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*Agency of Transportation*

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**CC:** Jaron Borg, ANR River Management Engineer  
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**FROM:** Madeline Glow, Hydraulics Project Engineer

**DATE:** August 21, 2024

**SUBJECT:** East Montpelier, TH-18 (Horn of the Moon Road), over Long Meadow Brook to the North Branch Winooski River  
Site location: B18, 230 feet east of TH-19 (Sanders Circle)  
Coordinates: [44.325361, -72.558556](#)

We have completed our hydraulic study for the above referenced site and offer the following for your use.

### **Hydrology**

The following physical characteristics are descriptive of this drainage basin:

Drainage Area	1.6 square miles
Land Cover	Forested, meadows, and residential parcels
Water Bodies and Wetlands (NLCD 2006)	2.7%

Using the USGS hydrologic method, the following design flow rates were selected:

Annual Exceedance Probability (AEP)	Flow Rate in Cubic Feet per Second (cfs)
50 %	61
10 %	130
4 %	170 Design Flow – Local Road
2 %	210
1 %	250 Check Flow

### **Channel Morphology**

The channel for this perennial stream is sinuous with an upstream stream slope of approximately 5% and a downstream channel slope of 3%. Field measurements of bankfull width varied from 16 to 19 feet upstream of the structure. The channel showed evidence of over widening due to flooding from Hurricane Beryl, so channel width measurements may not best represent typical flow conditions.

### **Existing Conditions**

The existing structure is an approximate 7.5-foot diameter corrugated metal pipe, providing a waterway opening of approximately 44 square feet.

During the site visit observations were made that most of the downstream side of the roadway had collapsed due to severe washouts from the flooding event. Additionally, a section of the outlet of the pipe had been separated from the rest of the structure and washed away further downstream. Our calculations, field observations and measurements indicate that while the existing structure does meet current standards of the VTrans Hydraulic Manual, it does not meet state stream equilibrium standards for bankfull width (span length).

This structure results in a headwater depth of approximately 4.7 feet at 4% AEP and 6.1 feet at the 1% AEP.

### **Replacement Recommendations**

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

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

- A steel structural plate pipe arch with a clear span of 195.4 inches and height of 130.2 inches. The invert should be buried 2 feet. This will result in a clear height of 8.9 feet above streambed, providing 114 square feet of waterway area. Bed retention sills need to be added with a height of 12 inches and filled with E-Stone Type II as described for the box below. This structure results in a headwater depth of 2.4 feet at 4% AEP and 3.1 feet at 1% AEP.
- A box culvert with an inside opening span of 16 feet and minimum height of 10 feet. The box invert should be buried 2 feet. This will result in a clear height of 8 feet above streambed, providing 128 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 2.4 feet at 4% AEP and 3.0 feet at 1% AEP.
- An open bottom arch with a minimum clear span of 16 feet and clear height of 8.3 feet, providing a waterway area of 105 square feet. E-Stone, Type II, will need to be used to build the channel through this structure. The bottom of abutment footings should be at least 6 feet below the channel bottom, or to ledge, to prevent undermining. This structure results in a headwater depth of 2.5 feet at 4% AEP and 3.2 feet at 1% AEP.

***Note:** 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. If an open bottom structure is installed, the VTrans Hydraulics Manual requires 1-foot freeboard at the design AEP.*

To match the approximate existing structure slope, the structures recommended above have been modeled with a culvert slope of 10%.

Stone Fill, Type III OR E-Stone, Type II 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.

Prior to any action toward the implementation of any recommendations received from VTrans, 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 always desirable for a new structure to have flared wingwalls, matched into the channel banks at the inlet and outlet, to smoothly transition flow and protect the structure and roadway approaches from erosion.

It is also recommended that full-height concrete headwalls be constructed at the inlet and outlet. 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. Any new structure should be properly aligned with the channel, span the natural channel width, and be constructed on a grade that matches the channel.

If an open bottom structure is installed, the bottom of abutment footings shall be at least 6 feet below the channel bottom, or to ledge, to prevent undermining. Abutments on piles should be designed to be free standing for a scour depth at least 6 feet below channel bottom. A scour evaluation is recommended for any 3-sided structure that has a shallow foundation (spread footings).

Please note that while a site visit was made, these recommendations were made without the benefit of a survey and are based on limited information.

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