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**TO:** Chris Bump, District 4 Project Manager

**CC:** Jaron Borg, ANR River Management Engineer
Ben Matthews, ANR River Management Engineer

**FROM:** Keith Friedland, Hydraulics Technician

**DATE:** October 9, 2023

**SUBJECT:** Chelsea TH-3, Brook Road, Cram Brook tributary to First Branch White River
Site location: 0.6 miles NW of TH-33, Pent Road
Coordinates: 44.007206, -72.499291

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 | 1.0 square miles |
| Land Cover | Forest with fields, farms, and residences |
| Water Bodies and Wetlands (NLCD 2006) | 0.0 % |

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 % (Q2) | 52 | |
| 10 % (Q10) | 110 | |
| 4 % (Q25) | 150 | Design Flow – Local Road |
| 2 % (Q50) | 180 | |
| 1 % (Q100) | 220 | Check Flow |

## Channel Morphology

The channel for this perennial stream is straight to sinuous with an estimated local upstream channel slope of 1.2% and a downstream channel slope of 4%. Field measurements of bankfull width varied from 8 to 16 feet at a bankfull depth of 1 to 3 feet upstream and downstream of the structure.

## Existing Conditions

The existing structure is a corrugated metal pipe arch with a clear span of 5.7 feet and a clear height of 4 feet, providing an approximate waterway opening of 19 square feet. 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.

The existing structure results in water overtopping the roadway before the 4% 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 low height from the streambed to the road might limit the replacement options. Pipe 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 culvert with an inside opening span of 12 feet and minimum height of 6.5 feet. The box invert should be buried 2 feet. This will result in a clear height of 4.5 feet above streambed, providing 54 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 2.9 feet at 4% AEP and 3.8 feet at 1% AEP.

- A metal box culvert with an inside opening span of 12.4 feet and minimum height of 6.6 feet. The box invert should be buried 2 feet. This will result in a clear height of 4.6 feet above streambed, providing approximately 43 square feet of waterway area. Bed retention sills need to be added and filled as described for the concrete box above. This structure results in a headwater depth of 3.4 feet at 4% AEP and 4.4 feet at 1% AEP.

- An open bottom arch with a minimum clear span of 12 feet and clear height of 5 feet, providing a waterway area of 45 square feet. E-Stone, Type II, may 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 3.4 feet at 2% AEP and 4.4 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 a minimum of 1-foot of freeboard at the design AEP.*

To match the approximate local stream slope, the structures recommended above have been modeled with a culvert slope of 3%. With this slope, the channel at the 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.

Stone Fill, Type II should be used to protect any disturbed channel banks or roadway slopes at the structure inlet, up to a height of at least one-foot above the top of the opening. Stone Fill, Type III should be used to protect any disturbed channel banks at the structure outlet. 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, and may be modified, 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. E-Stone thickness plus the bottom of structure thickness should be included when determining the total cutoff wall depth.

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.

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.

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. We can always check other options if the town settles on something not noted above.