VERMONT

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Agency of Natural Resources

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AUTHORIZATION TO CONDUCT NEXT FLOOD MEASURES

Pursuant to Section F of the Vermont Stream Alteration General Permit

Project Number: **NFM-04-1882-2019**

Applicant Name: Town of Westford c/o Nanette Rogers Town Clerk Phone: 802-878-4587

Mailing Address: 1713 Vermont Route 128, Westford, VT 05494

Project Location: Rogers Brook, Rogers Road; 44.6079°N, -73.0515°W

Email: townclerk@westfordvt.us

The Secretary of the Vermont Agency of Natural Resources (VT ANR) has determined that:

1. This authorizes the replacement of a failing 48" diameter CMP with a new 14'-3" x 8'-11" pipe arch embedded 3'.
2. The proposed activity is eligible for coverage under the VT ANR Stream Alteration General Permit – Next Flood Measures.
3. The proposed activity will meet the terms and conditions of Section E of the General Permit provided:
   a) The project will be completed as shown on the report prepared by Fitzgerald Environmental, and is included with this authorization.
   b) The project is proportional to the threat and conditioned to cease when the threat to life or to improved property has ended.
   c) The project will not result in a threat to life, public health or safety.
   d) The project will meet the standards detailed in subsection E.2.1 and E.2.2 of the General Permit.
   e) The project will meet Stream Alteration Standards to the greatest extent possible.
   f) A pre-construction meeting is held between the contractor, owner/applicant, and the ANR River Management Engineer.
   g) The River Management Engineer is notified by phone, text or email when construction begins and when the project is complete.

If there are any changes in the project plan or deviation in construction from the plan, the Permittee must notify the River Management Engineer immediately.

If the project is constructed as you have described, as shown on the above referenced approved plans and according to the above conditions, there is no reason to expect any violation of Vermont Water Quality Standards.

Signed this 15th day of April, 2019
Emily Boedecker, Commissioner
Department of Environmental Conservation

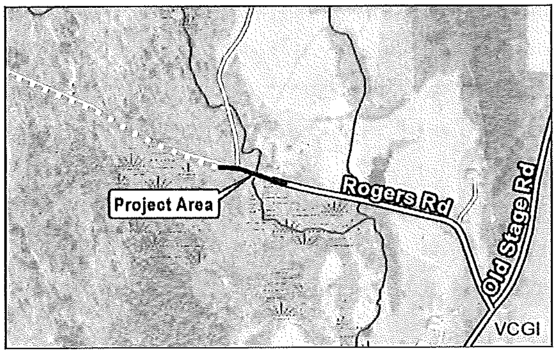
This authorization expires December 31, 2019

by: Christopher Brunelle
Chris Brunelle, River Management Engineer

ROGERS BROOK
(44.6079, -73.0515)

Town: Westford	**Road Name:** Rogers Road	**Date Visited:** 4/25 & 5/24, 2018

Road Segment IDs: 7080_Rogers_Rd_15



Existing Conditions
Field Determined Slope: 2-3%
Road Type: Gravel
Conveyance Area/Turnout: 3 Poor
Erosion Types Present: Gully, Rill
Drainage Culverts: 0
Driveway Culverts: 0
Stream Culverts: 1

Municipal Road General Permit Standards:
+ Meets Standard, -- Partially Meets Standard (needs work), ■ Does Not Meet Standard

Roadway Crown/Travel Lane	--	Grader Berm/Windrow	+
Road Drainage	--	Conveyance Area/Turnout	■
Municipal Drainage Culverts	+	Driveway Culverts (within ROW)	+

Existing Conditions Notes: Rogers Brook drains a mostly forested watershed with primarily D-type soils (i.e., limited infiltration) and flows through a 48" metal culvert under Rogers Road. The culvert has a 4% slope and a 0.5-foot outlet drop into a 2-foot deep pool. Based on the watershed area, hydraulic geometry regressions, and field observations we estimated the bankfull channel width to be between 12 and 14 feet. Runoff also follows the road from the Class 4 segment to the west, eroding a gully on the downstream side of the road. The undersized culvert has a perched outlet and portions of the CMP are completely rusted away. The upstream and downstream headers are unstable and collapsing. A new culvert could be installed to prevent further sedimentation of the stream, restore aquatic organism passage, and provide safe crossing for landowners seeking to access property across the brook. A culvert header should be installed that stabilizes the road around the culvert, and the road should be graded to direct runoff into stable conveyance areas.

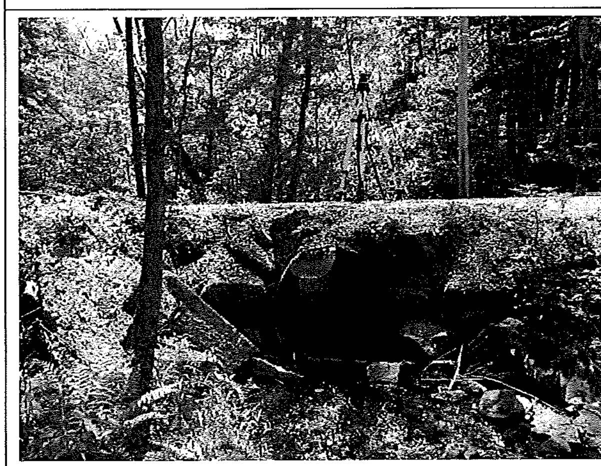


Photo 1: Inlet of the 48" culvert under Rogers Road.

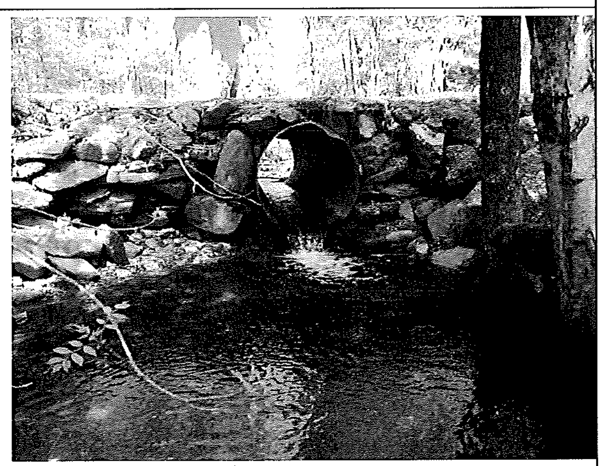


Photo 2: Perched culvert outlet with collapsing headwall.

Culvert Sizing Analysis

Field Survey

FEA completed a field survey at the Rogers Road culvert in May 2018. The culvert dimensions, cover depth, and culvert slope were measured in the field with laser surveying equipment. Elevations for longitudinal profile and four cross-sections (two upstream and two downstream, including the tailwater control) were also measured and referenced to LiDAR data for the site. Field verification efforts are very important for the construction of a hydraulic model from LiDAR derived Digital Elevation Models (DEMs), which are typically less accurate at stream crossings and along steep road embankments where the DEM may be adjusted to reflect the "bare earth" condition. Field measurements are necessary to adjust the LiDAR where it did not penetrate through the water to the channel bottom. The longitudinal profile for the existing and proposed structure is attached (Sheet 2).

Hydrology

FEA estimated flows expected at a range of flood magnitudes for Rogers Brook at the Rogers Road culvert. The 0.8-square mile (514-acre) is mostly forested with mainly D-type soils (low infiltration). The drainage area was delineated with USGS StreamStats software and verified with LiDAR-derived 2ft contours and hillshade mapping. The landcover and hydrologic soil groups for the upslope watershed were entered into the HydroCAD model (Weighted Curve Number = 76). Recurrence interval flow estimates were calculated based simulated rainfall depths from the Northeast Regional Climate Center (Table 1). The high runoff coefficients associated with D-type soils likely result in an overestimation of flow using the TR-20 method of calculation, so the StreamStats flows were used for culvert size analyses.

Table 1: Recurrence Interval Flow Estimates

Interval	Rainfall Depth (in)	StreamStats Flow (cfs)	TR-20 Flow (cfs)
2-year	2.20	30.5	84
5-year	2.67	49.6	139
10-year	3.09	64.7	195
25-year	3.75	87.2	291
50-year	4.34	107	384
100-year	5.03	128	497
500-year	7.09	187	853

Hydraulics

FEA completed a preliminary hydraulic capacity analysis for the stream culvert under Rogers Road. HEC-RAS 5.0.3 software (USACE,2016) was used to create a one-dimensional steady flow river and floodplain hydraulics model for 225 feet of Rogers Brook, approximately 100 feet upstream and downstream of the culvert. We assigned roughness values (Manning's N values) based on land cover from aerial imagery, and field survey observations. Roughness values ranged from 0.02 (corrugated metal pipe) to 0.08 (forest with underbrush) following Chow (1959) and Arcement et al. (1989). We ran a series of culvert sizing simulations in HEC-RAS to improve capacity and to reduce the outlet drop.

The capacity of the existing culvert in the HEC-RAS model is approximate 85 cfs, slightly under the 25-year StreamStats flow. Based on the HEC-RAS model for the site, a 14'3" by 8'11" pipe arch culvert embedded

3 feet is predicted to have a capacity of 345 cfs, large enough to contain the 500-year StreamStats flow and the 25-year TR-20 flow without overtopping the road (Figure 1). This sizing aligns with VTF&W guidance for culvert design (Bates & Kirn 2009), which recommends a culvert approximately the width of the bankfull bed plus the banks.

The VTF&W guidelines (Bates & Kirn 2009) recommend installing the culvert to a depth where the bottom is below the low vertical adjustment range profile and embedding the structure so the depth of material in the culvert is the greater of either 1.5 times the size of the largest immobile bed material or four times the size of the largest mobile particle. We estimate the largest immobile particle is 18"-24" in diameter, suggesting the culvert should be embedded 2-3 feet. At 3 feet of embedment the culvert still passed the 500-year StreamStats flow as well as the highly conservative 25-year TR-20 flow and requires less fill brought in to raise the road to adequately cover the structure.

The proposed work includes raising the road grade for approximately 90 feet with approximately 110 cubic yards of fill. The culvert is shown with 1.5 feet of cover to maintain an approach slope of approximately 5%. However, the Town should consider adding more cover if heavy construction equipment or increased traffic are expected. The Corrugated Steel Pipe Design Manual from the NCSPA presents a range of recommended minimum cover for a structure based on expected axle loads (NCSPA, 2008).

Anticipated flow velocities at the structure were in the range of 10-12 feet/second. A minimum of Type II stone (VTRANS) should be placed at the inlet and outlet of the culvert along the slopes adjacent the structure (Fischenich 2001). For added safety and stability, Type III stone is recommended.

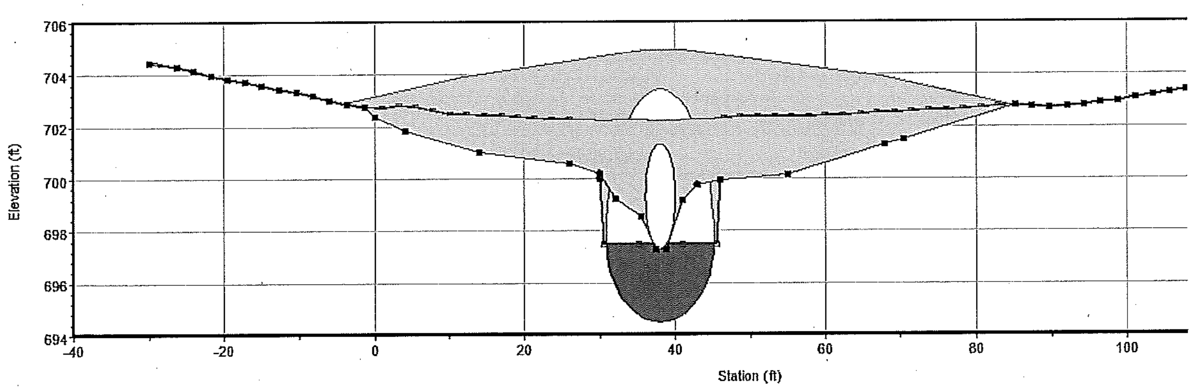


Figure 1: Existing (black outline) and proposed (pink outline) culvert profiles for the Rogers Brook stream crossing at Rogers Road.

Proposed Scope of Work

Roadway/Travel Lane Practices

	Improve Road Crown	X	Adjust Road Grade
X	Remove Grader Berm/Lower Shoulder	X	Edge of Road Stabilization/Maintenance

Roadway Drainage Practices

	Install New Ditch		Improve Existing Ditch
	Side Slope Excavation for New Ditch		

Conveyance/Turnout Practices

	Install Turnout	X	Stabilize/Improve Existing Turnout
	Install Sediment Trap		Stone Armor on Bank/Slope
	Install Check Dams in Existing Feature		

Culvert Practices

X	New Municipal Culvert	X	Upgrade Municipal Culvert
	New Driveway Culvert		Upgrade Driveway Culvert
X	Headwall or Armor at Culvert Inlet/Outlet		Clean Sediment/Debris from Culvert

Estimated Project Costs

Practice	Units	Unit Cost	Quantity	Total
Improve Road Crown	Linear Foot	$ 5		$ -
Raise Road Grade	Cubic Yard	$ 15	110	$ 1,650
Remove Grader Berm/Lower Shoulder	Linear Foot	$ 5	50	$ 250
Edge of Road Stabilization/Maintenance	Linear Foot	$ 8	125	$ 1,000
New Stone-Lined Ditch	Linear Foot	$ 25		$ -
New Grass-Lined Ditch	Linear Foot	$ 8		$ -
Side Slope Excavation for New Ditch	Linear Foot	$ 10		$ -
Improve Existing Ditch (Stone)	Linear Foot	$ 20		$ -
Improve Existing Ditch (Grass)	Linear Foot	$ 5		$ -
Install/Improve Turnout	Each	$ 200	4	$ 800
Install Sediment Trap	Each	$ 750		$ -
Install Stone Armor (Bank/Slope)	Cubic Yard	$ 40		$ -
Install Check Dam	Each	$ 40		$ -
New/Upgrade Cross-Culvert (18" to 24")	Foot	$ 1,500		$ -
New/Upgrade Conveyance Culvert	Each	$ 15,000	1	$15,000
New/Upgrade Driveway Culvert	Each	$ 750		$ -
Install Culvert Headwall/Armor	Each	$ 2,500	1	$ 2,500
Remove Sediment/Debris from Culvert	Each	$ 100		$ -
			Total Cost:	**$21,200**

*Stream culvert price estimate includes removal of the existing culvert, excavation of road and upslope channel, installation of gravel bedding, 14'3" by 8'11" pipe arch culvert (10 gauge), and site restoration. The cost of the culvert was based on bids received by USFW in 2010 for a culvert of this size, which ranged from $350 to $828 per foot ($7,000-$16,500).

References

Arcement, George J., and V.R. Schneider, 1989. Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains. USGS Paper 2339.

Bates, Kozmo Ken, and Kirn, Richard, 2009. Guidelines for the Design of Stream/Road Crossings for Passage of Aquatic Organisms in Vermont. Prepared for the Vermont Department of Fish and Wildlife.

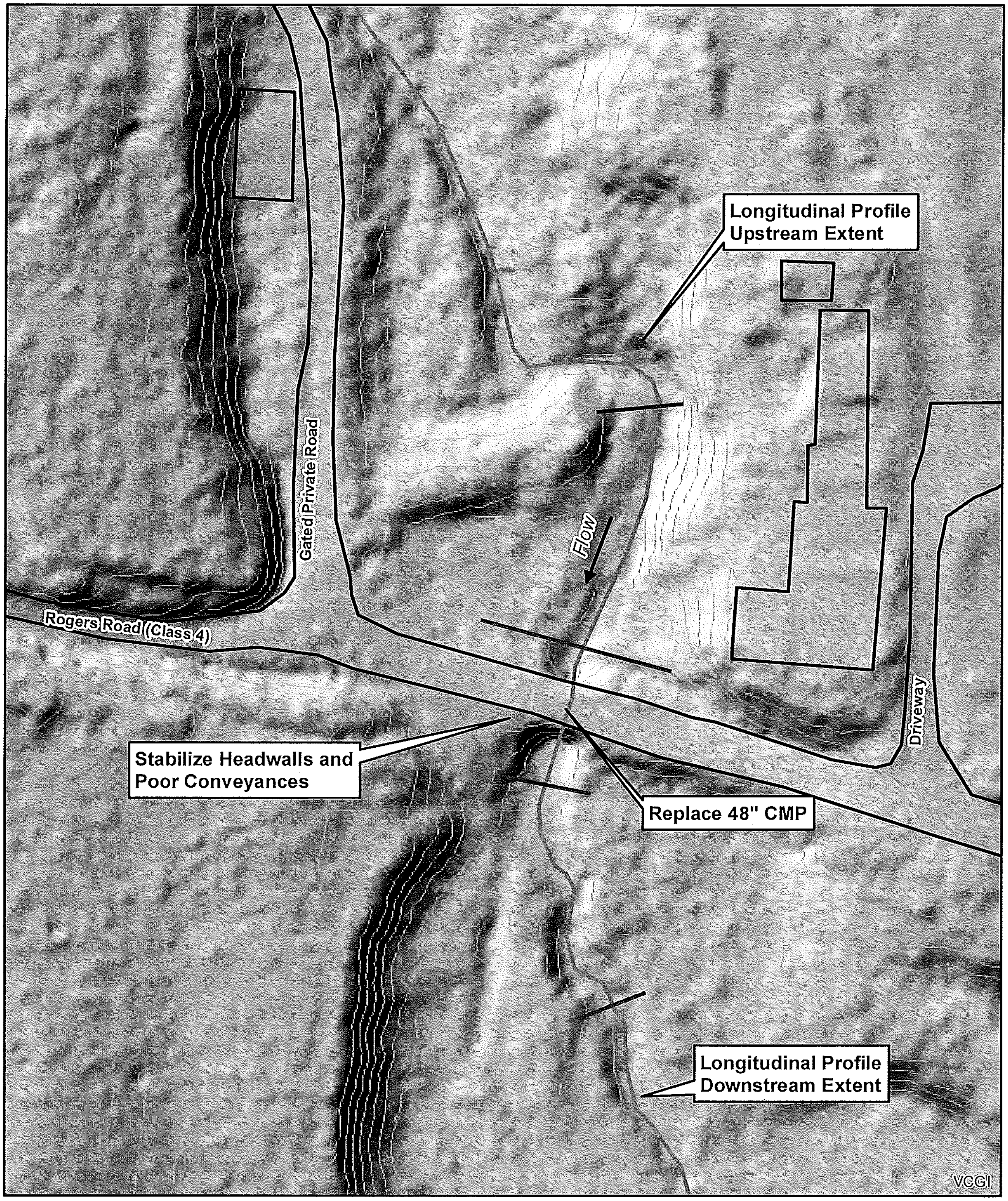
Chow, V.T., 1959. Open Channel Hydraulics. New York, NY: McGraw-Hill Book Co.

Fischenich, Craig, 2001. Stability Thresholds for Stream Restoration Materials. US Army Corps of Engineers Defense Technical Information Center Document.

NCSPA (National Corrugated Steel Pipe Association), 2008. Corrugated Steel Pipe Design Manual. Available at: https://ncspa.org/wp-content/uploads/2016/07/2ndedncspsacspdm.pdf

Olson, S. A., 2014, Estimation of Flood Discharges at Selected Annual Exceedance Probabilities for Unregulated, Rural Streams in Vermont, United States Geologic Survey, USGS Scientific Investigations Report 2014-5078.

USACE (US Army Corps of Engineers), 2016. HEC-RAS River Analysis System, Version 5.0.3. Available at: http://www.hec.usace.army.mil/software/hec-ras/documentation.aspx



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SHEET 1
Rogers Road
Concept Plan

Westford, VT

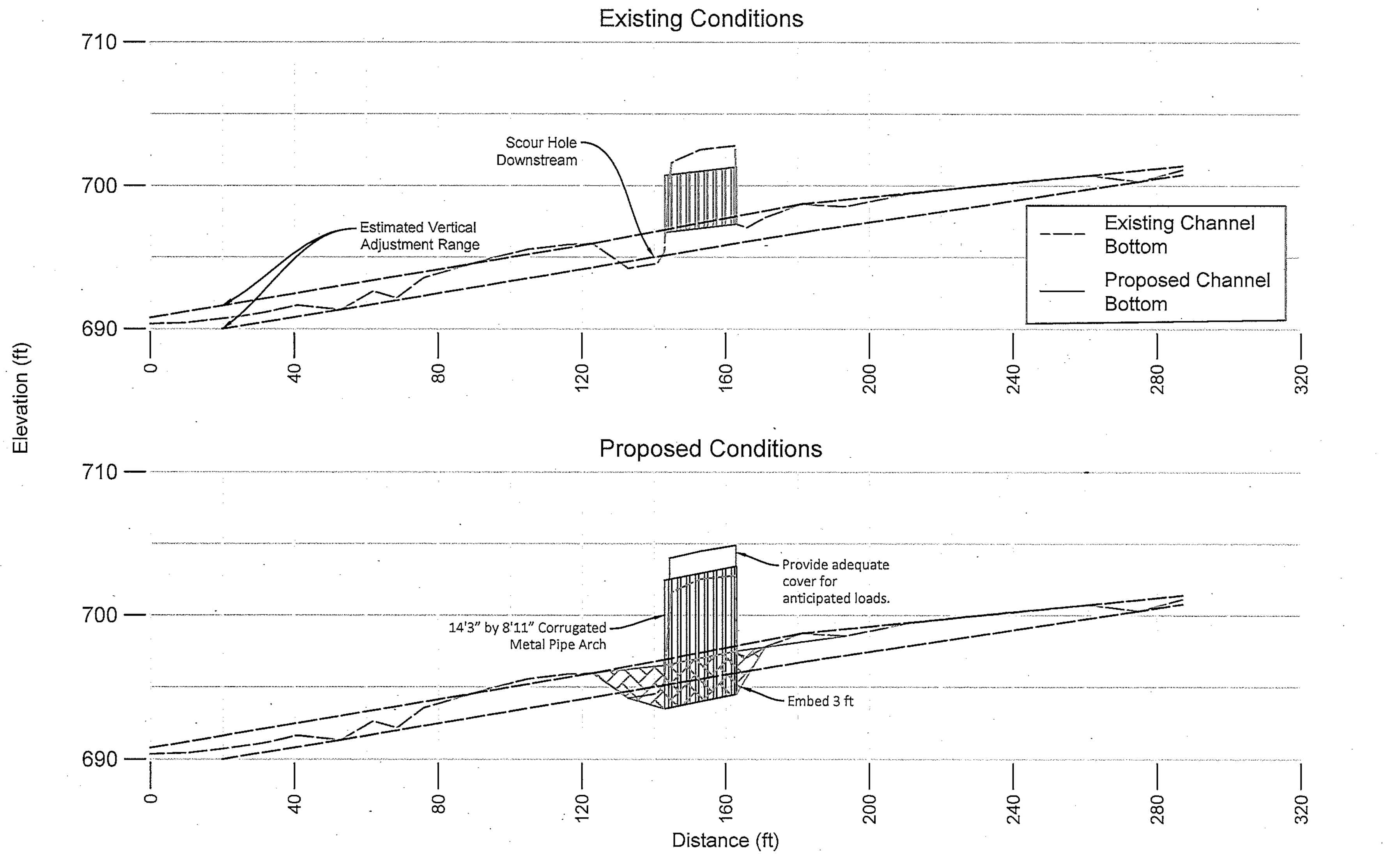
Cross Sections
Stream Centerline
2-Foot Contours (LiDAR)

0 25 50 Feet
1 inch = 50 ft

N

Notes:
- Watershed delineation from StreamStats (USGS).
- Imagery from VCGI.

Date: June 19, 2018 **Drawn:** EHB



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Rogers Road Concept Design
Westford, VT

SHEET 2: Rogers Brook Longitudinal Profile

Vertical Scale: 1"=10'
Horizontal Scale: 1"=40'
June 19, 2018
Drawn: EHB
Checked: EPF