VERMONT

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Agency of Transportation

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FROM: Cassidy Cote, Hydraulics Engineer
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DATE: September 16, 2019

SUBJECT: Weathersfield TH-11, Lottery Lane, over unnamed stream tributary of North Branch Black River
Site location 270 feet north of VT-131
GPS coordinates: N 43.409260°, W 72.503205°

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	3.6 square miles
Avg. Drainage Basin Slope	7.0 %
Water Bodies and Wetlands (NLCD 2006)	1.3 %

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

Annual Exceedance Probability (AEP)	Flow Rate in Cubic Feet per Second (cfs)	
43 %	160	
10 %	300	
4 %	400	Design Flow – Local Road
2 %	490	
1 %	580	Check Flow

Channel Morphology

The channel for this perennial stream is straight with an estimated local channel slope of 0.6-1.9%. Approximately 0.2 miles upstream of the structure, the channel runs through BR-11 beneath VT-131. Evidence of possible beaver activity was noted upstream, and incised channel banks were observed downstream. Wetlands are present on both sides of the crossing. Field measurements of bankfull width varied from 10 to 13 feet at a bankfull depth of 2 to 3.5 feet upstream and downstream of the structure.

The confluence of this brook with the North Branch Black River is 0.37 miles downstream of this structure. These hydraulic conditions indicate that the culvert in question may be affected by water backing up from the North Branch Black River during flood flows on that river. **Further analysis would be required to determine the extent of this possibility as this memo strictly addresses replacement options considering free flow conditions and environmental standards. Headwater depths may vary significantly as a result of backwater developed by the North Branch Black River and/or available floodplain storage.**

Existing Conditions

The existing structure is a corrugated metal pipe arch with a clear span of approximately 72.2 inches and a clear height of 44.4 inches, providing a waterway opening of 17.5 square feet. The inlet has observed scour, particularly on channel right, measuring 0.9 ft. below the inlet invert. An outlet scour pool is present downstream. Scour pools on both sides of the crossing have resulted in the presence of standing water through this crossing.

Our calculations, field observations and measurements indicate the existing structure does not meet current standards of the VTrans Hydraulic Manual nor does the existing structure meet 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 lead to erosion and failure of channel banks. This structure results in water overtopping the roadway prior to the 43% AEP.

Replacement Recommendations

In sizing a new structure, we attempt to select structures that meet both the current VTrans hydraulic standards, state environmental standards regarding span length and opening height, and allow for roadway grade and other site constraints. Please note that the tools implemented to produce these recommendations are most applicable to steeper gradient well defined streams. Due to the proximity of wetlands, a smaller structure than recommended may be adequate for this crossing, however this would require a more detailed study and/or input from regulators.

The low height from the streambed to the road may limit the replacement options to a box structure, as the roadway could have to be raised substantially for the pipe arch recommended below. This option is not recommended as an increase in roadway elevation could create a dam, thereby increasing the extent of flooding upstream. Manufacturers can provide specific recommendations regarding minimum and maximum fill heights and required pipe thickness. 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 13 feet and minimum height of 7 feet. The box invert should be buried 2 feet. This will result in a clear height of 5 feet above streambed, providing 65 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. **It is anticipated that the roadway profile will need to be raised to install this structure.** Using an elevated roadway, this structure results in a headwater depth of 5.3 feet at 4% AEP and 7.1 feet at 1% AEP.

- A pipe arch with a clear span of 154.4 inches and height of 99.7 inches. The invert should be buried 24 inches. This will result in a clear height of 75.7 inches above streambed, providing 64 square feet of waterway area. Bed retention sills need to be added and filled as described for the box above**. It is anticipated that the roadway profile will need to be raised to install this structure.** Using an elevated roadway, this configuration results in a headwater depth of 6.1 feet at 4% AEP and 8.3 feet at 1% AEP.

Note: *Any similar structure that fits the site conditions could be considered. Please contact the VTrans Hydraulics Section with alternatives that have significantly different inlet geometry so headwater depths may be calculated. Any structure with a closed bottom should have bed retention sills and a buried invert as described above.*

Stone Fill, 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. Stone fill should not constrict the channel or structure opening.

Prior to any action toward the implementation of any recommendations received from VTrans, stream type and structure size must be confirmed, and may be modified, by the VT ANR River Management Engineer to ensure compliance with state environmental standards for stream crossing structures. Regulatory authorities including the US Army Corps of Engineers may have additional concerns or requirements regarding this structure. This crossing is within a mapped FEMA flood insurance study floodplain.

General Comments

The new structure should be properly aligned with the channel, span the natural channel width, and be constructed on a grade that matches the channel. It is always desirable for a 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 be equipped with cutoff walls, extending a depth equal to the culvert rise, up to 4 feet below the streambed, or to ledge, to serve as undermining prevention.

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. 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.