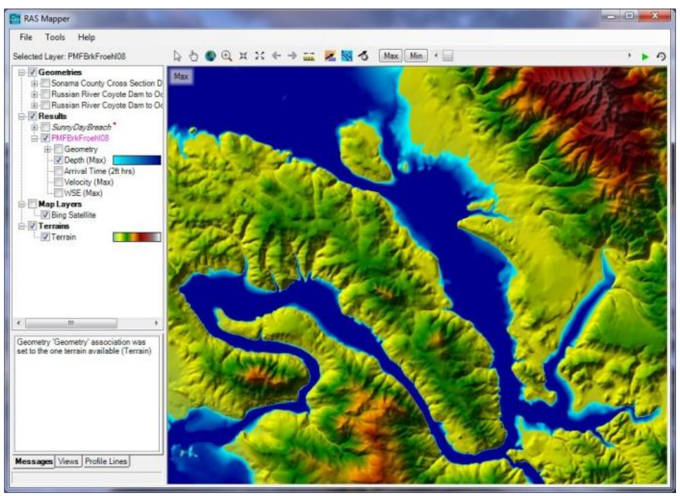


Recommended Soil Sample Locations provided within the Manual

Design Criteria – 7. Hydraulic Modeling

Optimal Standard

HEC-RAS (or equivalent) analysis required.

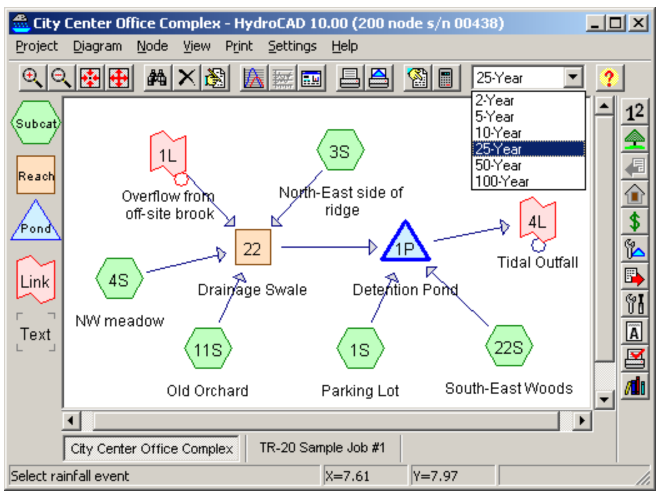


Source: U.S. Army Corps of Engineers, 2021

Base Standard

RIDOT Approval Required

HY-8, CulvertMaster, HydroCAD, (or equivalent) analysis required.

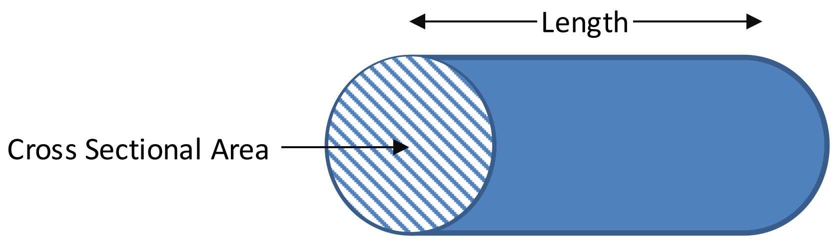


Source: HydroCAD, 2020

Design Criteria – 8. Openness Ratio

Optimal Standard	Base Standard *RIDOT Approval Required*
Openness ratio ≥ 1.64 feet and Height ≥ 6 feet. If conditions significantly inhibit wildlife, use openness of ≥ 2.46 feet and height ≥ 8 feet	Openness ratio ≥ 0.82 feet to the maximum extent practicable.

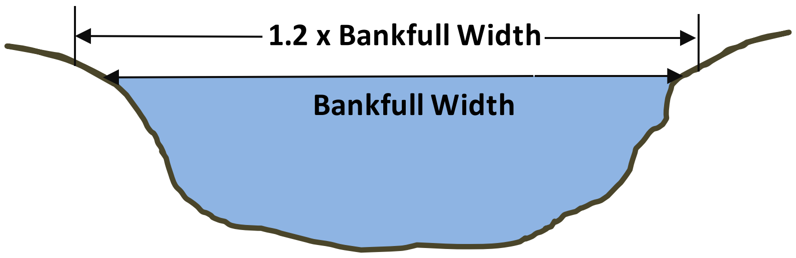
$$\textbf{Openness} = \frac{\textbf{Cross Sectional Area (ft}^2\textbf{)}}{\textbf{Length (Ft)}}$$



Design Criteria – 9. Stream Crossing Span

Optimal Standard	**Base Standard** *RIDOT Approval Required*
Hydraulic span ≥ 1.2 x BFW with banks on both sides *designed for applicable wildlife passage*.	Hydraulic span ≥ 1.2 x BFW with banks on both sides.

$$\mathbf{Span = 1.2\ x\ Bankfull\ Width}$$

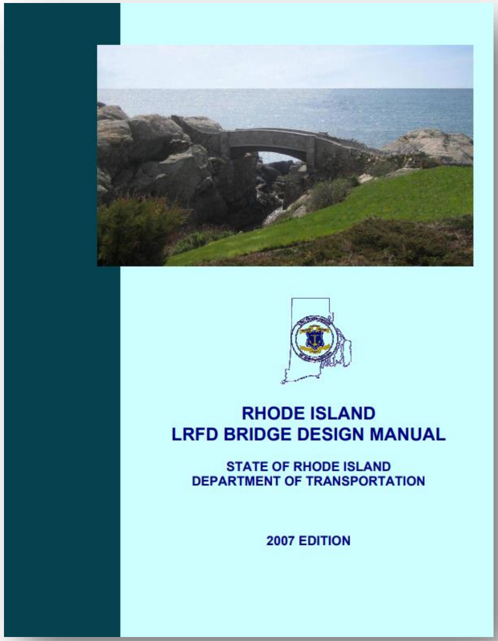


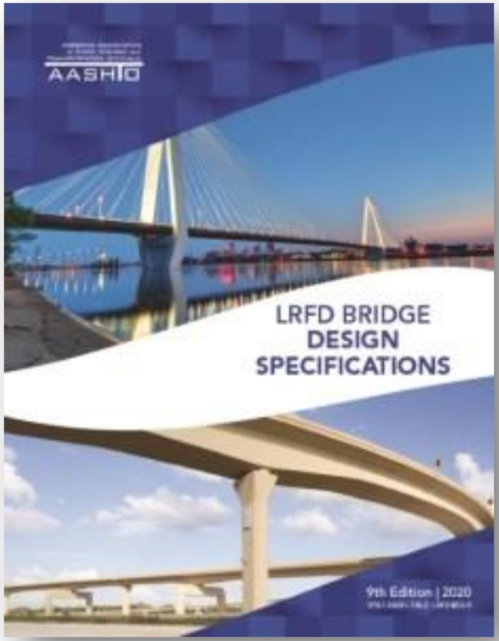
Additional guidance for span alignment and placement relative to the stream alignment is included within the Manual

Design Criteria – 10. Structural Stability

Optimal & Base Standards

Design in accordance with Rhode Island and AASHTO LRFD standards. Structural design includes appropriate loading including streamflow, span configuration and freeboard, wingwall layout and design, and footing design.





Design Criteria – 11. Tidal/Coastal Modeling

Optimal Standard

- Velocity comparable to natural channel during the ebb and flow for <u>high tide or maximum flow conditions</u> & <u>low tide or low flow conditions</u> using a detailed unsteady hydraulic modeling analysis.
- Includes AOP study

Base Standard

RIDOT Approval Required

- Designed to accommodate the exchange of the full tidal prism using a simplified quantitative analysis (i.e., spreadsheet).

Tidally influenced crossings must consider precipitation changes <u>and</u> sea level rise.

Source: NHDES, 2017

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Design Criteria – 12. Reporting Requirements

Optimal & Base Standards

Required as part of the RIDOT 30% Design Submission:

1. Geotechnical Investigation
2. Hydrologic and Hydraulic Computations
3. Road-Stream Crossing Standards Review Checklist(s)
   - Checklist A.1 Existing Conditions (if applicable) and A.2 Proposed Conditions
4. Table A.3 Hydraulic Design Data
5. The applicable Conceptual Design Figure
6. Road-Stream Crossing Report

Templates provided in Manual

Checklist A.1 Existing Conditions

Bridge # and/or Group #, Roadway Name, Waterbody Name and Town Name:		
Design Criteria	Optimal Standards	Base Standards
Structure Type	☐ Bridge ☐ 3-Sided Box Culvert ☐ Open-Bottom Culvert ☐ Arch Culvert ☐ *Binned Overall Geomorphic Impact Score ≥3*	☐ Pipe Culvert with Embedment ☐ Box Culvert with Embedment
	☐ Existing crossing does not meet Base or Optimal Standards. Structure type: ____________	
Channel Velocities	☐ Velocity within the swimmable range of target species ☐ Velocity comparable to reference reach at bankfull flow and range of base flows (if no target species present) ☐ AOP study for target species ☐ *Binned Aquatic Passability Score ≥3*	☐ Velocity comparable to natural channel at bankfull flow
Climate Change	☐ Hydraulic capacity designed for sea level rise and/or increased precipitation projections based upon Hydraulic Design Requirements	
Crossing Profile	☐ Crossing profile matches existing natural stream based upon reference reach ☐ Profile designed using vertical adjustment potential (VAP) ☐ *Binned Aquatic Passability Score ≥3*	☐ Crossing profile to match existing natural stream grade upstream and/or downstream of the crossing location
	☐ Existing crossing does not meet Base or Optimal Standards. Description of crossing profile: ____________	
Embedment, Substrate and Channel Stability Embedment depth: ______	☐ 1 foot (minimum) of natural substrate material above any required scour protection material ☐ Channel cross section designed to mimic low flow depths of natural channel ☐ Included grain size analysis and bed mobility/scour stability analysis ☐ *Binned Overall Geomorphic Impact Score or Binned Aquatic Passability Score ≥3*	☐ Natural bottom substrate ≥ 2 feet for all structures ≥ 8 feet in span; ≥ 25% of opening height for all spans < 8 feet ☐ Channel cross section designed to mimic low flow depths of natural channel
	☐ Existing crossing does not meet Base or Optimal Standards.	
Hydraulic Modeling	☐ HEC-RAS ☐ Equivalent Software: ____________ ☐ *Binned Transportation Disruption Score ≥3*	☐ HY-8 ☐ CulvertMaster ☐ HydroCAD ☐ Equivalent Software: ____________
Openness Ratio Openness ratio: ______	☐ Openness ratio ≥ 1.64 feet and height ≥ 6 feet ☐ If conditions significantly inhibit wildlife, openness of ≥ 2.46 feet and height ≥ 8 feet ☐ *Binned Aquatic Passability Score ≥4*	☐ Greater than or equal to 0.82 feet to the maximum extent practicable
	☐ Existing Crossing does not meet Base or Optimal Standards.	
Stream Crossing Span Bankfull width: ______ Crossing span: ______	☐ Hydraulic span greater than or equal 1.2 x BFW with banks on both sides designed for applicable wildlife passage. ☐ *Binned Flood Impact Potential Score ≥3*	☐ Hydraulic span greater than or equal to 1.2 x BFW with banks on both sides
	☐ Existing crossing does not meet Base or Optimal Standards.	
Structural Stability	☐ Designed in accordance with Rhode Island and AASHTO LRFD standards. Structural design includes appropriate loading including streamflow, span configuration and freeboard, wingwall layout and design, and footing design. ☐ Unknown	
Tidal/Coastal Guidance	☐ Non-tidal ☐ Velocity comparable to natural channel during the ebb and flow for high tide or maximum flow conditions and low tide/low flow conditions based upon a detailed unsteady hydraulic modeling analysis. ☐ *Binned Climate Change Vulnerability Score ≥3*	☐ Non-tidal ☐ Designed to accommodate the exchange of the full tidal prism using a simplified quantitative analysis (i.e. spreadsheet)

RIDOT Road-Stream Crossing Assessment Handbook (2019)

Checklist A.2 Proposed Conditions

Bridge # and/or Group #, Roadway Name, Waterbody Name and Town Name:			
Design Criteria	Optimal Standards	Base Standards	**Replacement Crossing: MEP** Elaborate on reason for MEP within Road-Stream Crossing Report
Design Approach	☐ Stream Simulation	☐ AOP Design ☐ Modified Hydraulic Design	☐ Maximum Extent Practicable
Structure Type	☐ Bridge ☐ 3-Sided Box Culvert ☐ Open-Bottom Culvert ☐ Arch Culvert	☐ Pipe Culvert with Embedment ☐ Box Culvert with Embedment	☐ Maximum Extent Practicable
Channel Velocities	☐ Velocity within the swimmable range of target species ☐ Velocity comparable to reference reach at bankfull flow and range of base flows (if no target species present) ☐ AOP study for target species	☐ Velocity comparable to natural channel at bankfull flow	☐ Maximum Extent Practicable
Climate Change	☐ Designed for sea level rise and/or increased precipitation projections based upon Hydraulic Design Requirements		
Crossing Profile	☐ Crossing profile matches existing natural stream based upon reference reach ☐ Profile designed using vertical adjustment potential (VAP)	☐ Crossing profile to match existing natural stream grade upstream and/or downstream of the crossing location	☐ Maximum Extent Practicable
Embedment, Substrate and Channel Stability Embedment depth: ________	☐ 1 foot (minimum) of natural substrate material above any required scour protection material ☐ Channel cross section designed to mimic low flow depths of natural channel ☐ Includes grain size analysis and bed mobility/scour stability analysis	☐ Natural bottom substrate ≥ 2 feet for all structures ≥ 8 feet in span; ≥ 25% of opening height for all spans < 8 feet ☐ Channel cross section designed to mimic low flow depths of natural channel	☐ Maximum Extent Practicable
Hydraulic Modeling	☐ HEC-RAS ☐ Equivalent Software: ____________	☐ HY-8 ☐ CulvertMaster ☐ HydroCAD ☐ Equivalent Software:________	☐ Maximum Extent Practicable
Openness Ratio Openness ratio: _____	☐ Openness ratio ≥ 1.64 feet and height ≥ 6 feet ☐ If conditions significantly inhibit wildlife, openness of ≥ 2.46 feet and height ≥ 8 feet	☐ Greater than or equal to 0.82 feet to the maximum extent practicable	
Stream Crossing Span Bankfull width: _____ Crossing span: _____	☐ Hydraulic span greater than or equal 1.2 x BFW with banks on both sides designed for applicable wildlife passage.	☐ Hydraulic span greater than or equal to 1.2 x BFW with banks on both sides	☐ Maximum Extent Practicable
Structural Stability	☐ Design in accordance with Rhode Island and AASHTO LRFD standards. Structural design includes appropriate loading including streamflow, span configuration and freeboard, wingwall layout and design, and footing design. Hydraulic modeling and geotechnical analysis provide direction on foundation requirements and site-specific scour mitigation measures.		
Tidal/Coastal Guidance	☐ Non-tidal ☐ Velocity comparable to natural channel during the ebb and flow for high tide or maximum flow conditions and low tide/low flow conditions based upon a detailed unsteady hydraulic modeling analysis.	☐ Non-tidal ☐ Designed to accommodate the exchange of the full tidal prism using a simplified quantitative analysis (i.e. spreadsheet)	
Reporting Requirements	☐ Road-Stream Crossing Report (with H&H computations), Geotechnical Investigation, Hydraulic Performance Data Table, Conceptual Design Figure(s)		

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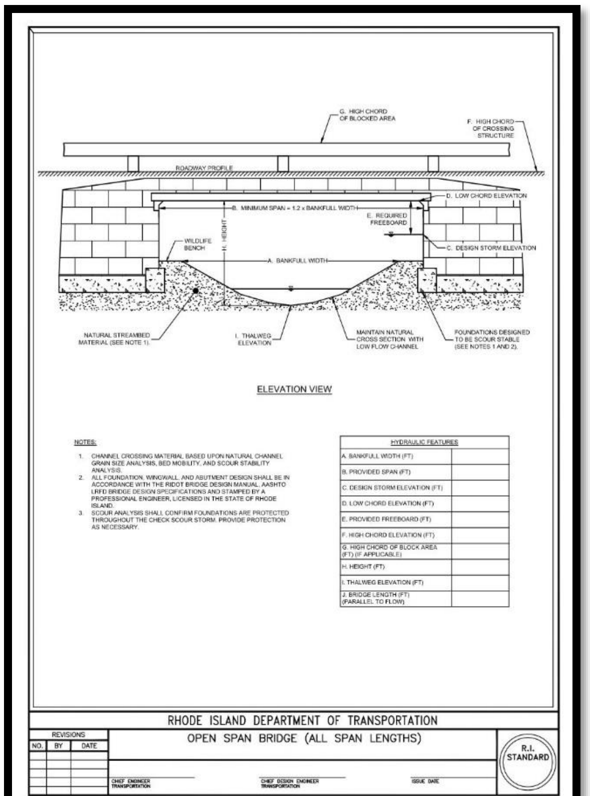
Table A.3 Hydraulic Design Data

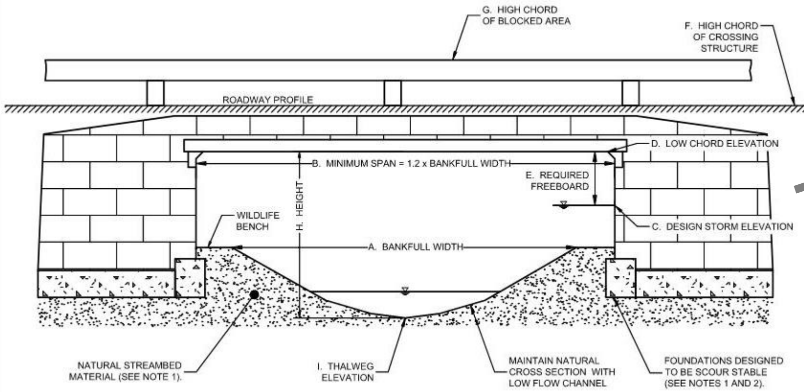
Project Background	
Bridge ID # and Group # (if applicable):	
Roadway Name:	
Waterbody Name:	
City/Town Name:	
Proposed Crossing Span (feet):	
Highway Functional Classification:	
Planned Construction Dates:	
Structure Service Life (years):	
Project within Special Flood Hazard Area and/or Floodway? If yes, provide FEMA Flood Zone details and elevation (if available):	
Crossing Geometry	
Existing Condition Low Chord Elevation (feet):	
Proposed Condition Low Chord Elevation (feet):	
Hydraulic Design Requirements	
Design Storm Event:	
Existing Condition Design Storm Event Elevation (feet):	
Proposed Condition Design Storm Event Elevation (feet):	
Freeboard Requirement (feet):	
Freeboard Provided (feet):	
Design Scour Event:	
Check Scour Event:	
Climate Check Event:	
Pass Climate Check Event (Y/N/N.A.):	
Tidal and Sea Level Rise Influence	
Is the crossing currently impacted by tidal flow? (Y/N):	
Climate Change Projection Horizon Year:	
Will the crossing be impacted by the future MHHW based upon sea level rise for the Climate Change Projection Horizon Year? (Y/N/N.A.):	

Conceptual Design Figures



- <u>Four</u> different Conceptual Design Figures provided in Appendix B of Manual
- Designer should choose the figure that most similarly represents their crossing and complete to associated table
- Available as PDF and CAD .dwg files for editing

Option #1 - Bridge



ELEVATION VIEW

NOTES:

1. CHANNEL CROSSING MATERIAL BASED UPON NATURAL CHANNEL GRAIN SIZE ANALYSIS, BED MOBILITY, AND SCOUR STABILITY ANALYSIS.
2. ALL FOUNDATION, WINGWALL, AND ABUTMENT DESIGN SHALL BE IN ACCORDANCE WITH THE RIDOT BRIDGE DESIGN MANUAL, AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS AND STAMPED BY A PROFESSIONAL ENGINEER, LICENSED IN THE STATE OF RHODE ISLAND.
3. SCOUR ANALYSIS SHALL CONFIRM FOUNDATIONS ARE PROTECTED THROUGHOUT THE CHECK SCOUR STORM. PROVIDE PROTECTION AS NECESSARY.

HYDRAULIC FEATURES	
A. BANKFULL WIDTH (FT)	
B. PROVIDED SPAN (FT)	
C. DESIGN STORM ELEVATION (FT)	
D. LOW CHORD ELEVATION (FT)	
E. PROVIDED FREEBOARD (FT)	
F. HIGH CHORD ELEVATION (FT)	
G. HIGH CHORD OF BLOCK AREA (FT) (IF APPLICABLE)	
H. HEIGHT (FT)	
I. THALWEG ELEVATION (FT)	
J. BRIDGE LENGTH (FT) (PARALLEL TO FLOW)	

RHODE ISLAND DEPARTMENT OF TRANSPORTATION

OPEN SPAN BRIDGE (ALL SPAN LENGTHS)

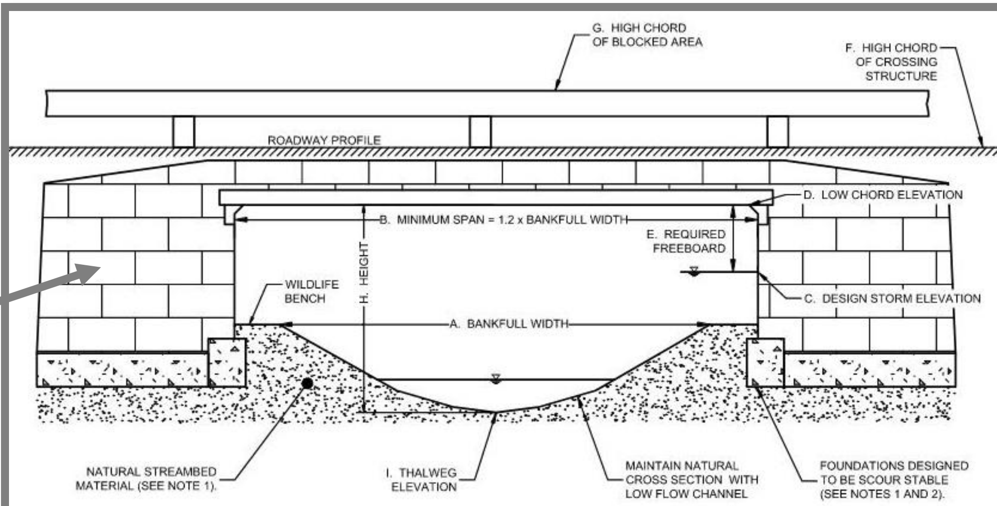
REVISIONS		
NO.	BY	DATE

CHIEF ENGINEER TRANSPORTATION

CHIEF DESIGN ENGINEER TRANSPORTATION

ISSUE DATE

R.I. STANDARD



HYDRAULIC FEATURES	
A. BANKFULL WIDTH (FT)	
B. PROVIDED SPAN (FT)	
C. DESIGN STORM ELEVATION (FT)	
D. LOW CHORD ELEVATION (FT)	
E. PROVIDED FREEBOARD (FT)	
F. HIGH CHORD ELEVATION (FT)	
G. HIGH CHORD OF BLOCK AREA (FT) (IF APPLICABLE)	
H. HEIGHT (FT)	
I. THALWEG ELEVATION (FT)	
J. BRIDGE LENGTH (FT) (PARALLEL TO FLOW)	

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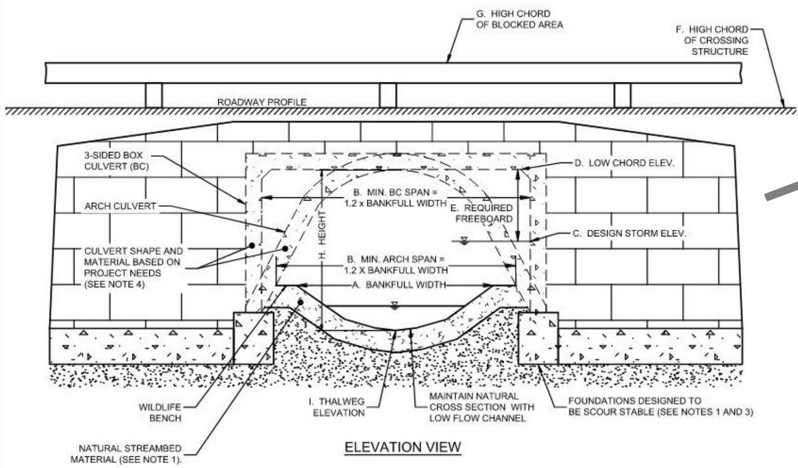
Option #2 – Open-Bottom Structure



NOTES:

1. CHANNEL CROSSING MATERIAL BASED UPON NATURAL CHANNEL GRAIN SIZE ANALYSIS, BED MOBILITY, AND SCOUR STABILITY ANALYSIS.
2. ALL FOUNDATION, WINGWALL, AND ABUTMENT DESIGN SHALL BE IN ACCORDANCE WITH THE RIDOT BRIDGE DESIGN MANUAL, AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS AND STAMPED BY A PROFESSIONAL ENGINEER, LICENSED IN THE STATE OF RHODE ISLAND.
3. SCOUR ANALYSIS SHALL CONFIRM FOUNDATIONS ARE PROTECTED THROUGHOUT THE CHECK SCOUR STORM. PROVIDE PROTECTION AS NECESSARY.
4. VIEW ILLUSTRATES BOTH 3-SIDED BOX CULVERT OPTION AND ARCH CULVERT. DESIGNER TO CHOOSE BASED UPON PROJECT NEEDS.

HYDRAULIC FEATURES	
A. BANKFULL WIDTH (FT)	
B. PROVIDED SPAN (FT)	
C. DESIGN STORM ELEVATION (FT)	
D. LOW CHORD ELEVATION (FT)	
E. PROVIDED FREEBOARD (FT)	
F. HIGH CHORD ELEVATION (FT)	
G. HIGH CHORD OF BLOCK AREA (FT) (IF APPLICABLE)	
H. HEIGHT (FT)	
I. THALWEG ELEVATION (FT)	
J. BRIDGE LENGTH (FT) (PARALLEL TO FLOW)	

RHODE ISLAND DEPARTMENT OF TRANSPORTATION

3–SIDED BOX CULVERT & ARCH CULVERT

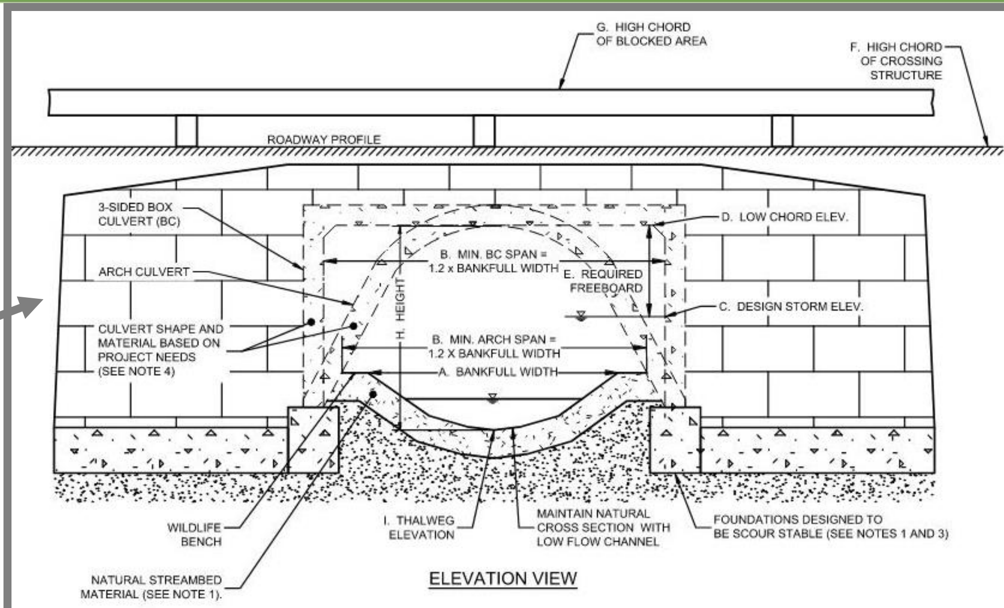
REVISIONS		
NO.	BY	DATE

CHIEF ENGINEER TRANSPORTATION

CHIEF DESIGN ENGINEER TRANSPORTATION

ISSUE DATE

R.I. STANDARD



HYDRAULIC FEATURES	
A. BANKFULL WIDTH (FT)	
B. PROVIDED SPAN (FT)	
C. DESIGN STORM ELEVATION (FT)	
D. LOW CHORD ELEVATION (FT)	
E. PROVIDED FREEBOARD (FT)	
F. HIGH CHORD ELEVATION (FT)	
G. HIGH CHORD OF BLOCK AREA (FT) (IF APPLICABLE)	
H. HEIGHT (FT)	
I. THALWEG ELEVATION (FT)	
J. BRIDGE LENGTH (FT) (PARALLEL TO FLOW)	

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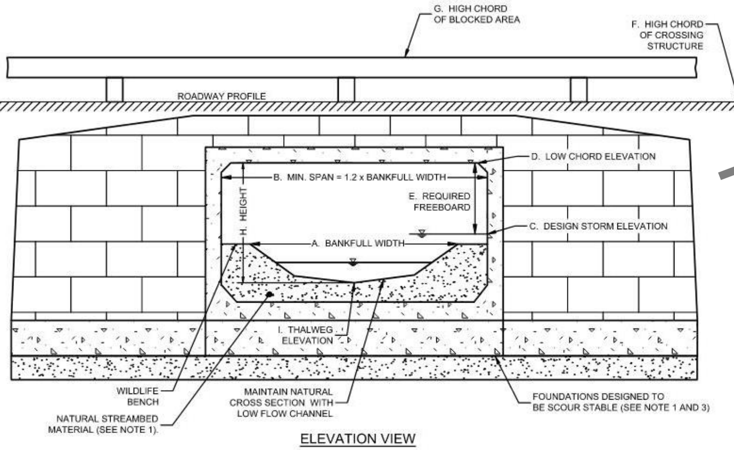
Option #3 – Box Culvert



NOTES:

1. CHANNEL CROSSING MATERIAL BASED UPON NATURAL CHANNEL GRAIN SIZE ANALYSIS, BED MOBILITY, AND SCOUR STABILITY ANALYSIS.
2. ALL FOUNDATION, WINGWALL, AND ABUTMENT DESIGN SHALL BE IN ACCORDANCE WITH THE RIDOT BRIDGE DESIGN MANUAL, AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS AND STAMPED BY A PROFESSIONAL ENGINEER, LICENSED IN THE STATE OF RHODE ISLAND.
3. SCOUR ANALYSIS SHALL CONFIRM FOUNDATIONS ARE PROTECTED THROUGHOUT THE CHECK SCOUR STORM. PROVIDE PROTECTION AS NECESSARY.

HYDRAULIC FEATURES	
A. BANKFULL WIDTH (FT)	
B. PROVIDED SPAN (FT)	
C. DESIGN STORM ELEVATION (FT)	
D. LOW CHORD ELEVATION (FT)	
E. PROVIDED FREEBOARD (FT)	
F. HIGH CHORD ELEVATION (FT)	
G. HIGH CHORD OF BLOCK AREA (FT) (IF APPLICABLE)	
H. HEIGHT (FT)	
I. THALWEG ELEVATION (FT)	
J. BRIDGE LENGTH (FT) (PARALLEL TO FLOW)	

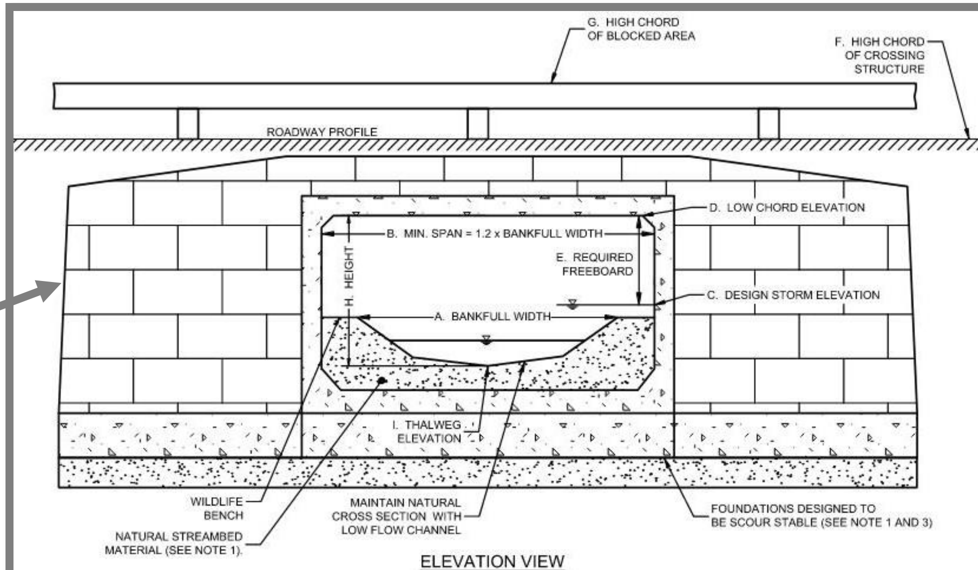
RHODE ISLAND DEPARTMENT OF TRANSPORTATION

EMBEDDED BOX CULVERT

REVISIONS		
NO.	BY	DATE

CHIEF ENGINEER TRANSPORTATION | CHIEF DESIGN ENGINEER TRANSPORTATION | ISSUE DATE

R.I. STANDARD



HYDRAULIC FEATURES	
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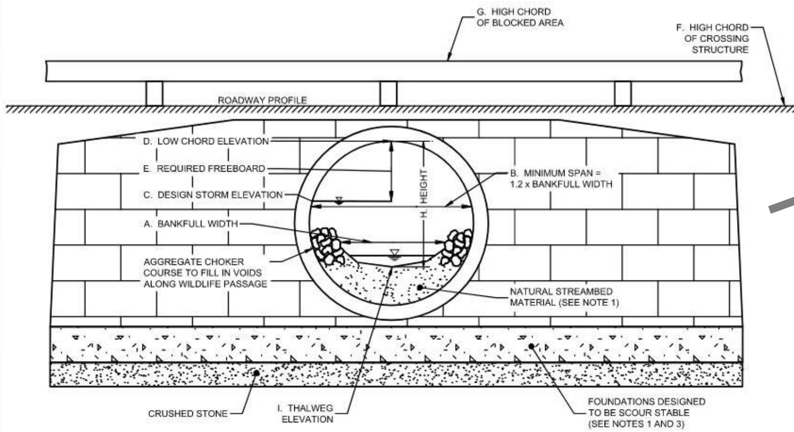
H. HEIGHT (FT)	
I. THALWEG ELEVATION (FT)	
J. BRIDGE LENGTH (FT) (PARALLEL TO FLOW)	

Option #4 - Pipe



ELEVATION VIEW

NOTES:

1. CHANNEL CROSSING MATERIAL BASED UPON NATURAL CHANNEL GRAIN SIZE ANALYSIS, BED MOBILITY, AND SCOUR STABILITY ANALYSIS.
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RHODE ISLAND DEPARTMENT OF TRANSPORTATION

EMBEDDED PIPE CULVERT

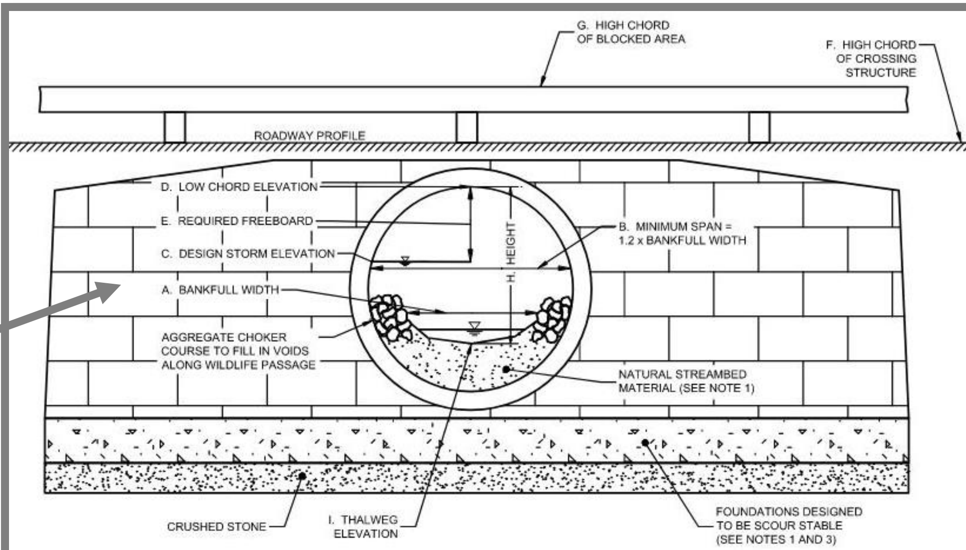
REVISIONS		
NO.	BY	DATE

CHIEF ENGINEER TRANSPORTATION

CHIEF DESIGN ENGINEER TRANSPORTATION

ISSUE DATE

R.I. STANDARD



ELEVATION VIEW

HYDRAULIC FEATURES	
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H. HEIGHT (FT)	
I. THALWEG ELEVATION (FT)	
J. BRIDGE LENGTH (FT) (PARALLEL TO FLOW)	

Driven to get you there

Final Design Considerations

- Construction Dewatering
  - Minimize impacts to the streambed, surrounding environment, and aquatic animals
  - Cofferdam and flow diversion guidance
- Operation & Maintenance (O&M)
  - Key items for construction and post-construction inspection
  - O&M plan guidance and standard practices for stream crossings

Source: Maine.gov

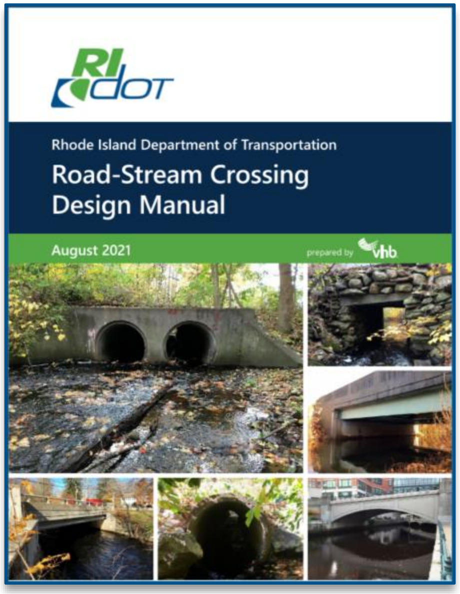
Driven to get you there

Project Cost and Scoping

- Currently $1M added to costs on a project by project basis in the TIP when crossing is undersized.
- Planning future crossing assessments in advance for upcoming crossing replacements in the TIP to determine high priorities for upgrades.
- RIDOT has $8M/Year in Protect money to add to projects if needed in the future.
- Ongoing advocacy for adding resiliency/protect funds.

Projects in Design

- The Manual is in effect as of **<u>10/15/21</u>** for all new RIDOT projects
  - Standards are incorporated in Army Corps RI PGP (effective March 2022)
  - We anticipate more projects in pipeline from new federal infrastructure bill (IIJA), which will use the Manual
- Projects underway:
  - West River Bridge, Providence
  - Round Swamp Bridge, Jamestown



RI DOT
Driven to get you there

Key Takeaways

- ✓ All RIDOT owned road-stream crossings must be designed using the Road-Stream Crossing Design Manual
  - ✓ The Manual is now available on the RIDOT website!
- ✓ New or replacement crossings should always aim to meet the Optimal Standard for each Design Criteria.
  - ✓ ***With RIDOT approval***: A crossing may meet the Optimal Standard for some Design Criteria and only meet the Base Standard for other Design Criteria.
  - ✓ Don’t forget to include Checklist A.1 (if applicable), A.2, and A.3 in the 30% design submission.
- ✓ Replacement or retrofit projects should use the Assessment Handbook prior to the Design Manual whenever possible.

RI dot Driven to get you there

Thank You

Questions?

Annique Fleurat
afleurat@vhb.com

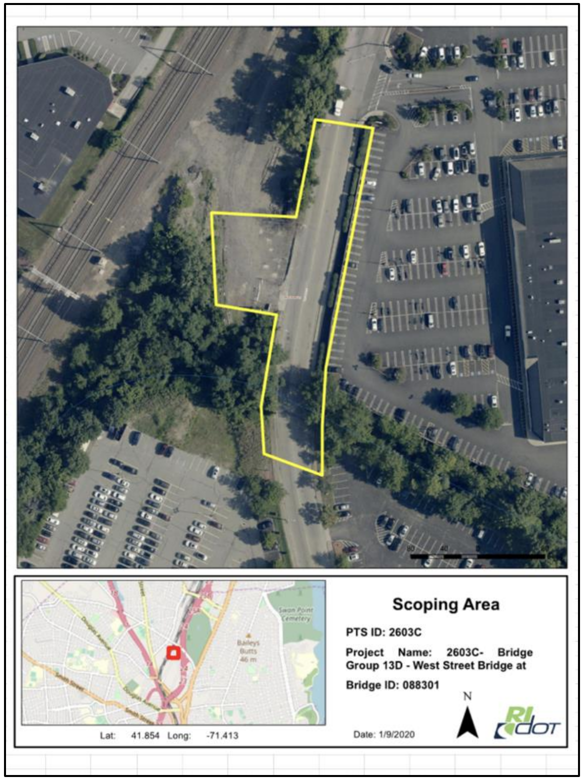
Ariana Wetzel
awetzel @vhb.com

Alisa Diaz Richardson
alisa.richardson@dot.ri.gov

Nicole Lineberry
nicole.leporacci@dot.ri.gov

West River Bridge

- West River St over West River in Providence
    - Planned for advertisement by end of 2022



Round Swamp Bridge

- North Road over West Passage (tidal) in Jamestown
  - Planned for ~2024

Source: Jamestown Press