

State of Vermont
Structures and Hydraulics Section
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Agency of Transportation

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TO: David Hosking, District 5 Project Manager
CC: Jeff DeGraff, State Hydraulics Engineer
Rachel Czar, ANR River Management Engineer
FROM: Keith Friedland, Hydraulics Technician
DATE: November 25, 2025
SUBJECT: Starksboro, TH-28, Ireland Road, over unnamed tributary to Lewis Creek
Site location: C067-14, 1.7 miles east of VT-116
Coordinates: [44.196907, -73.027186](#)

We have completed our hydraulic study for the above referenced site and offer the following for your use. Please note this study was conducted and performed from the desktop utilizing LiDAR elevations.

Due to the complexity of the upstream to downstream channel slope transition, we recommend hiring a consultant to perform a site design for this crossing structure.

Hydrology

The following physical characteristics are descriptive of this drainage basin:

Drainage Area	0.53 square miles
Land Cover	Forest
Water Bodies and Wetlands (NLCD 2006)	2.2%
Mean Annual Precipitation	49.2 inches

Using the adjusted USGS (2014) hydrologic method, the following design flow rates were selected:

Annual Exceedance Probability (AEP)	Flow Rate in Cubic Feet per Second (cfs)	
50 % (Q2)	37	
10 % (Q10)	84	
4 % (Q25)	120	Design Flow – Local Road
2 % (Q50)	150	
1 % (Q100)	190	Check Flow

Channel Morphology

The channel for this perennial stream is sinuous with an estimated local channel slope of 9%. The upstream channel has a slope of 3% and the downstream channel has a slope of 10 to 14%.

The Vermont Hydraulic Geometry Relationships anticipate a bankfull width of 10 feet for stream channels in equilibrium at this watershed size.

Due to the existing outlet invert being “perched” above the downstream stream channel, the VT ANR River Management Engineer will need to **determine if AOP is possible for this crossing structure.**

Existing Conditions

The existing structure is a metal boiler pipe with a diameter of 6 feet, providing a waterway opening of 28.3 square feet (based on information provided in the hydraulics study request).

Our calculations indicate the existing structure does meet current standards of the VTrans Hydraulic Manual (*see HEI 24-004 on the Engineering Instruction webpage for updated allowable headwater to depth ratios*). However, it does not meet the state stream equilibrium standards for bankfull width (span length). The existing structure constricts the channel width, resulting in an increased potential for debris blockage. This complication is known to cause ponding at the inlet, increase stream velocity and scour at the outlet, and may also lead to erosion and failure of channel banks.

The existing structure results in a headwater depth of approximately 4.5 feet at 4% AEP and 6.2 feet at 1% AEP.

Replacement Recommendations

In sizing a new structure, we attempt to select structures that meet both the current VTrans hydraulic standards, state environmental standards with regard to span length and opening height, and consider roadway grade and other site constraints.

The replacement structure's clear height above the streambed, as listed below, may need to increase to accommodate the installation of E-Stone.

Based on the above considerations and the information available, we recommend any of the following structures as a replacement at this site:

- A concrete box with an inside opening span of 10 feet and minimum height of 6 feet. The box invert should be buried 2 feet. This will result in a clear height of 4 feet above streambed, providing 40 square feet of waterway area. Bed retention sills should be added in the bottom of the structure. Sills should be 12 inches high at the edges of the box and 6 inches high in the center, creating a V-shape across the full width of the box. Sills should be spaced no more than 8 feet apart throughout the structure with one sill placed at both the inlet and the outlet. The structure should be filled level to the streambed with E-Stone, Type II, allowing flow to be kept above the surface, providing the conditions necessary for aquatic organism passage. This structure results in a headwater depth of 2.7 feet at 4% AEP and 3.7 feet at 1% AEP.
- A metal box with an inside opening span of 11'-10" and minimum height of 6'-5". The box invert should be buried 2 feet. This will result in a clear height of 4.4 feet above streambed, providing 38.5 square feet of waterway area. Bed retention sills need to be added and filled as described for the box above. This structure results in a headwater depth of 2.7 feet at 4% AEP and 3.9 feet at 1% AEP.
- A corrugated metal plate pipe arch with a clear span of 122.6 inches and a minimum height of 81.2 inches. The pipe invert should be buried 2 feet. This will result in a clear height of 4.8 feet above streambed, providing 37.4 square feet of waterway area. Bed retention sills need to be added and filled as described for the box above. This structure results in a headwater depth of 3.3 feet at 4% AEP and 4.5 feet at 1% AEP.
- A corrugated metal plate pipe with a minimum diameter of 10 feet. The pipe invert should be **buried 3 feet**. This will result in a clear height of 7 feet above streambed, providing 58.7 square feet of waterway area. Bed retention sills need to be added and filled as described for the box above. This structure results in a headwater depth of 3.3 feet at 4% AEP and 4.5 feet at 1% AEP.
- Any similar structure that fits the site conditions could be considered. *Any structure with a closed bottom should have bed retention sills and a buried invert as described above.*

The structures recommended above have been modeled with a culvert slope of 5%. **Due to the “perched” existing culvert outlet invert, the downstream channel at the replacement structure outlet will need to be built up to connect E-Stone through the culvert to the upstream end.** When complete, there should be no drop at the outlet. **The local stream slope should be verified prior to installation of the new culvert.** It is critical that any new structure is set at the average streambed profile.

Stone Fill, Type III should be used to protect any disturbed channel banks or roadway slopes at the structure’s inlet and outlet, up to a height of at least one-foot above the top of the opening. The stone fill should not constrict the channel or structure opening. E-Stone, Type II should be used for the restoration of any disturbed stream channel sections.

Prior to any action toward the implementation of any recommendations received from the VTrans Hydraulics Unit, structure size must be confirmed by the VT ANR River Management Engineer to ensure compliance with state environmental standards for stream crossing structures.

General Comments

It is recommended that a full height headwall and flared wingwalls be constructed at the inlet, matched into the channel banks to smoothly transition flow and protect the structure and roadway approaches from erosion.

Any closed bottom structure should also be equipped with cutoff walls, extending to a depth equal to the culvert rise, up to 4 feet, or to ledge, to serve as undermining prevention. E-Stone thickness plus the bottom of structure thickness should be included when determining the total cutoff wall depth.

Please note that a site visit was not made, these recommendations were made without the benefit of a survey and are based on limited information. The final decision regarding replacement of this structure must comply with state regulatory standards, and should take into consideration matching natural channel conditions, roadway grade, environmental concerns, safety, and other requirements.

Please contact us if you have any questions or if we may be of further assistance.

From: Czar, Rachel <Rachel.Czar@vermont.gov>

Sent: Monday, December 1, 2025 8:03 AM

To: Amanda Vincent <amanda@starksborovt.org>

Subject: RE: Starksboro, TH-28, Ireland Road, C067-14, Hydraulics Memo

Good morning,

I visited the site last week and took some measurements. I agree with recommendations from VTrans except for the minimum width opening. I measured bankfull width a few times up and downstream of the culvert and the **MINIMUM** width for a hydraulic opening should be no smaller than **14ft** to meet bankfull width of the natural channel.

In addition to this, I'm fairly certain that this location will need to meet AOP guidelines, meaning that the structure installed will have to allow for fish passageway. I understand that this will most likely be very difficult due to the large drop at the outlet.

If you want, I can reach out to fisheries and see if they have time to visit this location and determine if the natural drop could be considered a "natural barrier" and then the structure would not have to meet AOP standards.

Let me know if you have any questions, and/or if you would like me to reach out to fisheries. If this is something you would prefer to do, I can give you their contact information.

Rachel Czar|River Management Engineer
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RE: Starksboro, TH-28, Ireland Road, C067-14, Hydraulics Memo



Czar, Rachel <Rachel.Czar@vermont.gov>

To  Amanda Vincent



1/20/202



You replied to this message on 2/3/2026 12:59 PM.

Hi Amanda,

Yes I have heard from fisheries.

They have determined that AOP will most likely be required at this location. Even though this area is steep, it does not fall under a natural fish barrier since it is more of a cascade and not a free fall. AOP should be considered for this project.

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