Attachment A

Memorandum of Agreement Between Vermont Agency of Transportation and Vermont Agency of Natural Resources

Attachment B

Hydrologic Analysis

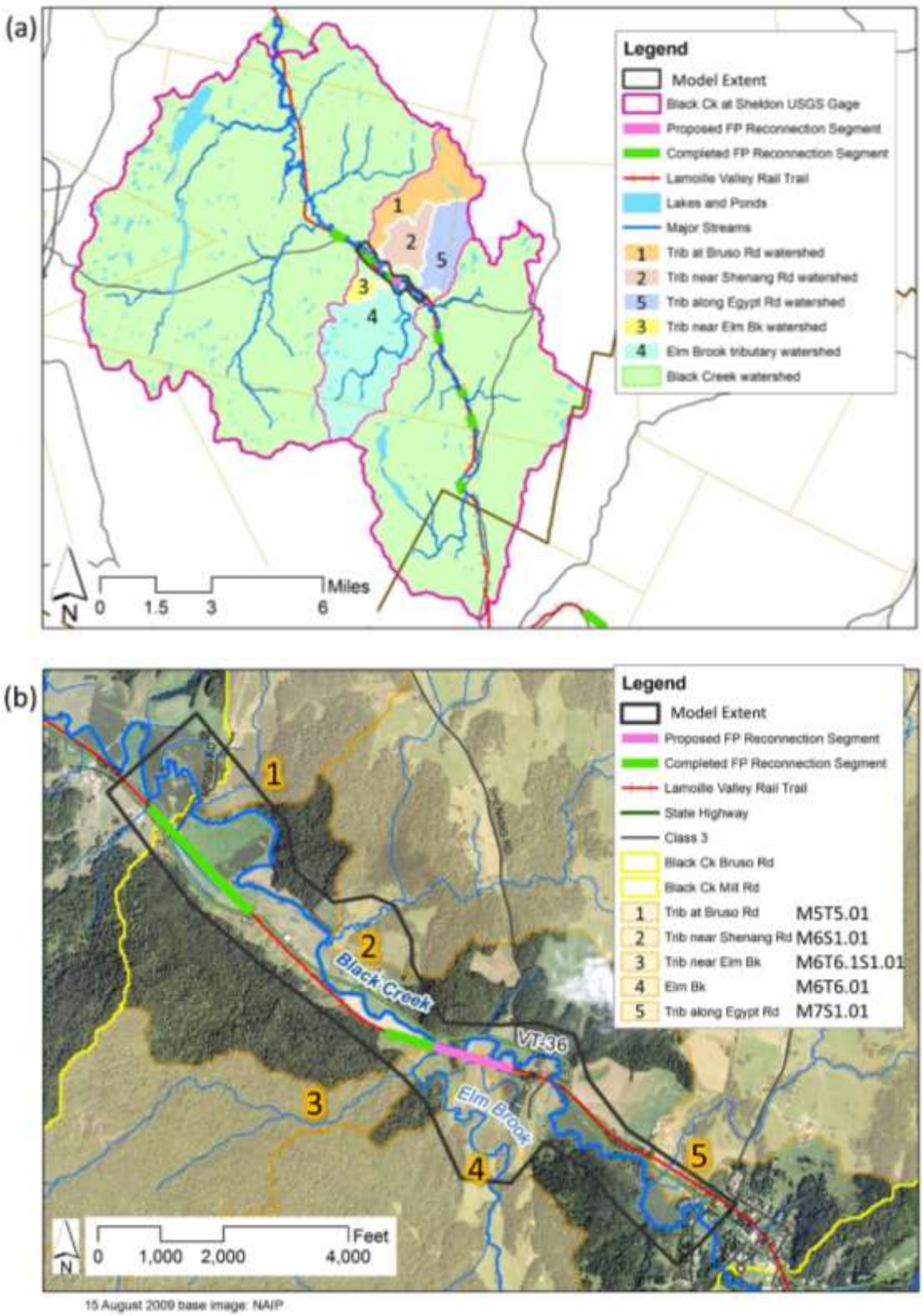


Figure B-1. Location of (a) hydraulic model domain within Black Creek watershed; and (b) major tributaries joining the Black Creek within model domain.

Table B-1. Summary of Basin Characteristics and Peak Flows for Study Area and Tributaries.

		A	B	C	D	1	2	3	4	5
		Black Ck at Missiquoi	Black Ck at UGSG Gage at Sheldon	Black Ck at Bruso Rd	Black Ck at Mill Rd	Trib at Bruso Rd	Trib near Shenang Rd	Trib near Elm Bk	Elm Brook	Trib along Egypt Rd
Latitude		44.89483	44.8806	44.80442	44.78375	44.80411	44.79819	44.79304	44.79309	44.78773
Longitude		-72.94381	-72.94276	-72.89328	-72.86075	-72.89281	-72.88489	-72.8791	-72.87678	-72.86495
Date Streamstats Accessed		11/13/2018	11/11/2018	11/10/2018	11/10/2018	11/11/2018	11/11/2018	11/11/2018	11/2/2018	11/11/2018
Basin Characteristics										
Parameter Code	*Unit*									
DRNAREA	square miles	120	119	53.2	36.3	3.45	1.67	0.49	7.61	2.36
LC06STOR	percent	4.08	4.1	2.23	2.94	1.4	0	1.05	0.56	0.27
PRECPRIS10	inches	44	44	45.8	46	45.7	43.8	44	46.1	44.9
CENTROIDX	feet	467572.7	467589.9	472282.3	473268.6	471593.5	470723.5	468753.7	468811.8	472323.3
CENTROIDY	feet	254015.6	253928.5	250315	248373.1	258767.4	256503.6	254404.6	251478.6	256283.9
EL1200	percent	4.85	4.89	8.67	10.4	4.15	0	0.69	8.99	0.2
LC11DEV	percent	3.99	3.89	3.39	3.36	2.63	3.37	0	2.08	3.75
LC11IMP	percent	0.72	0.69	0.51	0.49	0.11	0.3	0	0.33	0.45
OUTLETX	feet	464945	465015	468885	471445	468925	469545	470005	470185	471115
OUTLETY	feet	266165	264585	256095	253795	256065	255405	254835	254835	254235
Peak-Flow Statistics Flow Report										
2 Year Peak Flood	ft^3/s	2620	2590	1520	1030	140	86.6	23.8	325	115
5 Year Peak Flood	ft^3/s	3930	3890	2320	1570	223	140	39	513	185
10 Year Peak Flood	ft^3/s	4890	4850	2920	1990	288	182	51.3	660	240
25 Year Peak Flood	ft^3/s	6290	6240	3800	2600	385	245	69.6	878	323
50 Year Peak Flood	ft^3/s	7460	7400	4540	3110	469	301	85.7	1070	395
100 Year Peak Flood	ft^3/s	8680	8610	5330	3660	561	362	104	1270	474
200 Year Peak Flood	ft^3/s	10000	9950	6210	4260	663	431	124	1500	563
500 Year Peak Flood	ft^3/s	12000	11900	7520	5160	815	535	154	1850	697

Table B-1. (continued) (Abbreviations)

Parameter Code	*Parameter Description*	*Unit*
DRNAREA	Area that drains to a point on a stream	square miles
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	percent
PRECPRIS10	Basin average mean annual precipitation for 1981 to 2010 from PRISM	inches
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	feet
CENTROIDY	Basin centroid vertical (y) location in state plane units	feet
EL1200	Percentage of basin at or above 1200 ft elevation	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	percent
OUTLETX	Basin outlet horizontal (x) location in state plane coordinates	feet
OUTLETY	Basin outlet vertical (y) location in state plane coordinates	feet

Table B-2. Characteristics of USGS Streamflow Gauges used in Hydrologic Analysis

		Black Creek at Sheldon, VT [6]	Missisquoi R. at East Berkshire, VT [7]	Lamoille R. at Johnson, VT [7]
USGS Streamflow Gauge		# 04293795	# 04293500	# 04292000
Period of Record		2009-2011	1990-pres	1910-pres
Basin Characteristics				
Drainage Area	sq mi	119	479	310
Gauge Elevation	ft	340.4	402.5	506.7
Percent Storage [1]	%	4.1	1.01	3.5
Mean Annual Precipitation [2]	inches	44	50.8	45.6
Basin elevation above 1200 ft [3]	%	4.89	35.2	63.6
Percent Forest [8]	%	NA	45.0	68
Percent Development [4]	%	3.9	2.1	4.8
Percent Impervious [5]	%	0.69	3.6	0.94
Peak-Flow Statistics				
2 Year Peak Flood	cfs	2,590	10,100	7,270
5 Year Peak Flood	cfs	3,890	13,500	9,640
10 Year Peak Flood	cfs	4,850	15,900	11,300
25 Year Peak Flood	cfs	6,240	19,400	13,400
50 Year Peak Flood	cfs	7,400	22,100	15,100
100 Year Peak Flood	cfs	8,610	25,100	16,700
200 Year Peak Flood	cfs	9,950	28,300	18,500
500 Year Peak Flood	cfs	11,900	32,900	20,900

Notes:

1 Percentage of water bodies and wetlands determined from the NLCD 2006

2 Basin average mean annual precipitation for 1981 to 2010 from PRISM

3 Percentage of basin at or above 1200 ft elevation

4 Percentage of developed (urban) land from NLCD 2011 classes 21-24

5 Average percentage of impervious area determined from NLCD 2011 impervious dataset

6 Peak flows generated in Streamstats from regression equations of Olson (2014).

7 Peak flows estimated as presented in App 3 of Olson (2014).

8 StreamStats Data-Collection Stations Report accessed 12/28/2018 at:
https://streamstatsags.cr.usgs.gov/gagepages/html/04292000.htm
https://streamstatsags.cr.usgs.gov/gagepages/html/04293500.htm

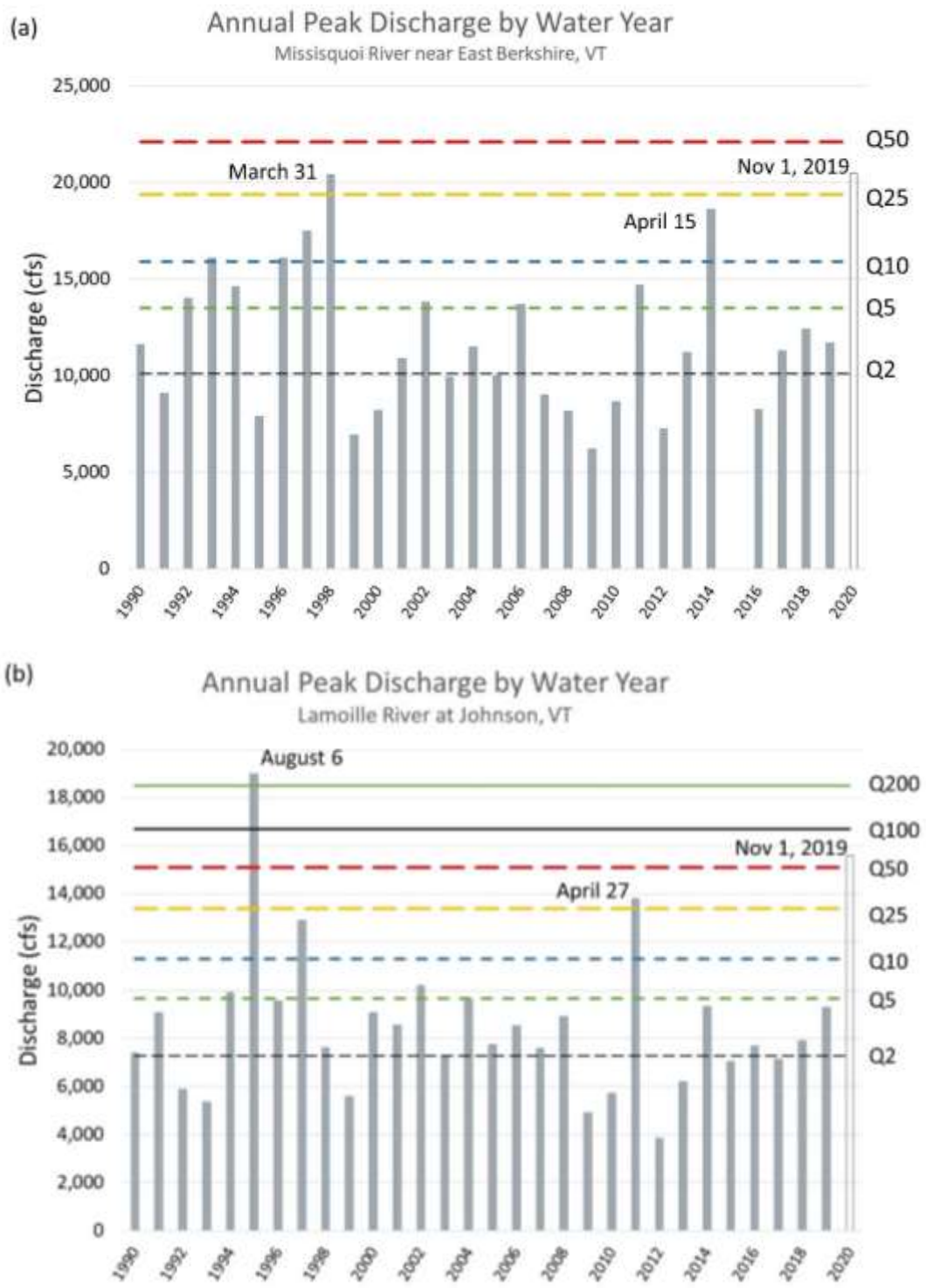


Figure B-2. Annual peak discharge recorded at USGS stream flow gauges on the (a) Missisquoi River at East Berkshire and (b) Lamoille River at Johnson. "Halloween storm" of November 1, 2019 is presented as maximum of provisional discharge recorded through 30 June 2020. Peak flow magnitudes, shown in colored dashed lines, are sourced from Appendix 3 of Olson (2014).

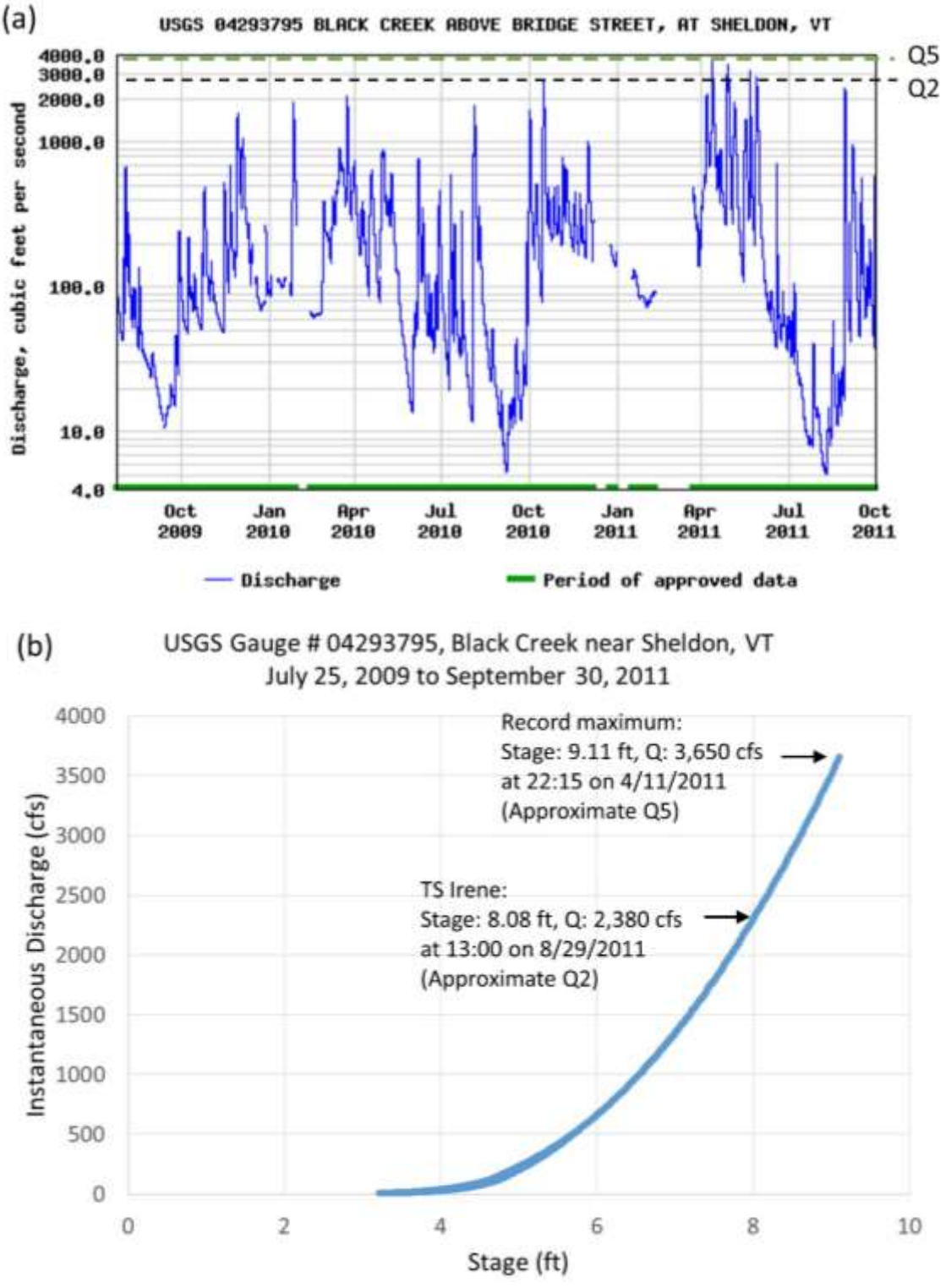


Figure B-3. USGS streamflow gauge on Black Creek at Sheldon (#04293795) operated from 25 July 2009 through 30 September 2011. The maximum discharge recorded had an estimated 5-year return interval, as depicted on: (a) instantaneous discharge record (b) stage-discharge relationship.

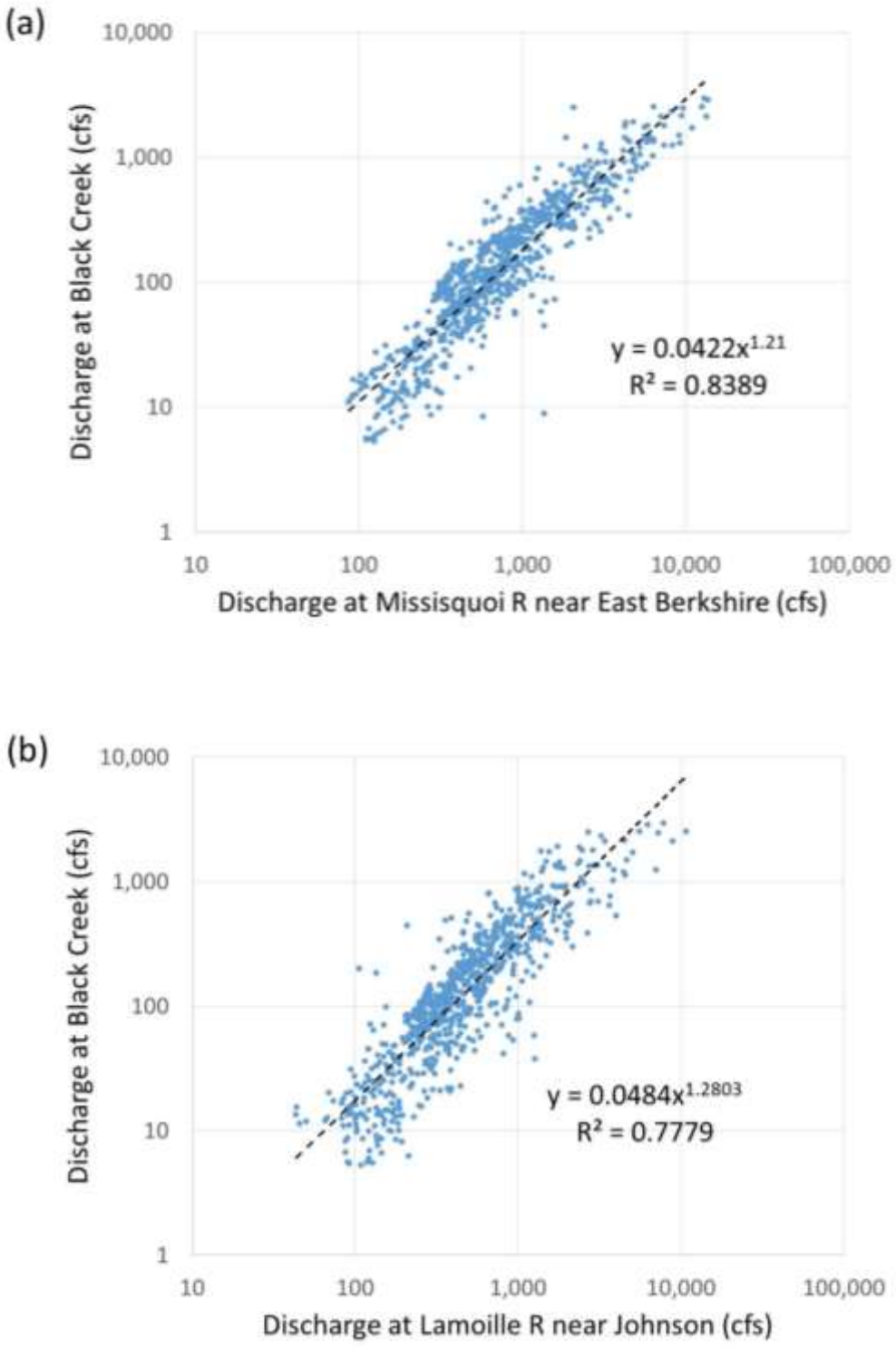


Figure B-4. Regression of daily mean discharge from USGS streamflow gauge on Black Creek at Sheldon (#04293795) on discharge at (a) Missisquoi River at East Berkshire and (b) Lamoille River near Johnson for the period from 25 July 2009 through 30 September 2011.

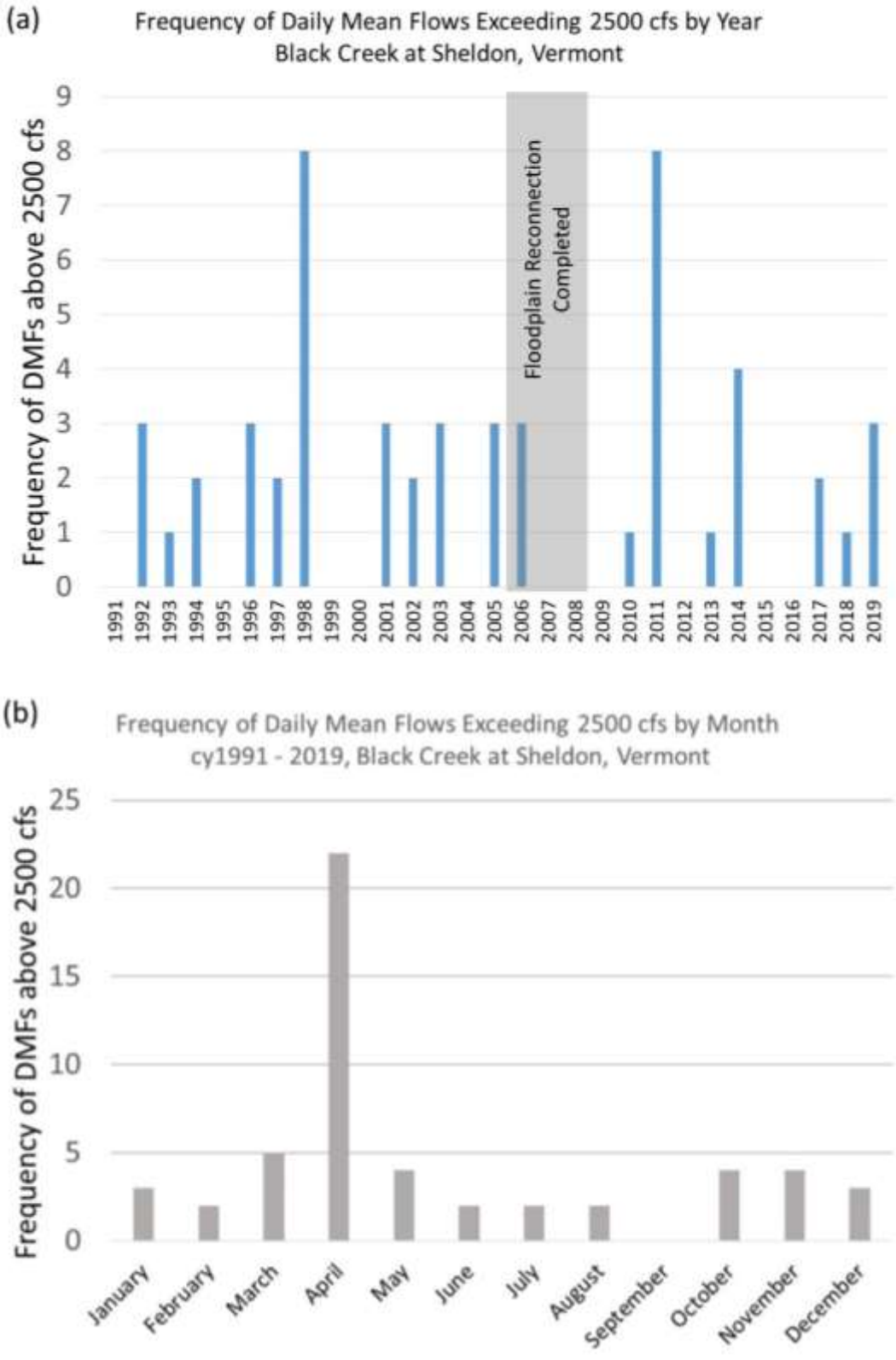


Figure B-5. Frequency of daily mean flow values above 2,500 cfs estimated for USGS streamflow gauge on Black Creek at Sheldon (#04293795) (a) by year (b) by month. Daily mean flow values estimated from a regression relationship between Black Creek gauge and Missisquoi River near East Berkshire gauge.

Attachment C

History of Rail Line and Channel/Floodplain Modifications near Fairfield 2b site, Fairfield, VT.

Table C-1. History of Rail line and Channel/Floodplain Modifications Along Black Creek near Fairfield 2b site, Fairfield, VT

Date	Description	Source
1870 – 1877	Construction of the Lamoille Valley Railroad began in 1870 and was completed in 1877; first train on 7/27/1877.	Aldrich, 1891; Kendall, 1940
	Railroad construction cut off at least two principal meander bends of the Black Creek through the study area.	1941 aerial photographs
	Railroad in vicinity of Elm Brook confluence was completed by blasting a channel through bedrock to straighten the river and avoid building an additional RR bridge. The blasted rock was then used as foundation under the rail line east of the blasted section toward Elm Brook Rd.	Rainville, 2019 (who recalled 1980s conversation with Sterns Jenkins, VTrans, who provided this history)
	Railroad bridge crossing constructed at former Black Creek channel position now carrying discharge from Elm Brook and a smaller tributary	1916 railroad valuation sheet (Source: VTrans)
	Railroad bridge crossing of Black Creek near Elm Brook Rd (steel girders on wooden pilings) constructed through former position of Elm Brook Rd crossing – road alignment moved and new crossing constructed just downstream.	1916 railroad valuation sheet (Source: VTrans)
1880	Name of RR changed to St. Johnsbury and Lake Champlain Railroad. Later: Boston & Lowell RR	Aldrich, 1891
1891	Name had been changed to Boston & Maine RR by this date	Aldrich, 1891
1941	By this date, a segment of the road now known as VT Route 36 was straightened near the junction of Shenang Road and is now more set back from the Black Creek. At present (2019), the alignment of this abandoned road segment is still elevated above the natural floodplain, but is in active hay production. Ditching is evident in area of Elm Brook floodplain south of the rail line.	1941 aerial photograph
1962	Between 1941 and 1962, a farm bridge is constructed across the Black Creek channel at lands now owned by Sudol in the vicinity of the bedrock gorge created by blasting in the 1870s. Ditching is evident in area of Elm Brook floodplain south of the rail line.	1941 aerial photograph 1962 aerial photograph
1980 - 1986	Lee (farm owner previous to Mike Rainville) worked fields at Howe property for a landowner previous to Howe. Tim Brandon was hired to ditch along the base of the hill south of the RR tracks.	Rainville, 2019
1990s	Rainville leased lands from owner previous to Howe (Mr. Selmolina from Texas). Chronic beaver activity would flood the fields.	Rainville, 2019

1990s	Rainville decided to cease farming fields on south side of tracks and "let the beavers have it". By plugging culvert(s), the beavers impounded the south side to an elevation about 4 feet higher than fields on the north side of the rail line. Water was seeping through the rail bed (coarse blast rock) to impact fields on the north side of the rail line.	Rainville, 2019
1997	Last train on the Lamoille Valley rail line, following substantial damages sustained in the floods of 1984, 1995, and 1997.	Schiff et al, 2008
c. 1998	Rainville ditched the field along the north side of the RR to keep the field dry. He coordinated this activity with Sterns Jenkins of the VT Dept of Transportation.	Rainville, 2019
2005	"…the rail line was federally rail banked and the tracks and ties were removed."	Schiff et al, 2008
2007	Segments "Fairfield 3-1" and "Fairfield 4-1" of the rail bed were lowered to the floodplain. These segments are located downstream of the Howe/ Sudol properties, spanning Bruso Road and Ryan Road, respectively.	Schiff et al, 2008
2008	Segment "Fairfield 2a" of the rail bed was lowered to the floodplain on lands of Sudol.	Schiff et al, 2008
2009 - 2011	Between these years, two culvert crossings under the rail line between the Sudol bridge and Elm Brook Road were installed and/or replaced.	2009 NAIP imagery, 2011 orthophotograph, Rainville, 2019
	In the summer or fall of 2009, a previous pinched culvert was replaced with a larger-diameter culvert (Site J).	Brown, 2020 – historic photodocumentation
	In the fall of 2010, culvert (Site I) was installed and ditch drainage along the northern edge of the rail line was improved.	Brown, 2020 – historic photodocumentation

References:

Aldrich, Lewis Cass, Ed, 1891. History of Franklin and Grand Isle Counties, VT: with illustrations and biographical sketches of some of the prominent men and pioneers. Syracuse, NY: D. Mason & Co. Publishers.

Beers, F. W., 1871. Atlas of Franklin and Grand Isle Counties, Vermont. NYC, NY: F. W. Beers & Co.

Brown, Ken, 2020 (Feb 13). Personal communication and photographs. Vermont Association of Snow Travelers.

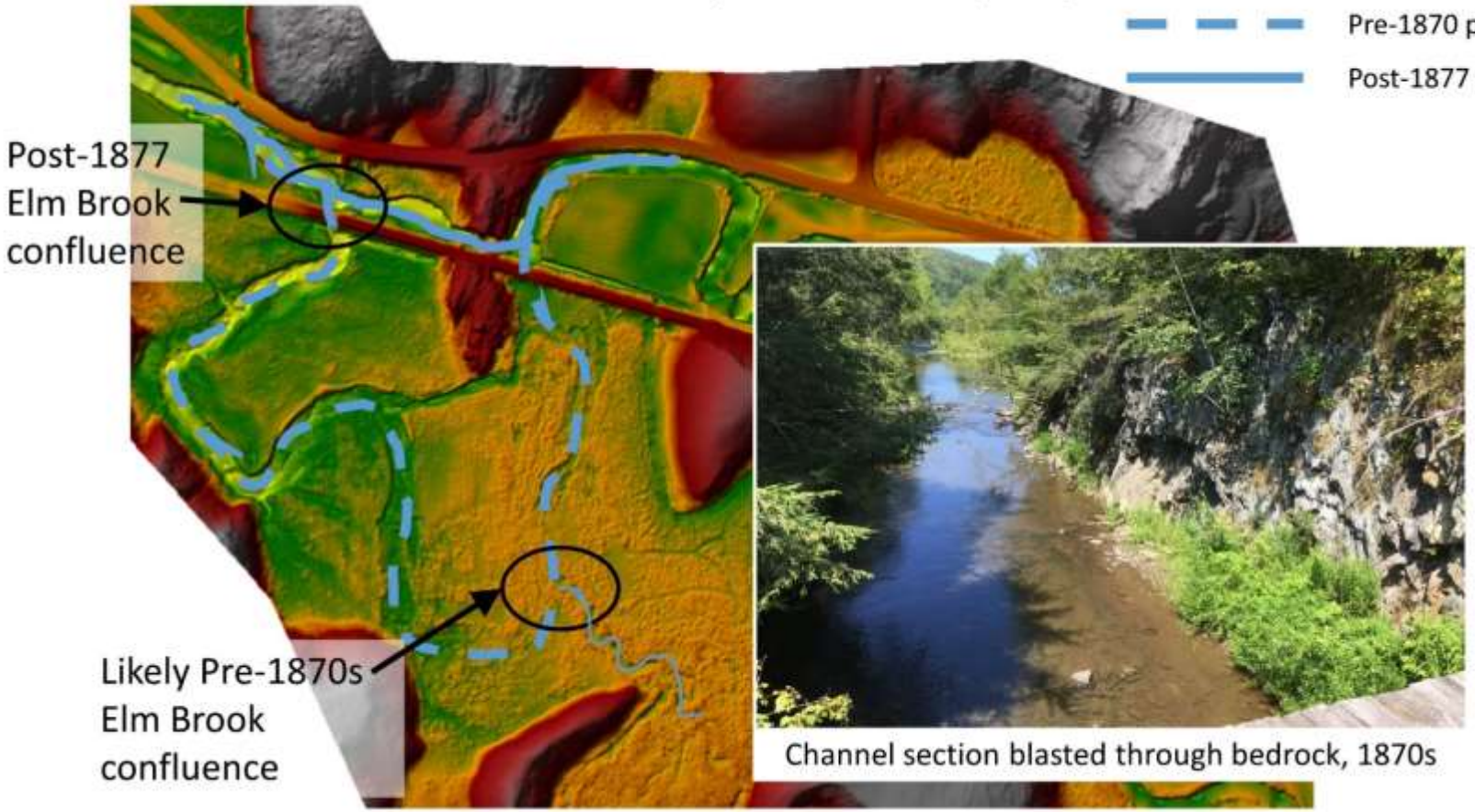
Kendall, John S., 1940. History of the St. Johnsbury & Lake Champlain Railroad.

Rainville, Mike, 2019 (July 24). Personal communication. Fairfield landowner and farmer who recalled conversations in the late 1980s with Sterns Jenkins, then Supervisor of rail issues with VT Dept of Transportation.

Schiff, R., Clark, J. and Cahoon, B., 2008. "The Lamoille River and Black Creek Floodplain Restoration Project", conference paper and presentation to the 2008 AWRA Summer Specialty Conference Riparian Ecosystems and Buffers, Virginia Beach, VA.

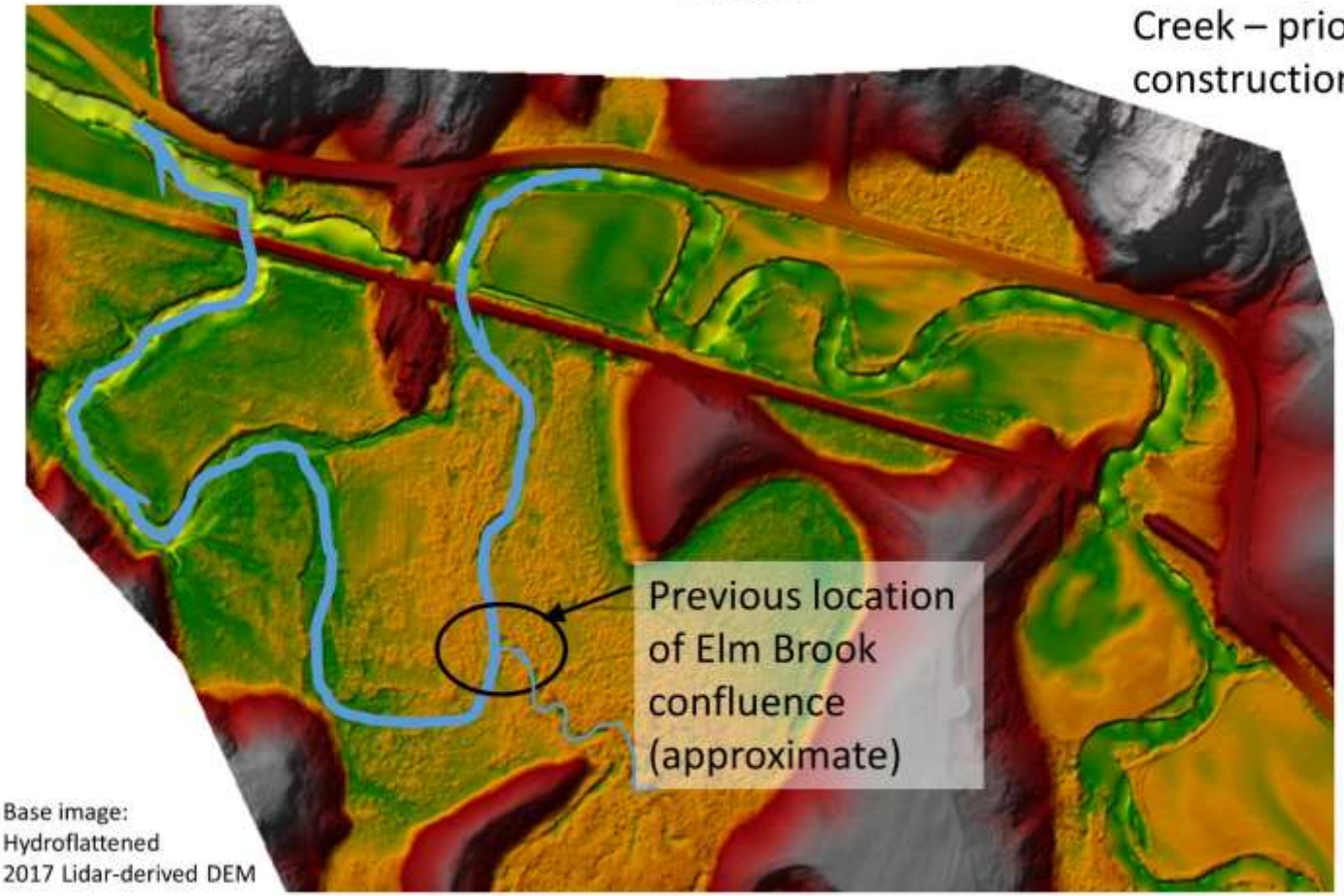
St. Johnsbury and Lake Champlain Railroad (Office of Valuation Engineer), 1916. Right-of-Way and Track Map: The St. Johnsbury and Lake Champlain R.R. Co.: Station 3922+80 to Station 3975+60.

Historic Path of Black Creek in Vicinity of Howe Property



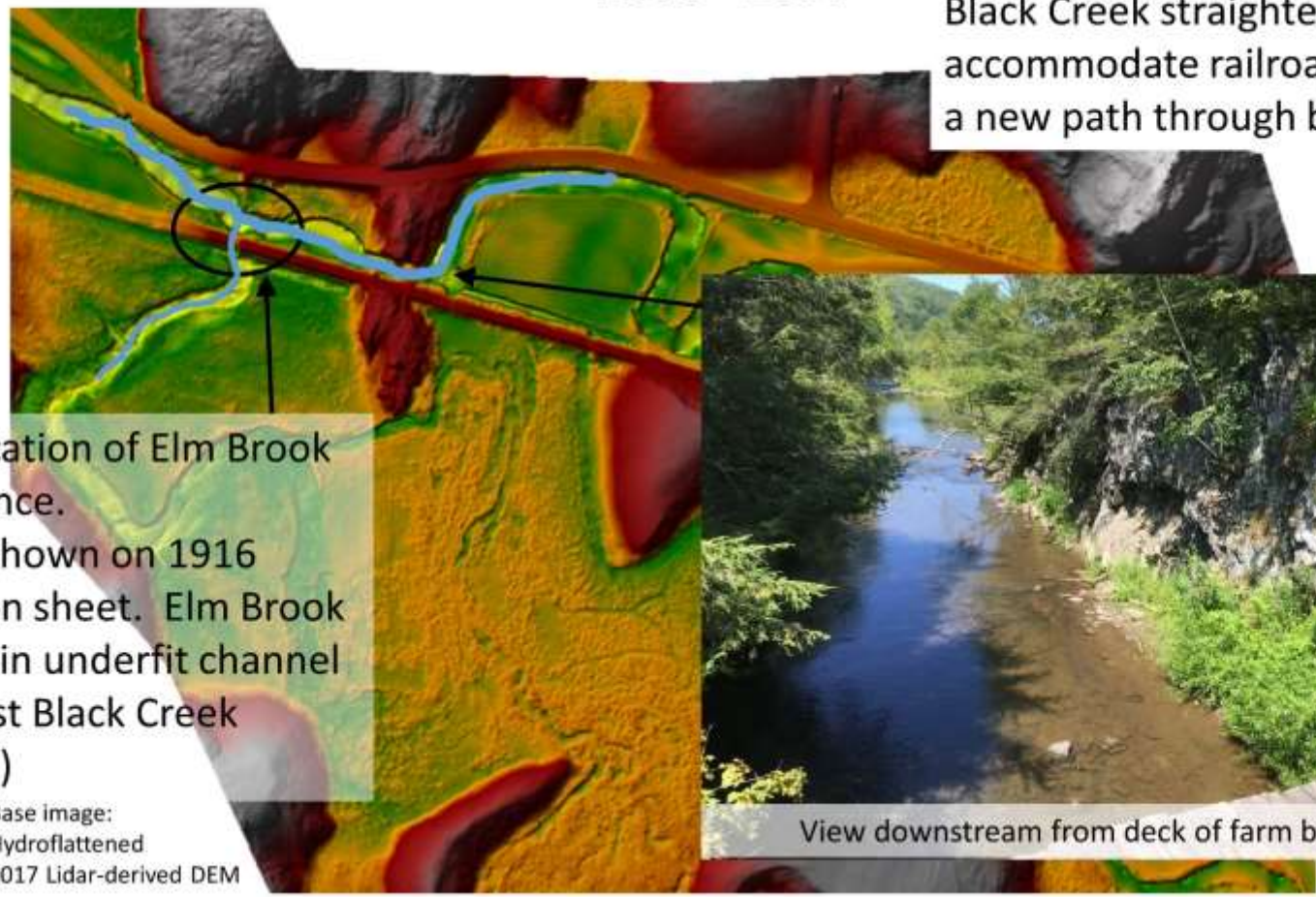
< 1870

Previous path of Black Creek – prior to construction of railroad



1870 - 1877

Black Creek straightened to accommodate railroad by blasting a new path through bedrock.



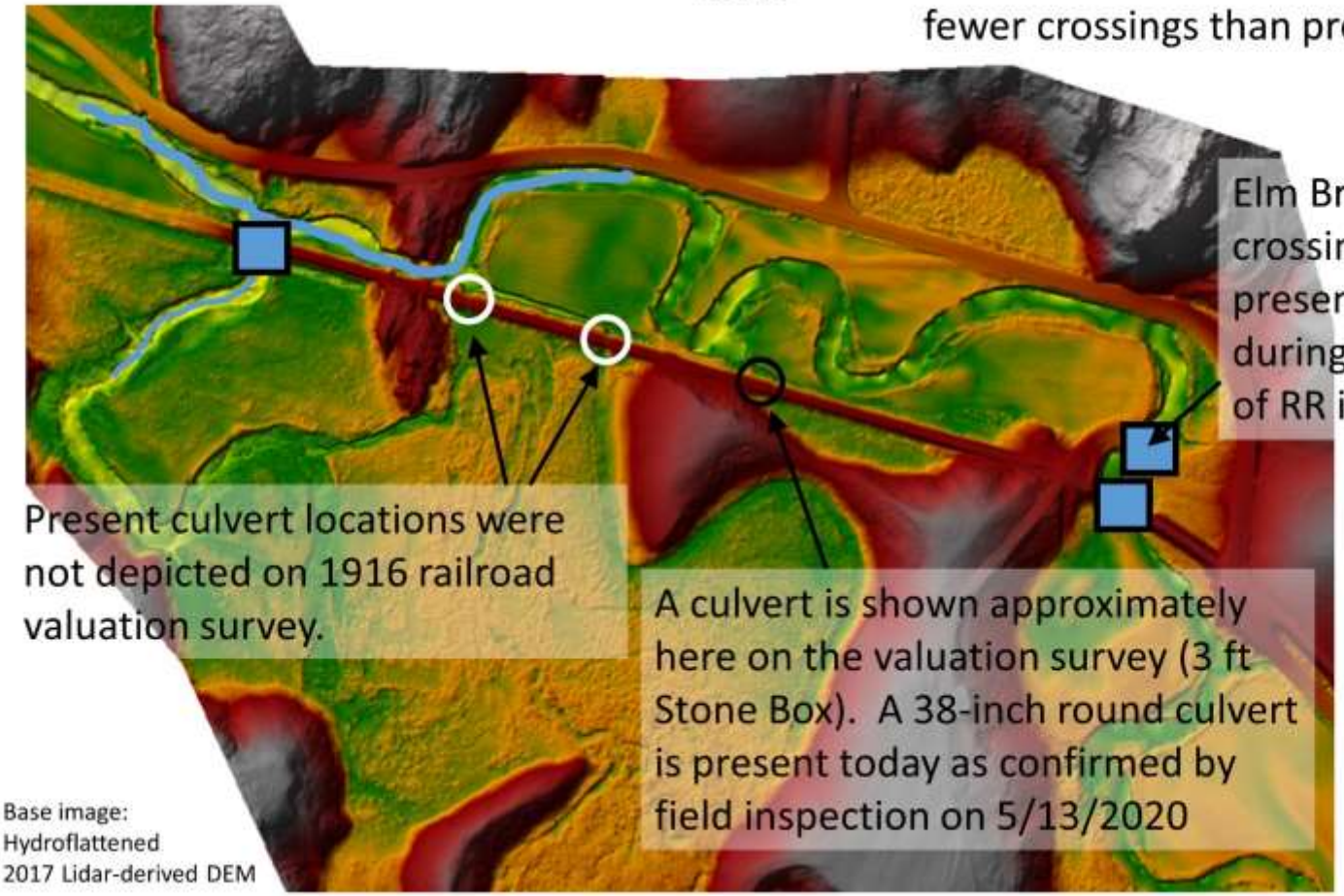
New location of Elm Brook confluence.
Bridge shown on 1916 valuation sheet. Elm Brook flowing in underfit channel (i.e., past Black Creek channel)

Base image:
Hydroflattened
2017 Lidar-derived DEM

View downstream from deck of farm bridge

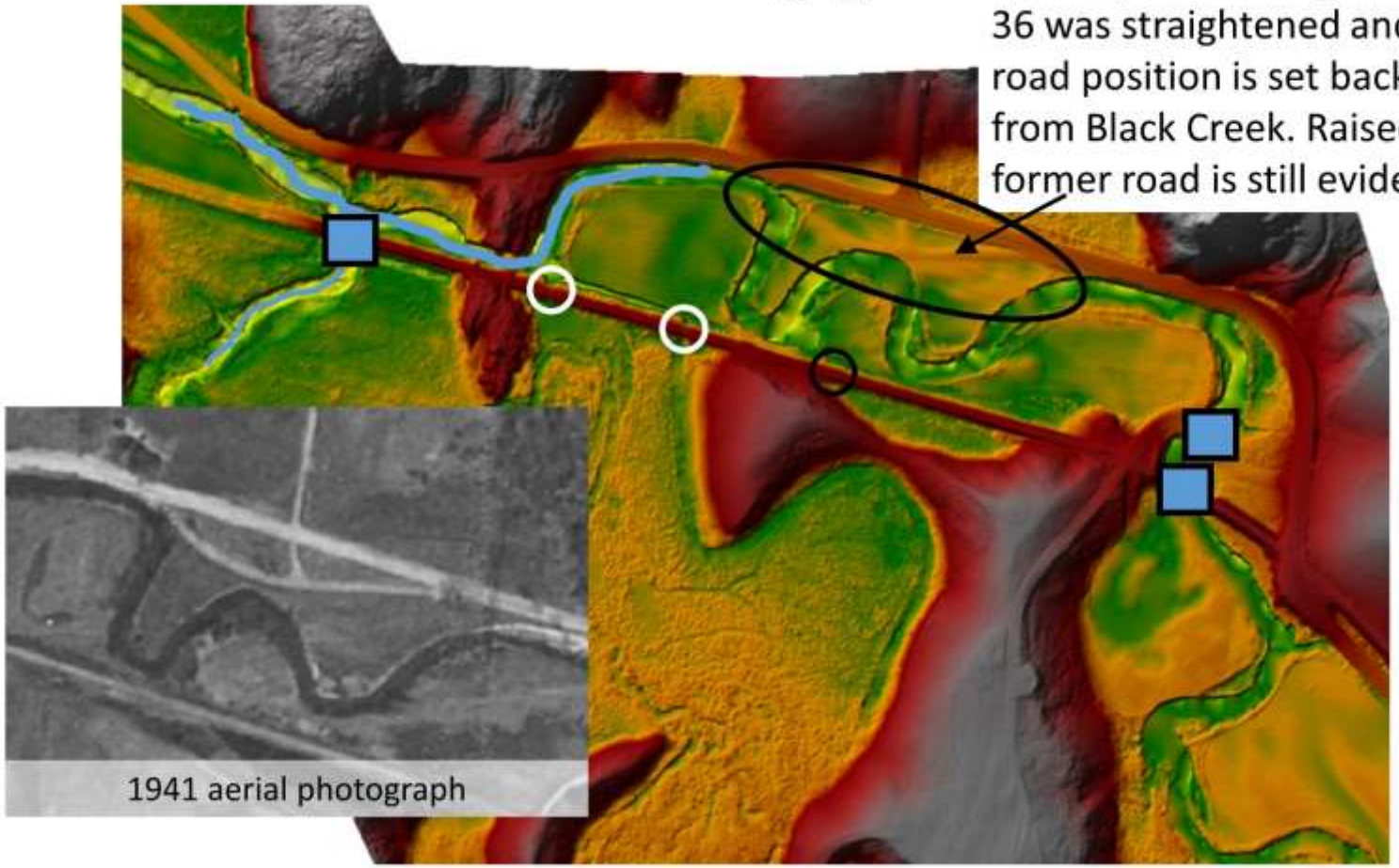
1916

Railroad valuation survey shows fewer crossings than present today



1941

By this year, the alignment of Route 36 was straightened and the present road position is set back further from Black Creek. Raised elevation of former road is still evident.



1941 aerial photograph

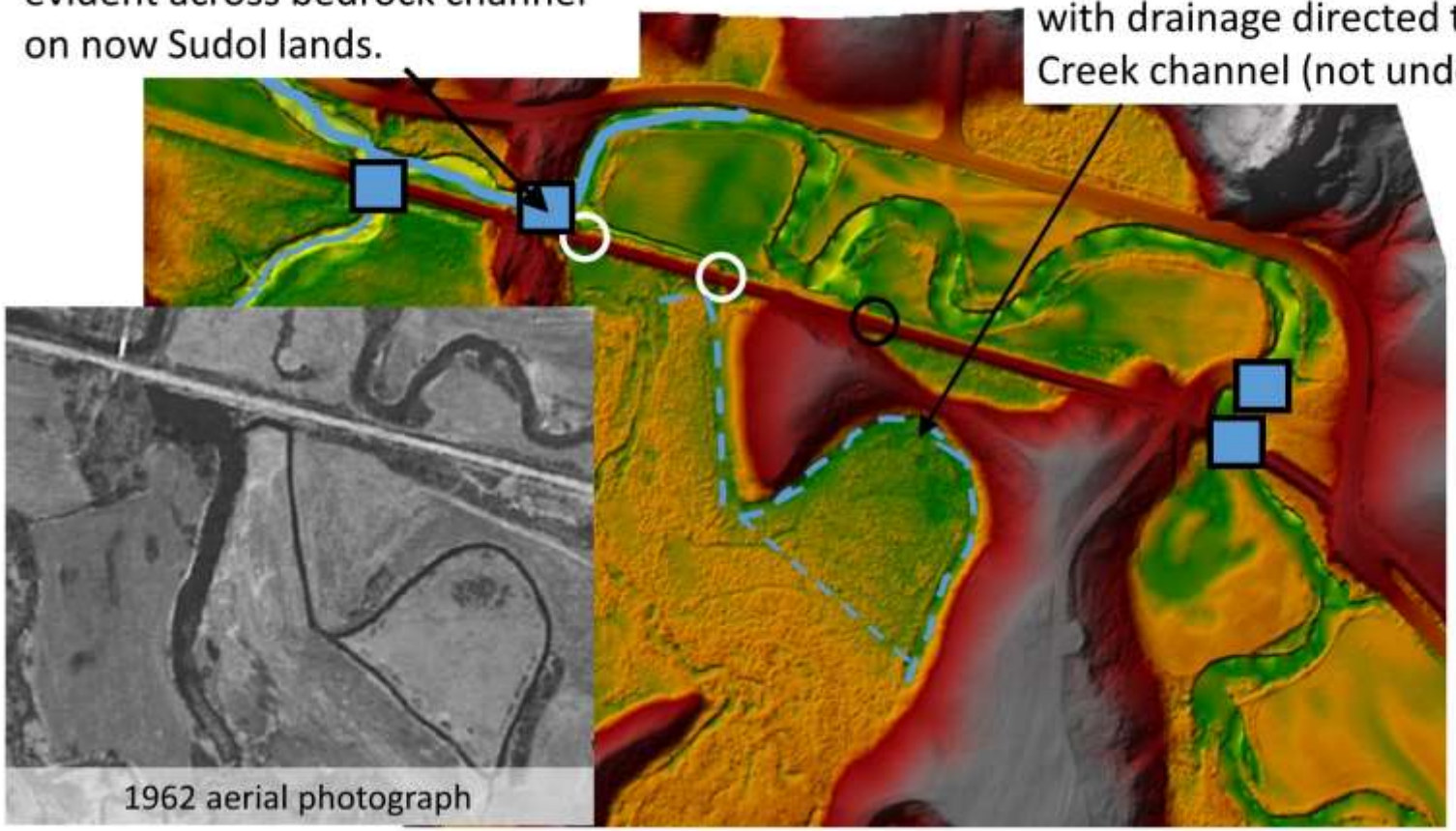
Bridge

Culvert

1962

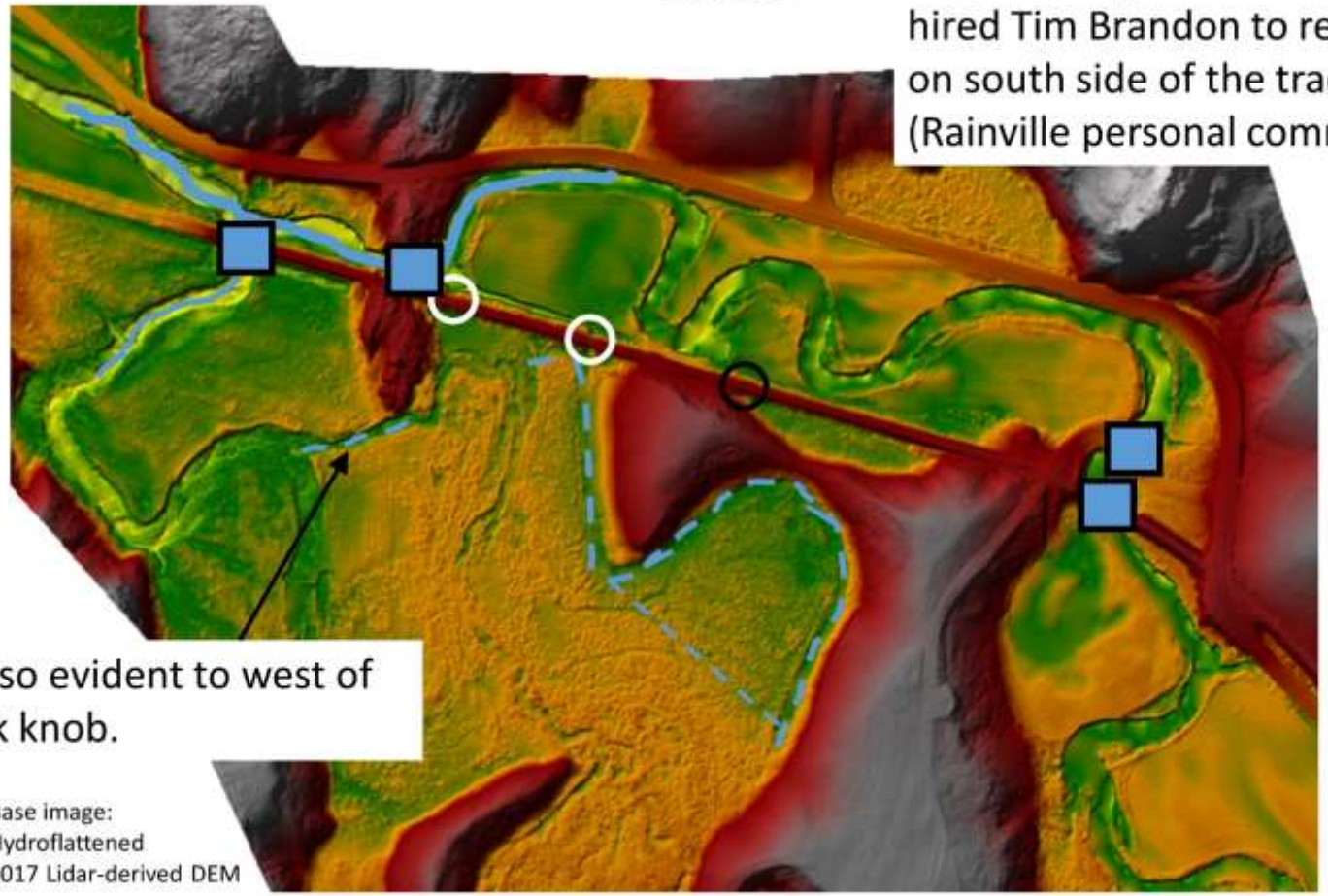
New farm equipment bridge evident across bedrock channel on now Sudol lands.

Ditching is evident in fields to south of railroad on aerial photograph, with drainage directed to old Black Creek channel (not under the RR).



1980s

Lee, farmer previous to Rainville, hired Tim Brandon to re-ditch fields on south side of the tracks. (Rainville personal commun., 2019)



Ditch also evident to west of bedrock knob.

Base image:
Hydroflattened
2017 Lidar-derived DEM

Bridge

Culvert

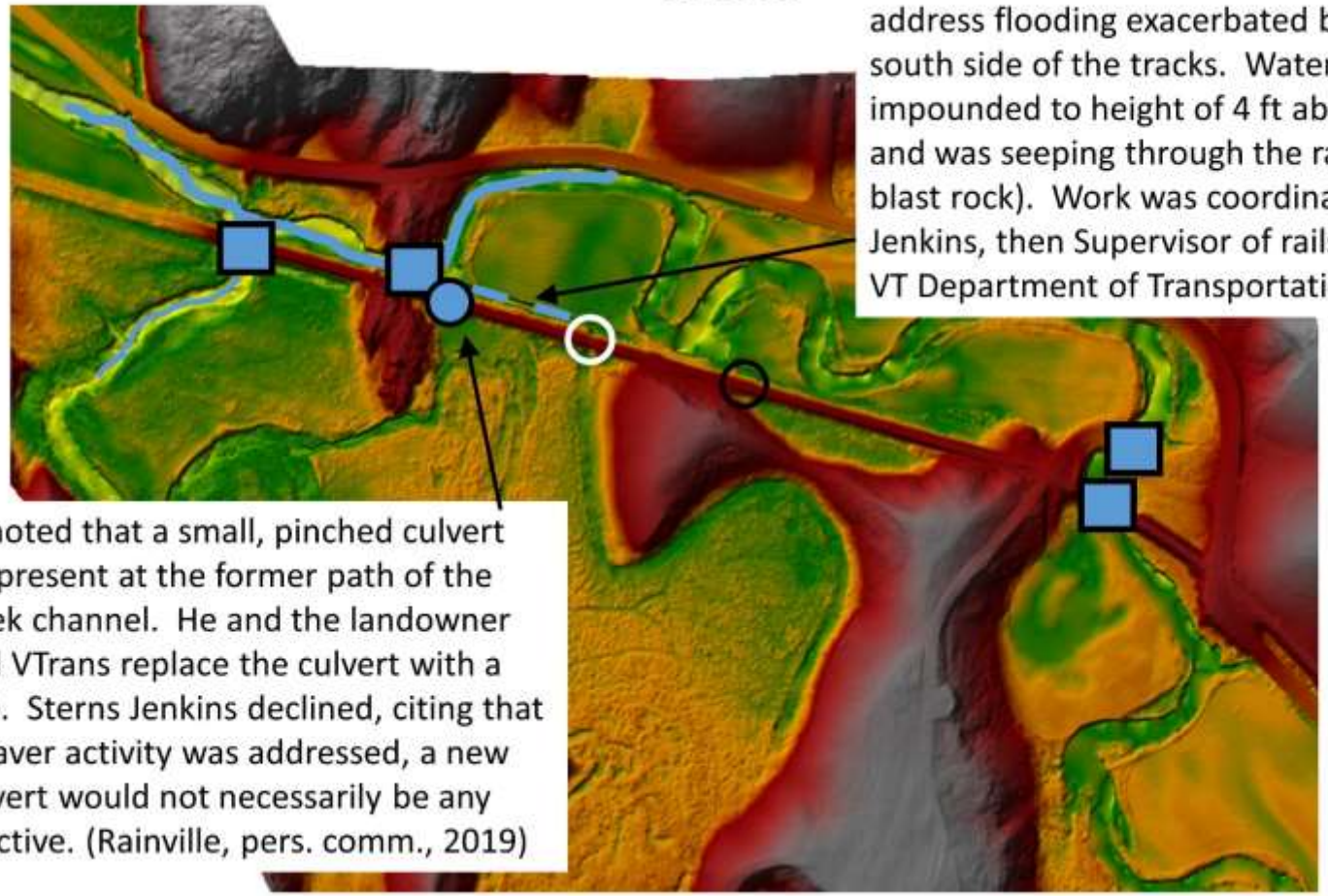
Train over railroad crossing near Elm Brook Road, 1981

The LVRC chopped the noses on some of their RS3s. 1981
Photo by Paul Charland

photo from http://nekrailroad.com/NEKOLD/Lamoille_Valley.html

c.1998

Rainville ditched the field to north of tracks to address flooding exacerbated by beavers, on south side of the tracks. Water was impounded to height of 4 ft above his fields and was seeping through the rail bed (coarse blast rock). Work was coordinated with Sterns Jenkins, then Supervisor of rails projects with VT Department of Transportation.



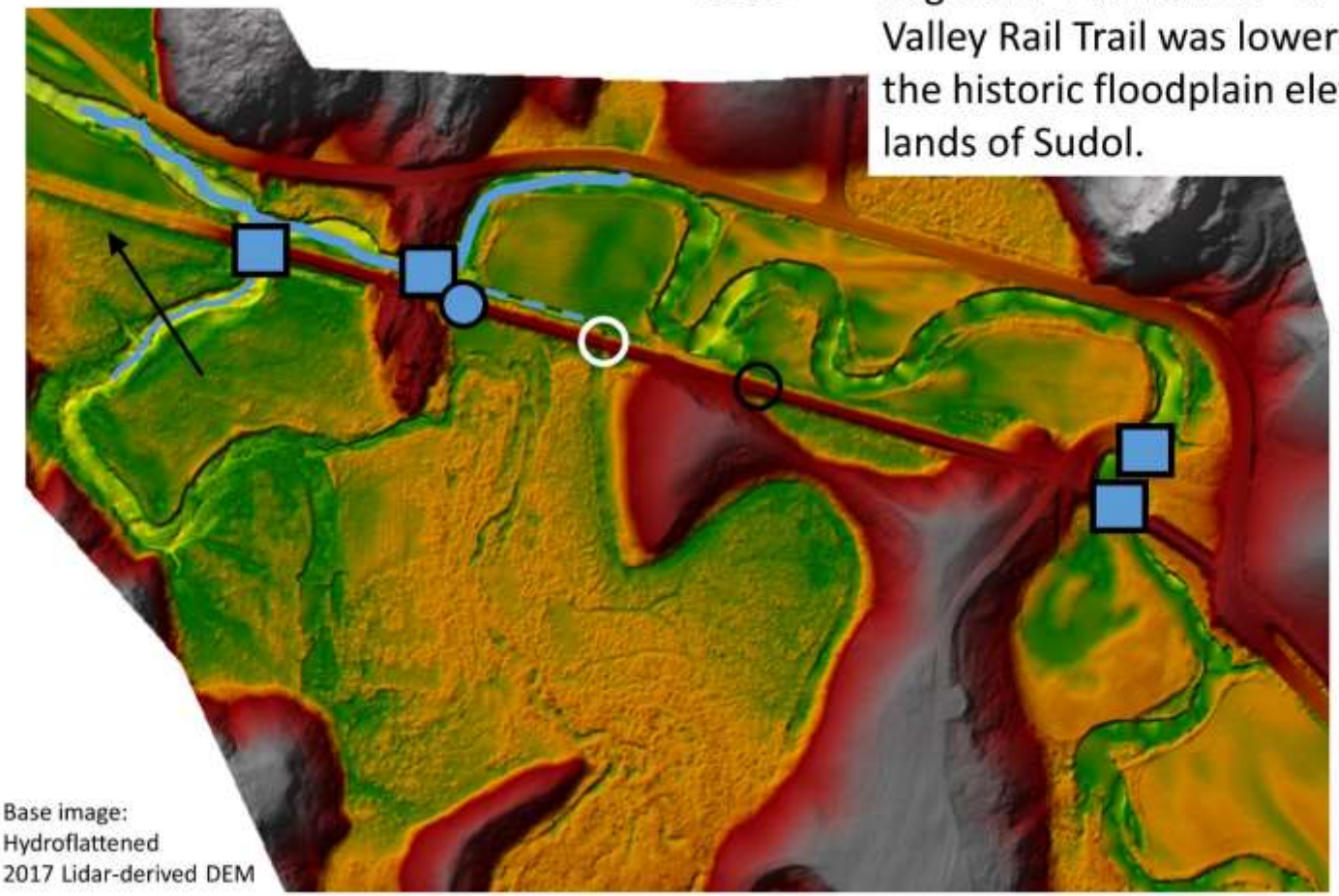
Rainville noted that a small, pinched culvert was then present at the former path of the Black Creek channel. He and the landowner requested VTrans replace the culvert with a larger size. Sterns Jenkins declined, citing that unless beaver activity was addressed, a new larger culvert would not necessarily be any more effective. (Rainville, pers. comm., 2019)

Bridge

Culvert

2008

Segment "Fairfield 2a" of the Lamoille Valley Rail Trail was lowered nearly to the historic floodplain elevation on lands of Sudol.

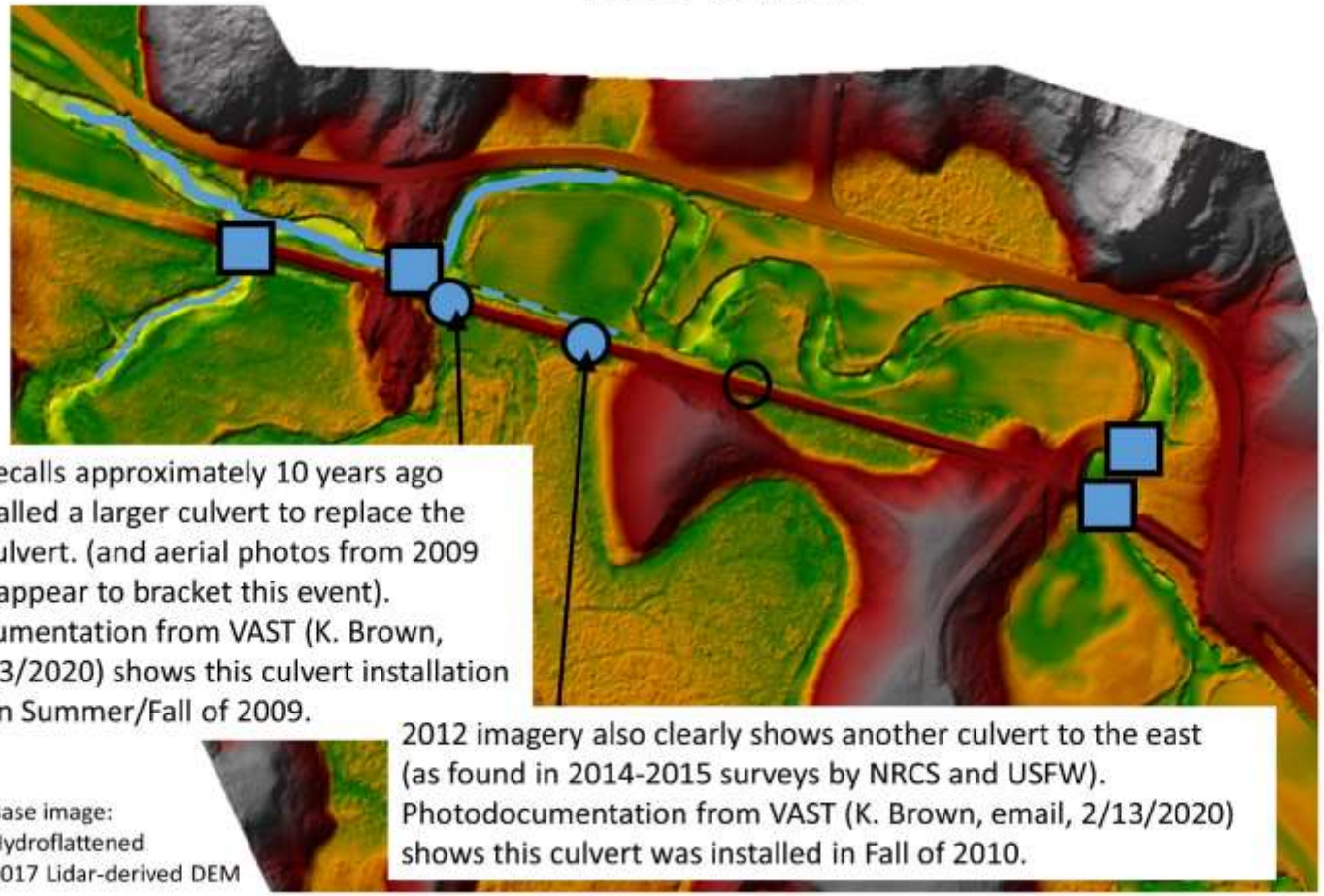


Base image:
Hydroflattened
2017 Lidar-derived DEM

Bridge

Culvert

2009 to 2012



Rainville recalls approximately 10 years ago Howe installed a larger culvert to replace the pinched culvert. (and aerial photos from 2009 and 2012 appear to bracket this event). Photodocumentation from VAST (K. Brown, email, 2/13/2020) shows this culvert installation occurred in Summer/Fall of 2009.

2012 imagery also clearly shows another culvert to the east (as found in 2014-2015 surveys by NRCS and USFW). Photodocumentation from VAST (K. Brown, email, 2/13/2020) shows this culvert was installed in Fall of 2010.

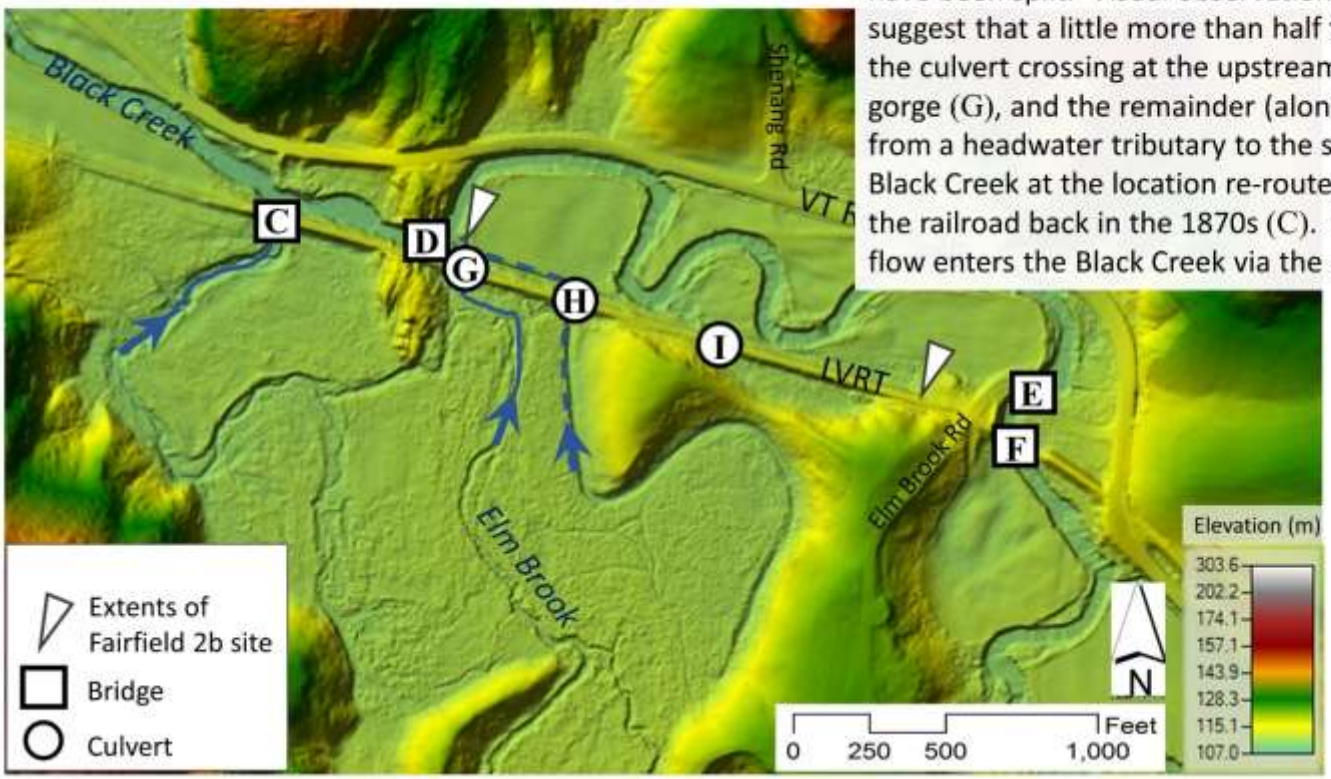
Base image:
Hydroflattened
2017 Lidar-derived DEM

Bridge

Culvert

2009 to 2012

Since about 2010, the Elm Brook flows (at low stages) have been split. Visual observations in July of 2019 suggest that a little more than half the flow enters below the culvert crossing at the upstream end of the bedrock gorge (G), and the remainder (along with contributions from a headwater tributary to the southwest) enters the Black Creek at the location re-routed to accommodate the railroad back in the 1870s (C). A small percentage of flow enters the Black Creek via the ditch network (H).

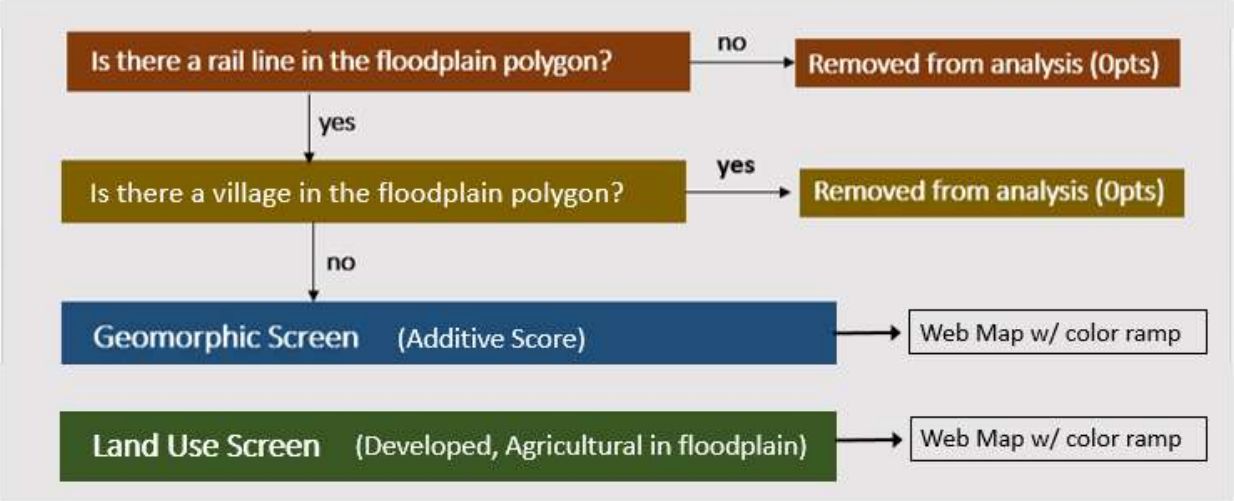


Appendix D

Screening Protocol for Rail Trail Reconnection Sites

Steps in Rail Trail Floodplain Reconnection Site Screening Protocol
(last updated: 7/20/2020)

Overall Screening Sequence



Geomorphic Screen

Valley Confinement

Valley Confinement	Score
VC $\geq$ 4	1
VC < 4	0

Valley Slope (%)

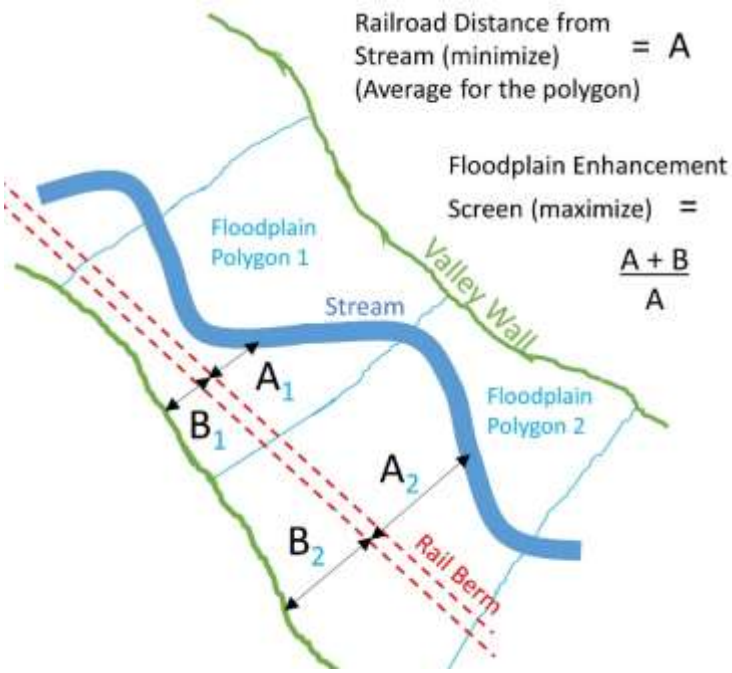
Valley Slope	Score
S < 0.5	1
0.5 $\leq$ IR < 1.0	0.6
1 $\leq$ IR < 2	0.3
S $\geq$ 2.0	0

Percent Wetland

Assessment	Score
% Wetlands > Mean Wetland % in the Watershed	1
Otherwise	0

Railroad proximity

Distance	Score
A < 20	1
20 ≤ A < 40	0.6
20 ≤ A < 40	0.3
A ≥ 60	0



Floodplain enhancement screen

Distance	Score
(A+B)/A < 2	0
2 ≤ (A+B)/A < 4	0.3
4 ≤ (A+B)/A < 6	0.6
(A+B)/A ≥ 6	1

Vertical Connectivity

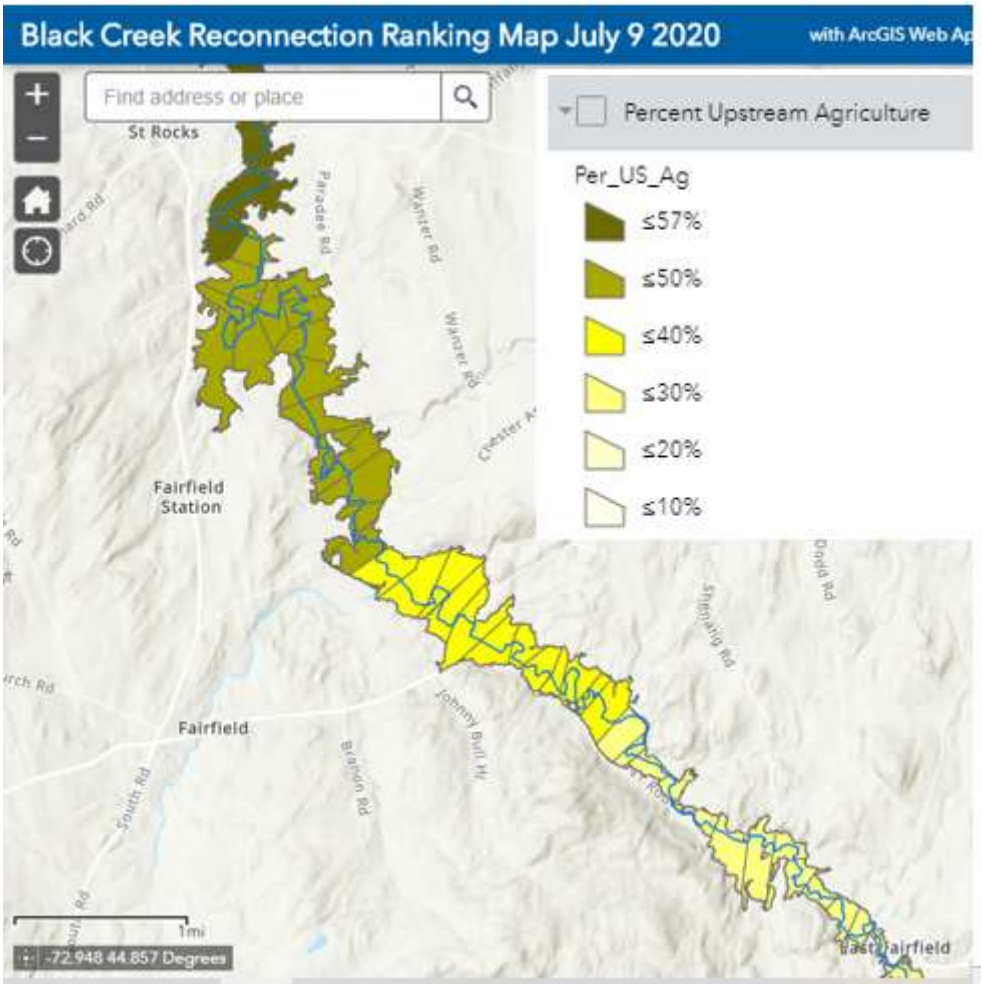
((500-year HAND Floodplain Area – 2-year HAND Floodplain Area)/ 2-year Floodplain Area) * 100.

Percent Increase	Score
% < 150	1
150 ≤ % < 300	0.6
300 ≤ % < 600	0.3
% ≥ 600	0

Land Use Screen

Cumulative Upstream Agricultural Land Uses (%) – in the cumulative floodplain polygons

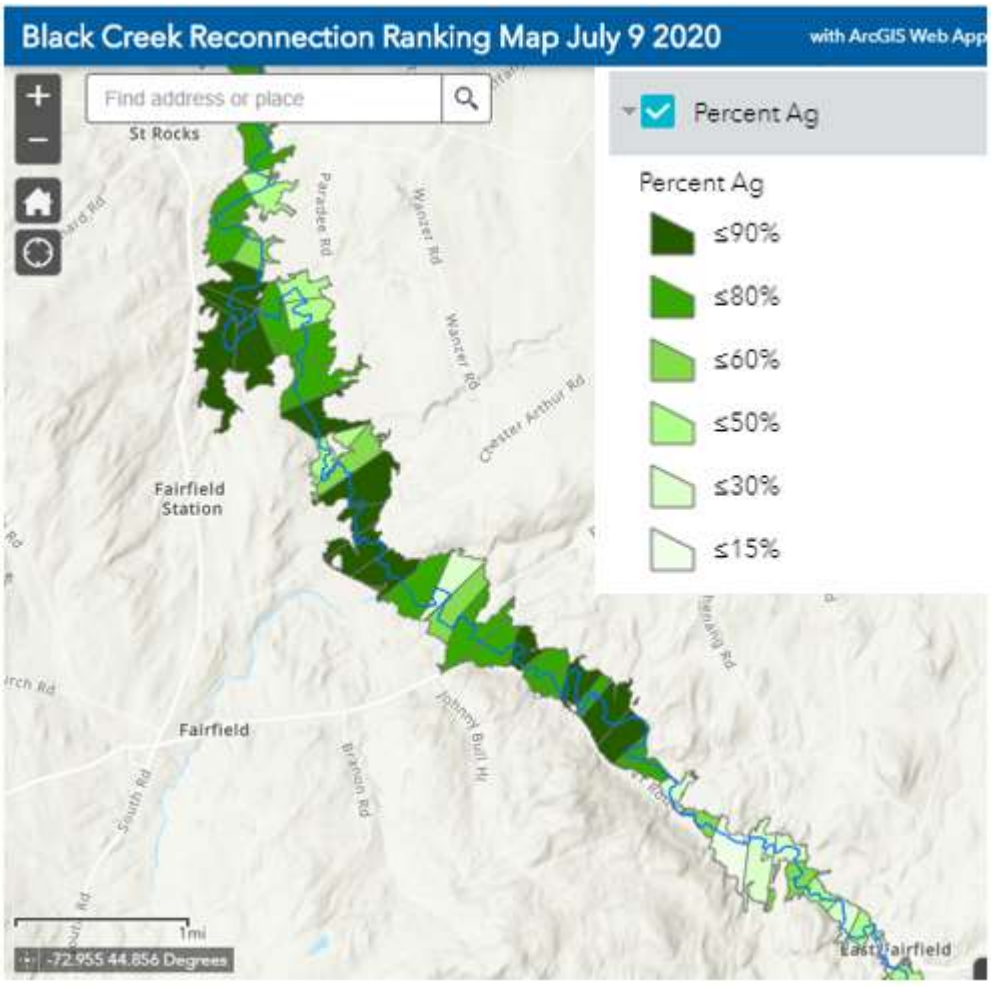
- This layer is viewed qualitatively, to infer possible benefits of floodplain reconnection to store sediments and nutrients from upstream sources.



Land Use Screen

Agricultural Land Uses (%) – in the individual floodplain polygon

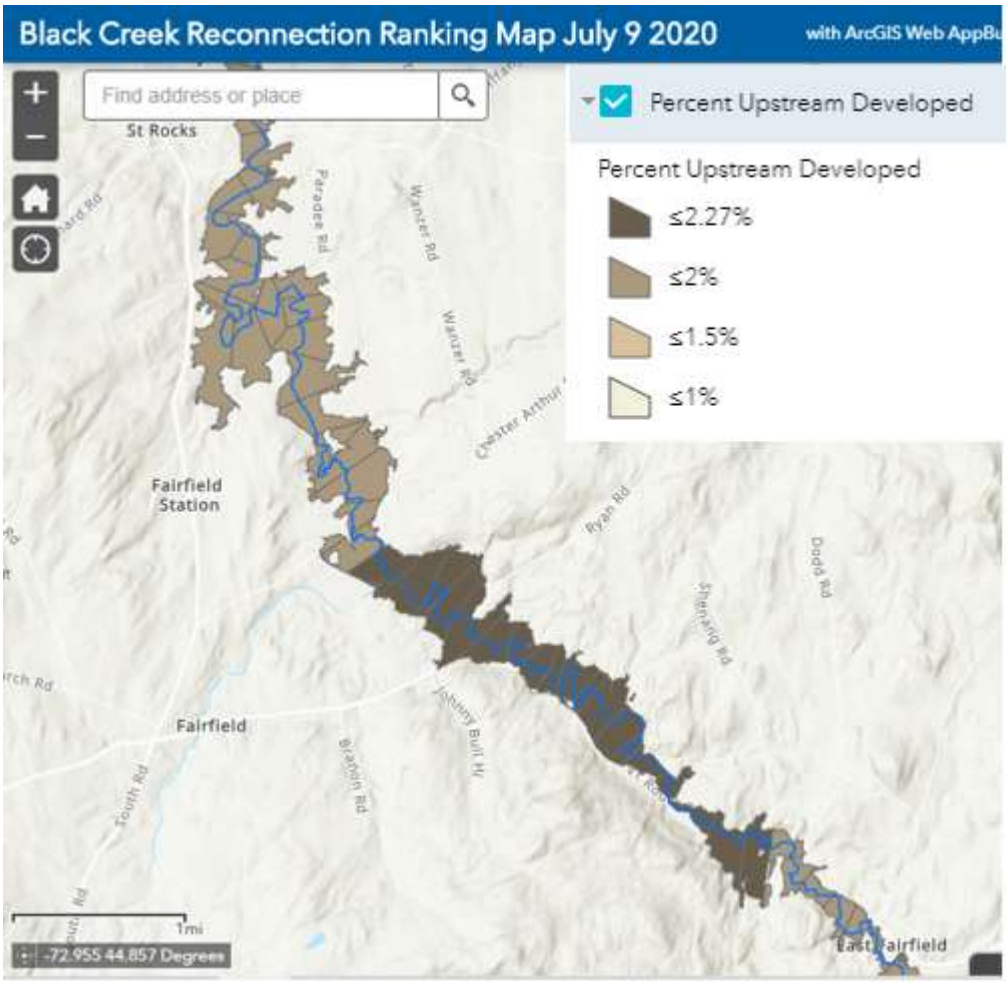
- This layer is viewed qualitatively, to consider possible benefits or impacts of floodplain reconnection on agricultural land uses local to a candidate reconnection site.



Land Use Screen

Cumulative Upstream Developed Land Uses (%) – in the cumulative floodplain polygons

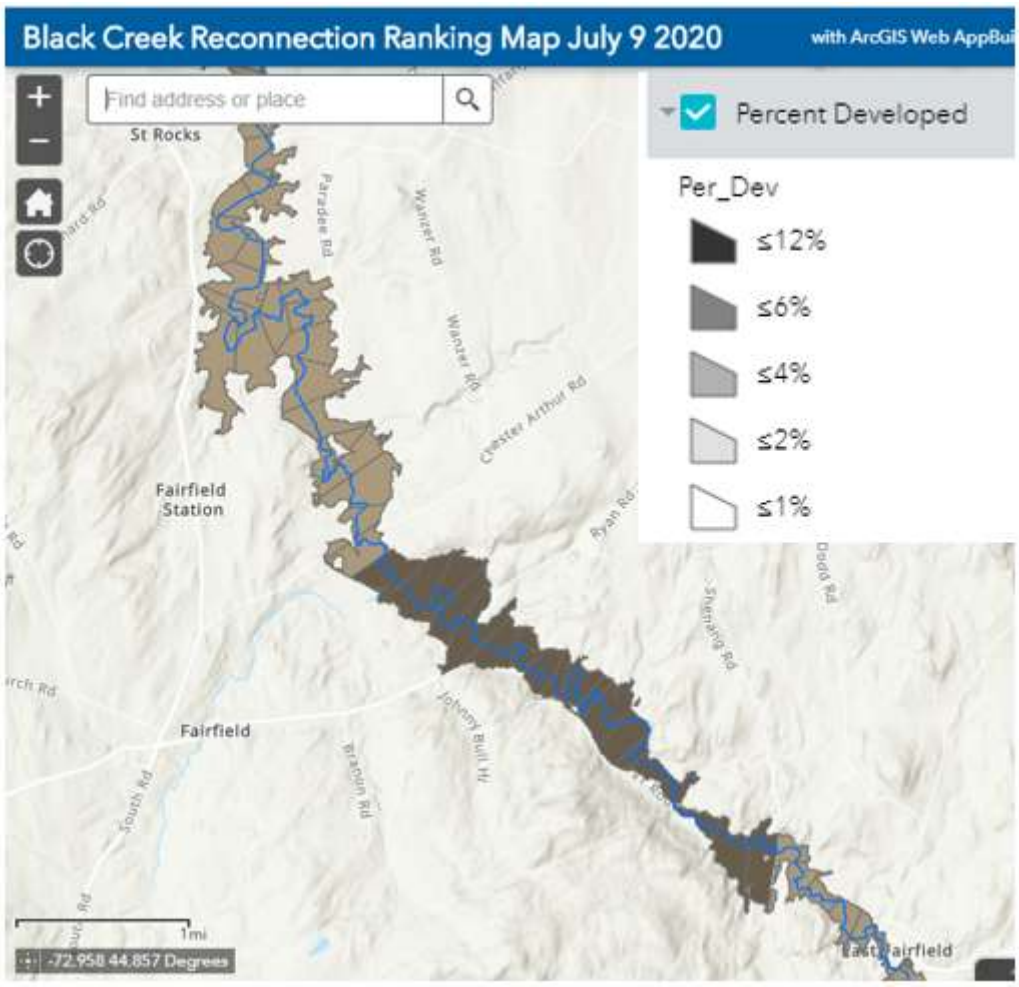
- This layer is viewed qualitatively, to infer possible benefits of floodplain reconnection to store sediments and nutrients from upstream developed sources.



Land Use Screen

Developed Land Uses (%) – in the individual floodplain polygon

- This layer is viewed qualitatively, to avoid possible impacts of floodplain reconnection on built infrastructure (including roads, as well as buildings, impervious surfaces).



Attachment E

Floodplain Sediment Sampling Protocol

DRAFT

Equipment List

- ☐ 30-meter fiberglass measuring tape
- ☐ Pocket tape measure or ruler in centimeters / millimeters
- ☐ Dog-tie-out anchor (cork-screw anchor) or metal stake (3)
- ☐ Survey flagging
- ☐ Flat-spade shovel
- ☐ Flat trowel or pocket knife
- ☐ Polyethylene 1-quart freezer bags
- ☐ Permanent marker
- ☐ Camera / Smart phone
- ☐ GPS – recreational grade
- ☐ Clip board w/ data sheets

Floodplain Sediment Sample Data Sheet

Waypoint _____ or Latitude _____ Longitude _____

Date: _____ Samplers: _____ Weather: _____

Site ID: _____ River: _____ Landowner: _____

Site Address: _____ Town: _____

Site Description: _____

Check One: ☐ Meadow/Hay ☐ Crop ☐ Pasture ☐ Forest ☐Urban/ Suburban ☐Other: _____

Notes: _____

_____

Site Sketch:

Picture Log

No.	View	Description

SAMPLE ID - KEY

Floodplain Sediment Sampling Method

WaterSt - Dog– US-1 - 050619

Site Name – abbreviation for landowner or location

River Name – abbreviation for river

Transect Position in Deposit –

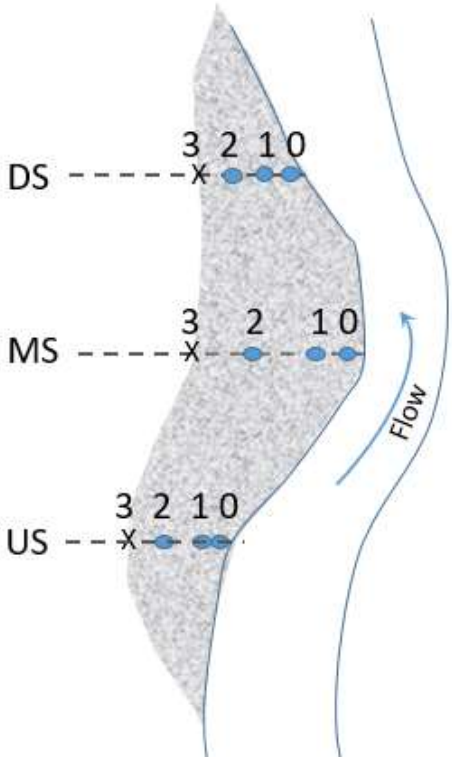
US	Upstream
MS	Midstream
DS	Downstream

Sample number in Transect

0	Proximal to Streambank
1	One-third along transect
2	Two-thirds along transect

Sample Date – MM/DD/YY

Floodplain Sediment Sampling Method



Transect Layout

Establish 3 transects perpendicular to the valley trace of the river at upstream (US), midstream (MS) and downstream (DS) positions within the sediment deposit.

At each transect, put a pin at the top of the river bank and lay out a tape measure along the transect.
Record the lateral extent of the deposits (total distance in meters from the top of the bank) (point number 3 in the illustration).

Measure deposit thickness and take a sediment sample:
(0) Close to the top of channel bank (note the distance from the pin)
(1) One-third of the total lateral distance
(2) Two-thirds of the total lateral distance

Sediment Sampling Log - Example

Date: 5/6/2019
Samplers: Jane Doe, Joe Smith
Site: Water Street Floodplain Reconnection Site, Northfield, VT
River: Dog River

Transect ID	Distance (m)	Thickness (cm)	Sample ID	Sample Time
US-0	0.1	4.2	WaterSt-Dog-US-0-050619	8:34
US-1	1.4	3.0	WaterSt-Dog-US-1-050619	8:45
US-2	2.8	1.3	WaterSt-Dog-US-2-050619	8:55
US-3	4.2	0	NS	--
MS-0	0.1	3.9	WaterSt-Dog-MS-0-050619	9:10
MS-1	1.8	2.8	WaterSt-Dog-MS-1-050619	9:25
MS-2	3.6	0.8	WaterSt-Dog-MS-2-050619	9:35
MS-3	5.4	0	NS	--
DS-0	0.1	1.2	WaterSt-Dog-DS-0-050619	9:40
DS-1	0.9	0.7	WaterSt-Dog-DS-1-050619	9:43
DS-2	1.8	Trace	NS	--
DS-3	2.7	0	NS	--

Floodplain Sediment Sampling Method

Establish sampling transects as described in the Transect Layout. Using a GPS unit, record Latitude and Longitude at the 0 point of each transect. (If you do not have access to a GPS unit, leave a survey flag in this point so that someone with a GPS unit can return to the site to collect Latitude / Longitude). Take a picture of each transect from the transect terminus (point 3) with a view toward the river. Record the photo numbers on the photo log.

At each sample point, cut a 15 cm x 15 cm square in the floodplain deposits with the flat-spade shovel. Identify the contact between the fresh sediment deposits and the underlying organic layer or vegetation (e.g., leaf litter from the previous Fall; current year's weed growth). (Figure 1). Measure and record the thickness of the fresh floodplain deposits in centimeters.

Figure 1. Identify contact between fresh sediment deposit and underlying organic layer.

Collect soil from the square (Figure 2) and place it in a polyethylene bag. Squeeze the remaining air out of the bag and seal it. Mark the bag with Sample ID, sample date, and sampler name. Use the Sample Identification (ID) Key to generate a Sample ID. Fill out the data sheet for the sample station. Include any notes or additional photographs to describe the nature of the deposit and your degree of confidence in the markers that indicate that sediment was deposited in the most recent flooding event.

Figure 2. Fresh sediments removed from a 15 cm x 15 cm square down to the underlying organic layer (i.e., leaf litter from previous fall).

Include any additional site information that may be relevant, such as the date of the flood event that generated the deposit, its size or intensity, the degree of floodplain inundation. Include any photos that you might have from the inundation event itself.

Sediment Sampling Log

Date: _____

Samplers: _____

Site: _____

River: _____

Transect ID	Distance (m)	Thickness (cm)	Sample ID	Sample Time

Appendix F

Bridge and Culvert Data

Table F-1. Bridge and Culvert Structures in Study Area Reaches

ID	Structure Form	Stream	Reach/ Segment	Road	Owner	Year Constructed	Material	Structure Length	Structure Width	Structure Type	Structure Label	Structure Number
F	Bridge	Black Creek	M07	Railroad			Iron					N/A
E	Bridge	Black Creek	M07	Elm Brook Rd	03	1919	Concrete	35	13.7	TL	B46	100605004606051
D	Bridge	Black Creek	M07	farm bridge	priv		Timber					N/A
B	Bridge	Black Creek	M06	VT Route 36	01	1983	Concrete	115	32.5	SL	B9	200298000906052
A	Bridge	Black Creek	M05B	Bruso Rd	03	1978	Concrete	40	14.9	TL	B44	100605004406051

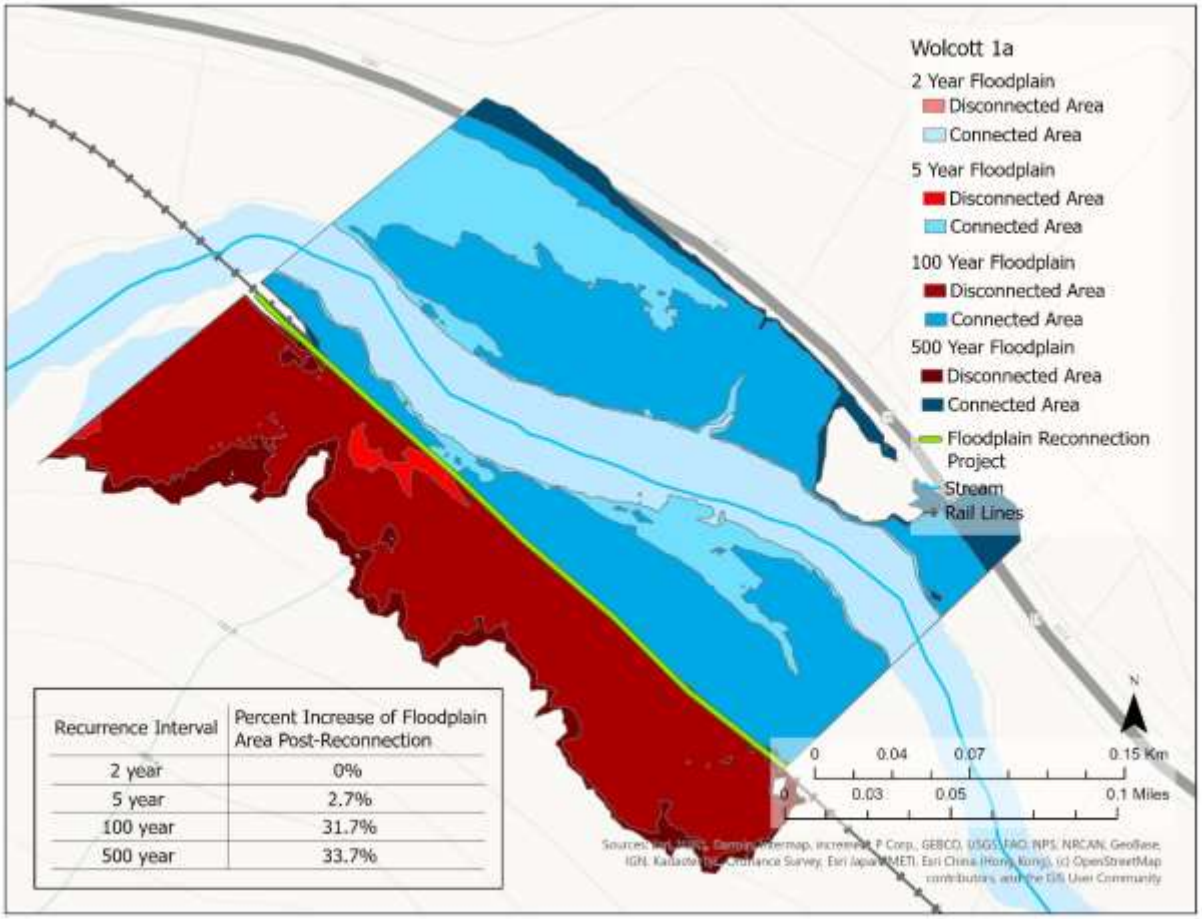
ID	Structure Form	Stream	Reach/ Segment	Road	Owner	Year Constructed	Channel Width (ft)	Span (ft)	Width (ft)	Clearance (ft)	% Bankfull	SGA ID Number
F	Bridge	Black Creek	M07	Railroad			45.0	120.0	10.1	9.0	266.7%	990000000106052
E	Bridge	Black Creek	M07	Elm Brook Rd	03	1919	45.0	24.0	19.2	6.0	53.3%	100605006106051
D	Bridge	Black Creek	M07	farm bridge	priv		45.0	39.0	10.0	12.0	86.7%	700000000006053
B	Bridge	Black Creek	M06	VT Route 36	01	1983	55.0	120.0	35.2	13.0	218.2%	200298000106052
A	Bridge	Black Creek	M05B	Bruso Rd	03	1978	32.0	30.0	15.6	2.5	93.8%	100605005706051

Source: VTrans Bridge Inventory System, and Structures database in the VTANR Stream Geomorphic Assessment DMS accessed 12/30/2018 at: https://anrweb.vt.gov/DEC/SGA/Default.aspx

Appendix G

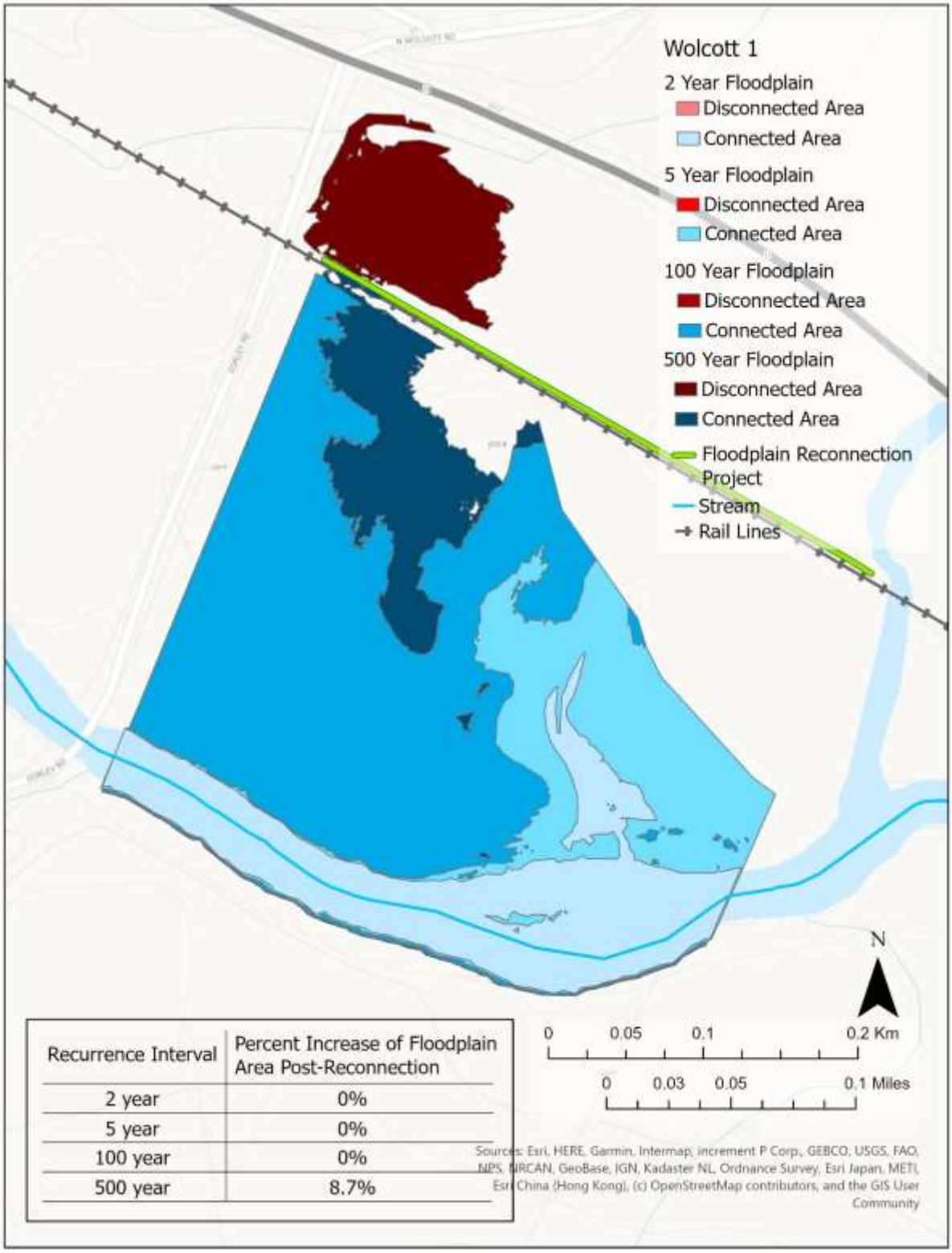
Modeled increase in floodplain area at historic reconnection sites

Lamoille River - Wolcott 1a



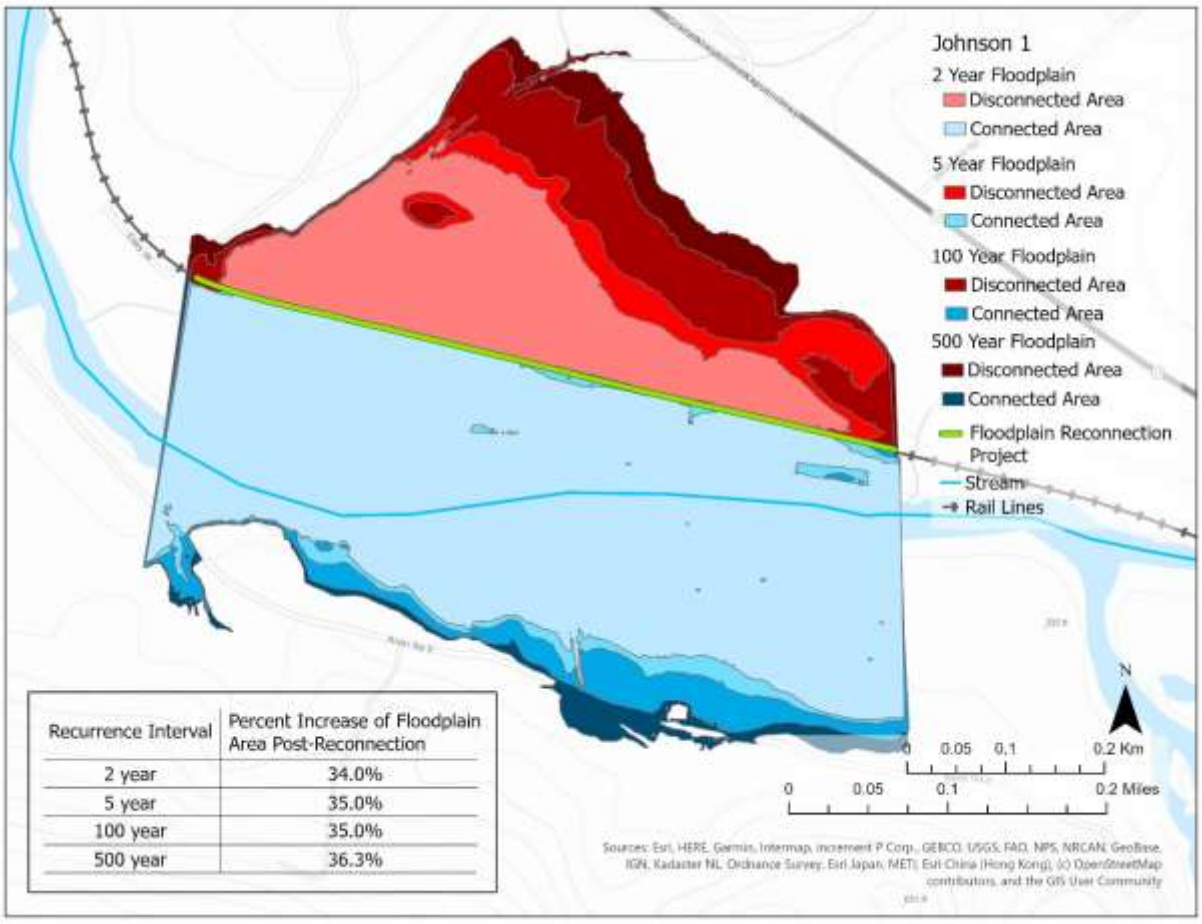
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	0%
5 year	2.7%
100 year	31.7%
500 year	33.7%

Lamoille River - Wolcott 1



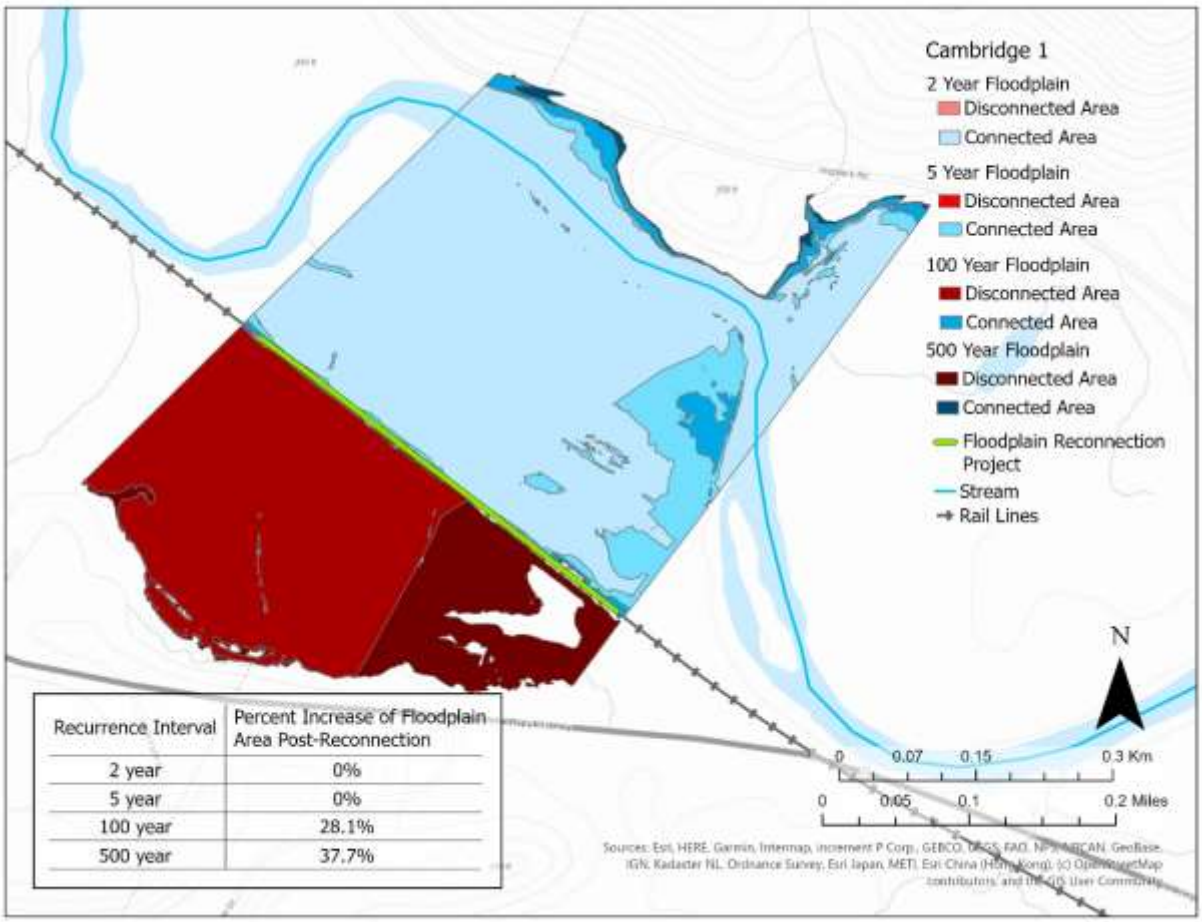
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	0%
5 year	0%
100 year	0%
500 year	8.7%

Lamoille River - Johnson 1



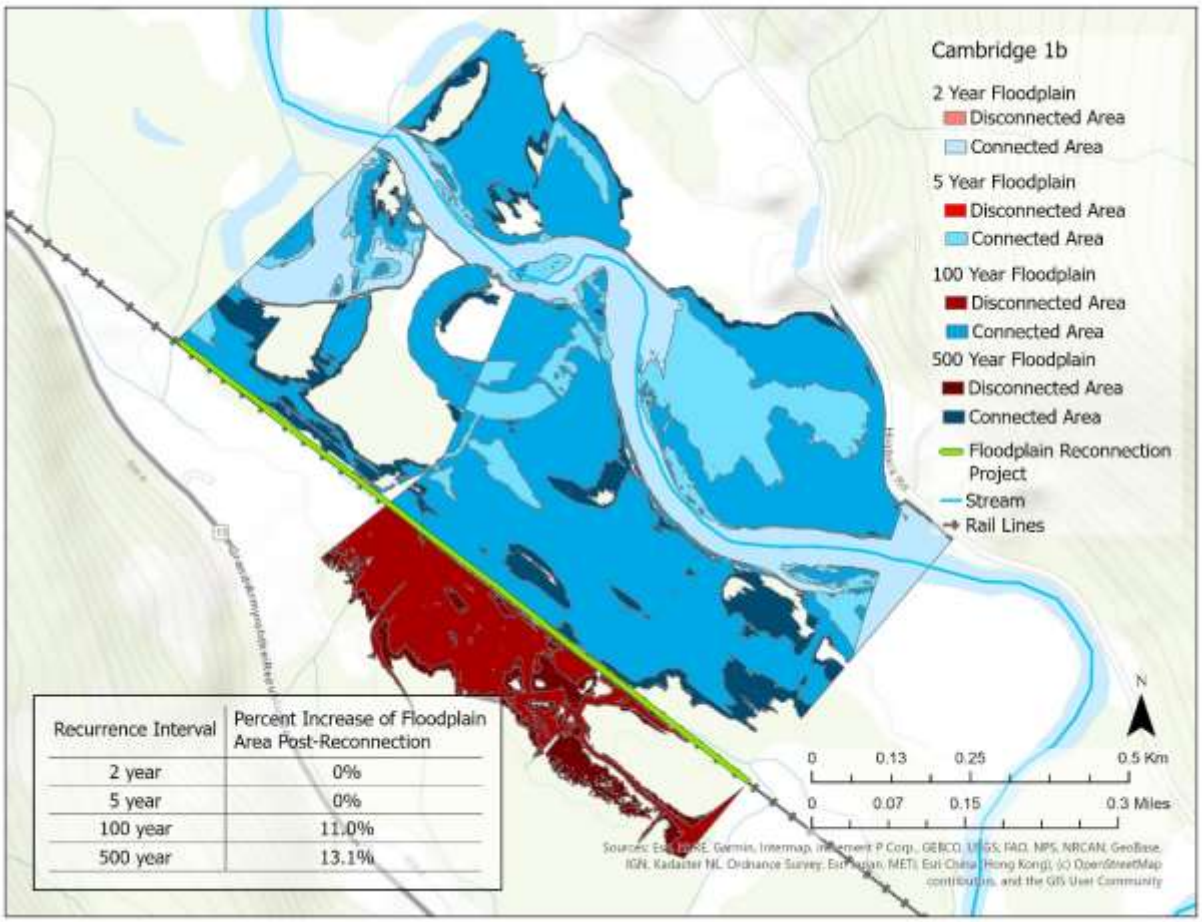
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	34.0%
5 year	35.0%
100 year	35.0%
500 year	36.3%

Lamoille River - Cambridge 1



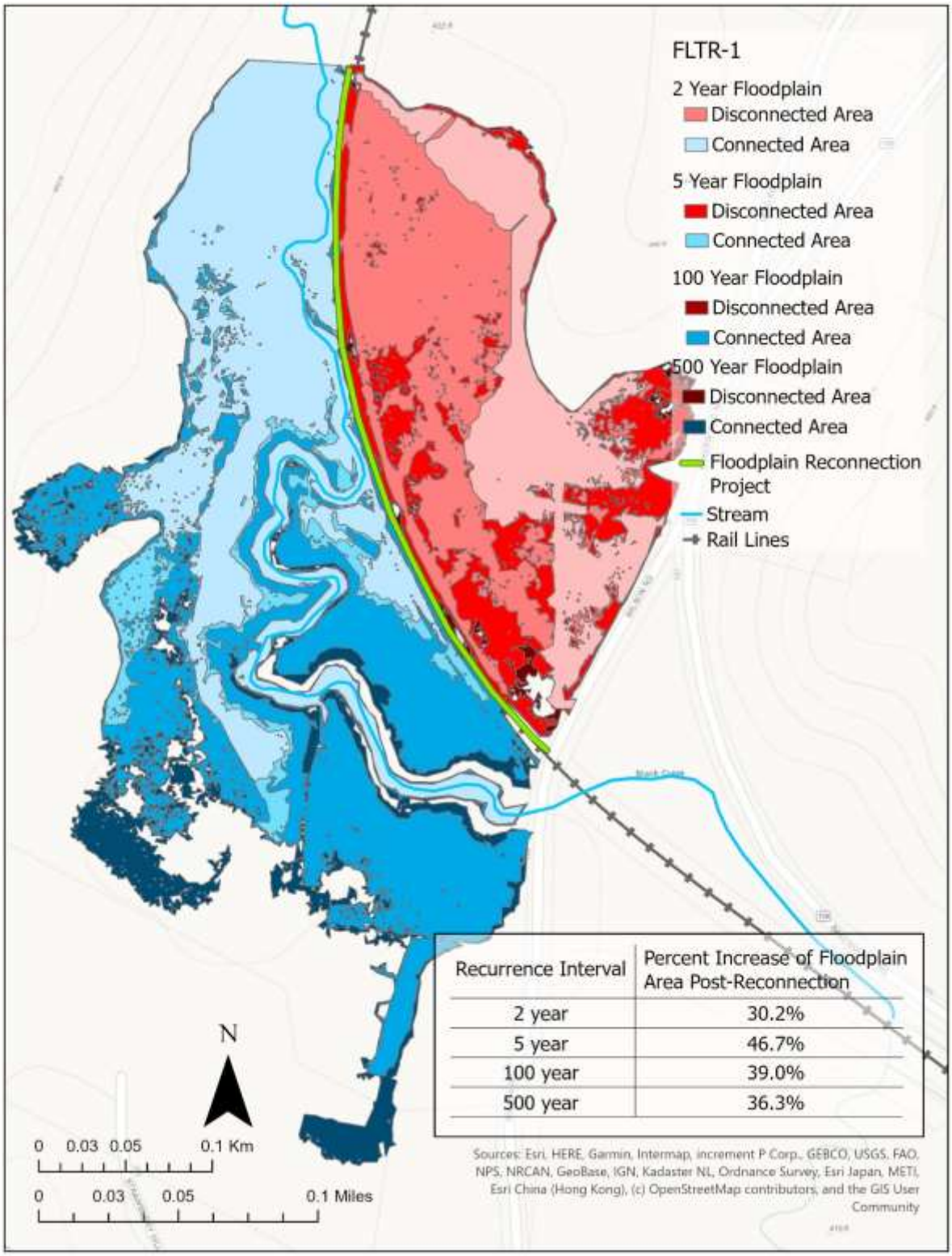
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	0%
5 year	0%
100 year	28.1%
500 year	37.7%

Lamoille River - Cambridge 1b



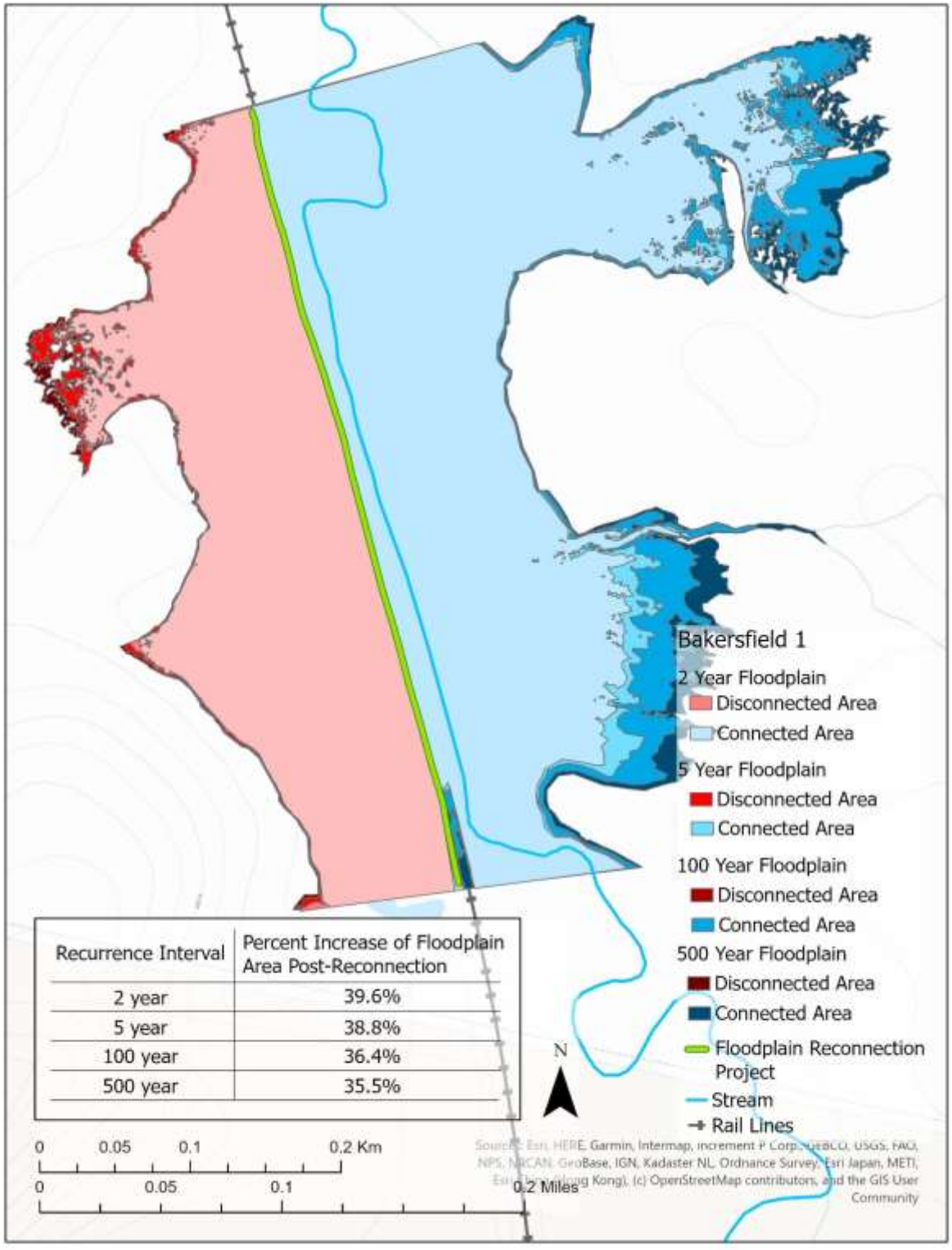
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	0%
5 year	0%
100 year	11.0%
500 year	13.1%

Black Creek – Fletcher 1



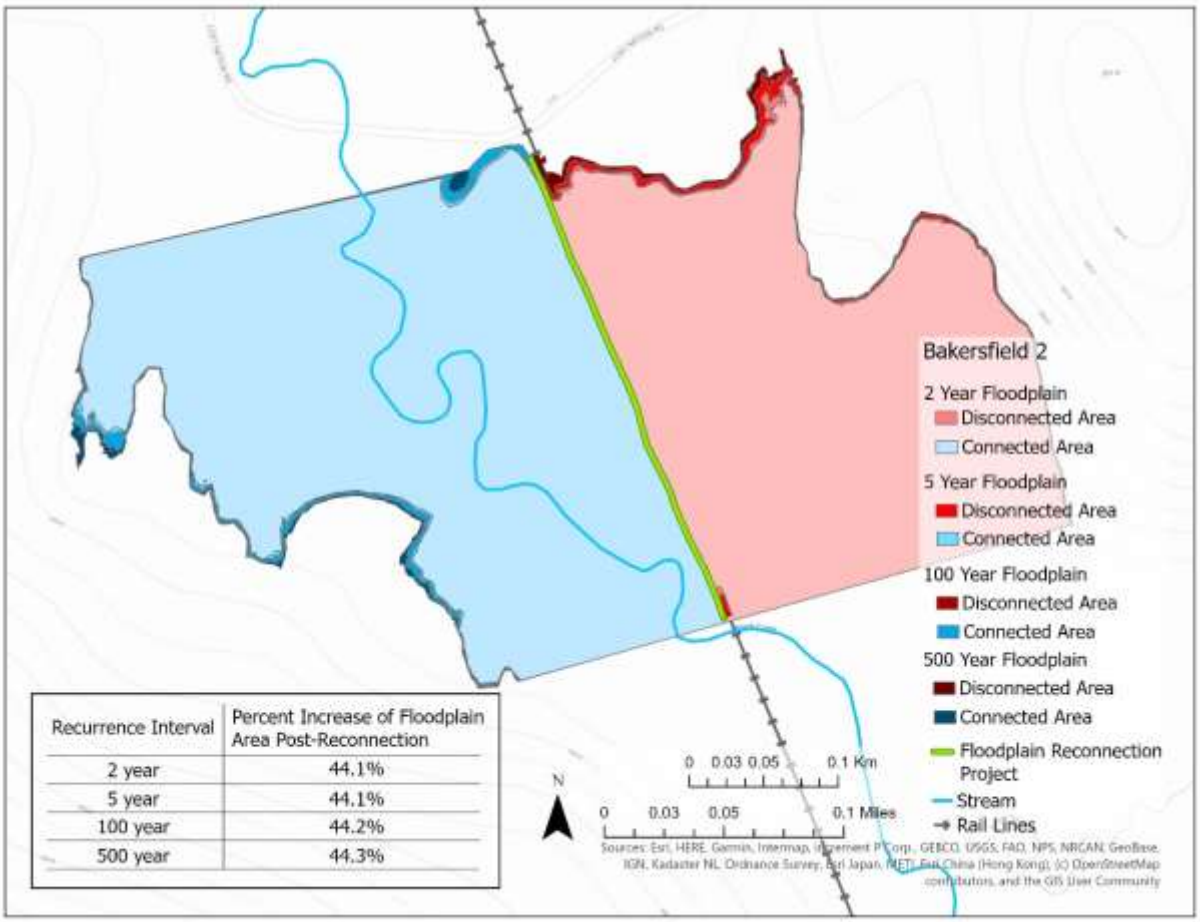
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	30.2%
5 year	46.7%
100 year	39.0%
500 year	36.3%

Black Creek – Bakersfield 1



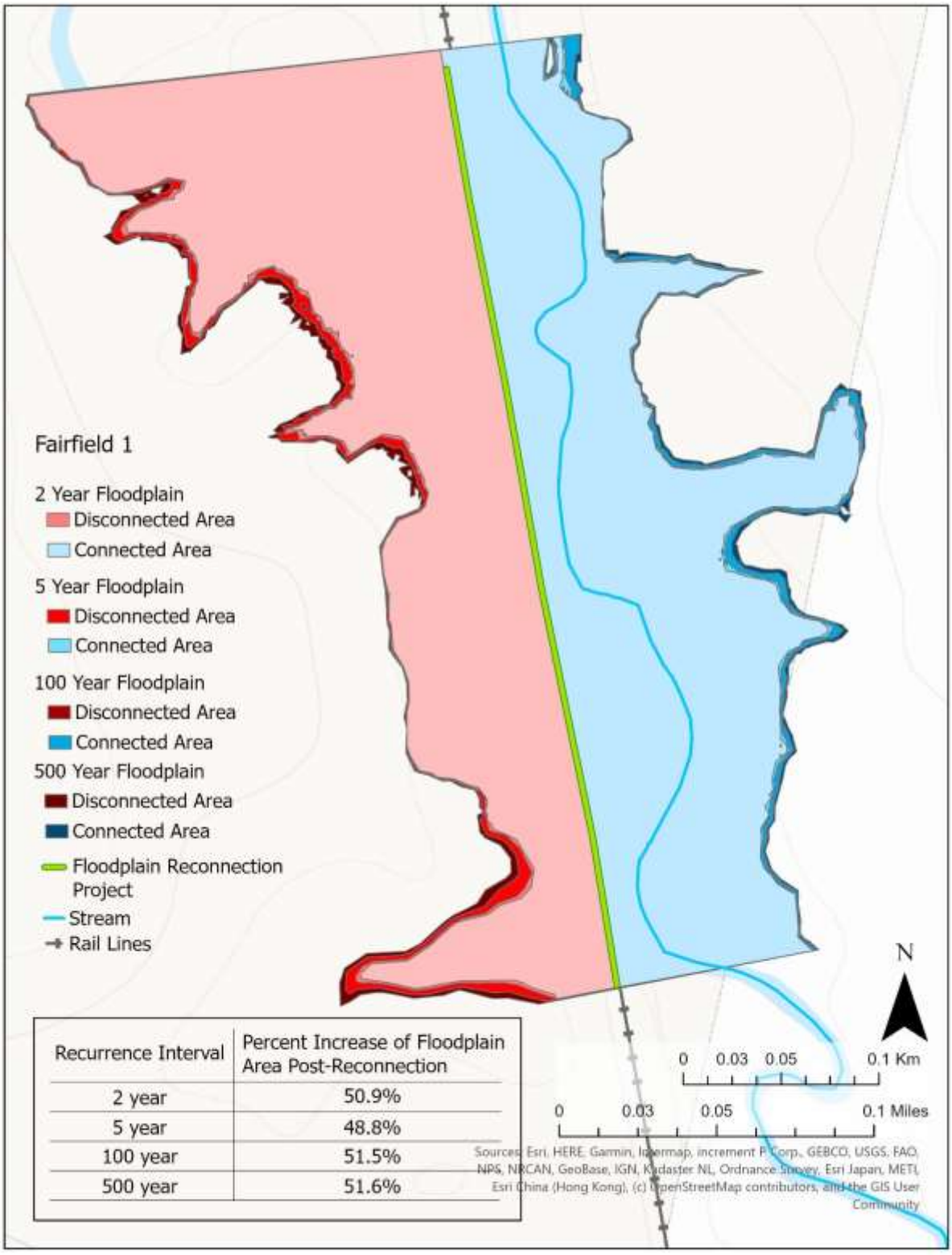
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	39.6%
5 year	38.8%
100 year	36.4%
500 year	35.5%

Black Creek – Bakersfield 2



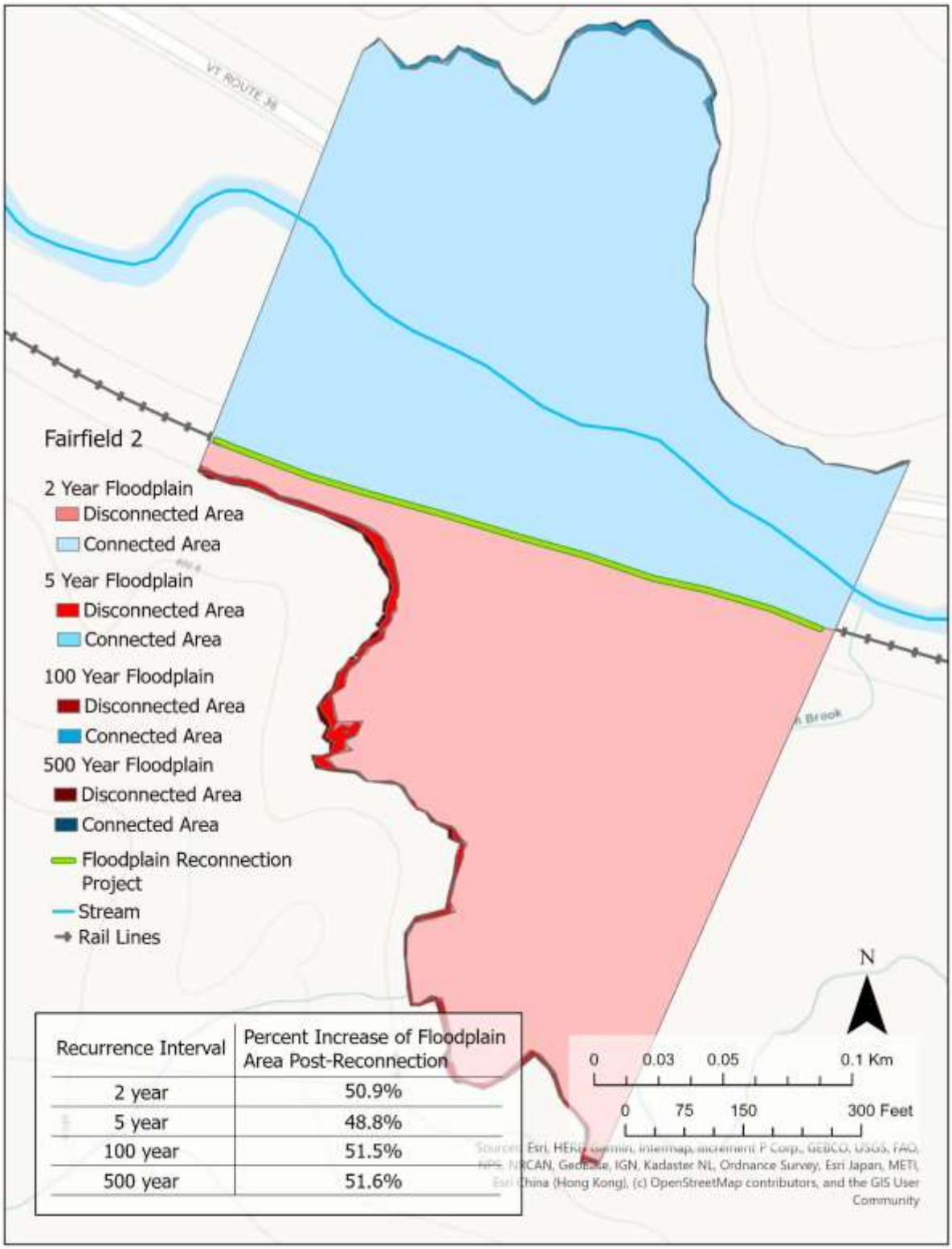
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	44.1%
5 year	44.1%
100 year	44.2%
500 year	44.3%

Black Creek – Fairfield 1



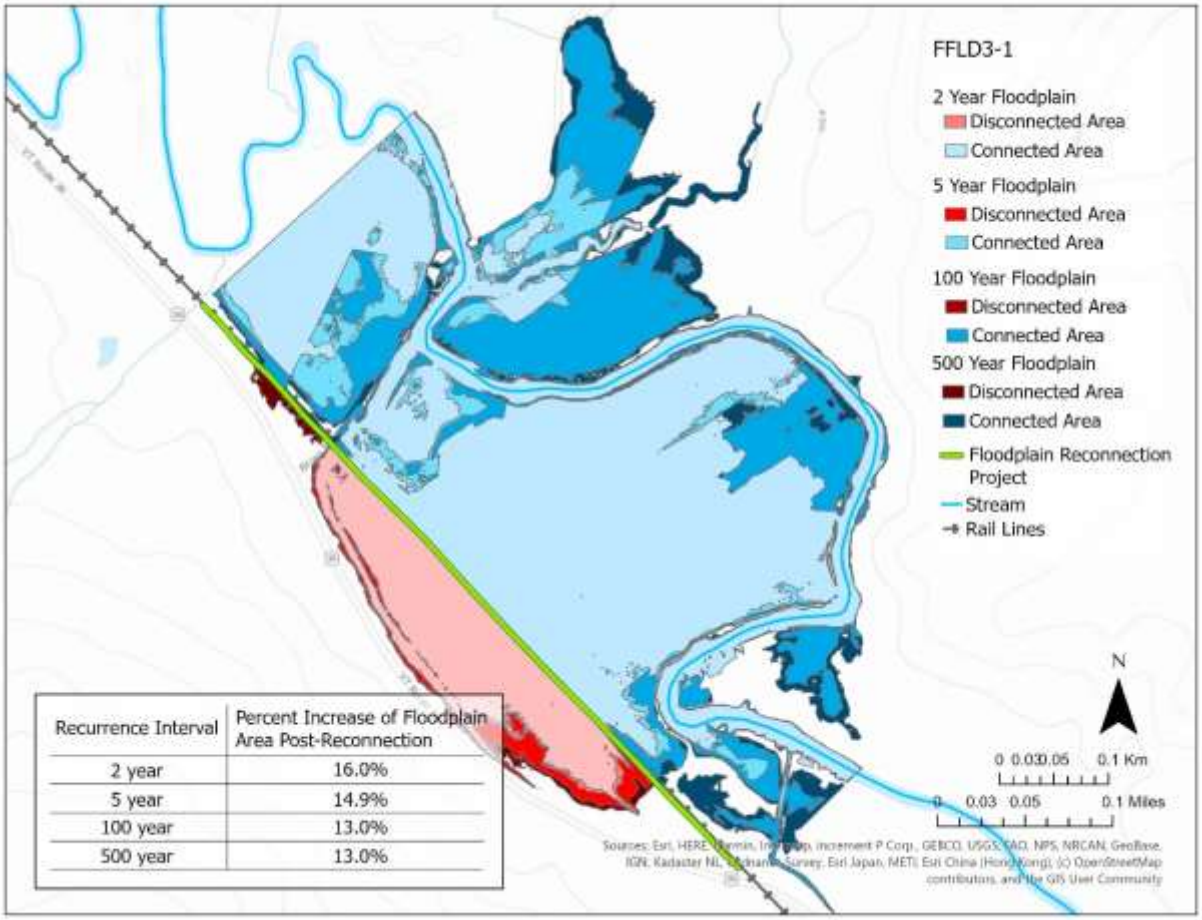
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	50.9%
5 year	48.8%
100 year	51.5%
500 year	51.6%

Black Creek – Fairfield 2a



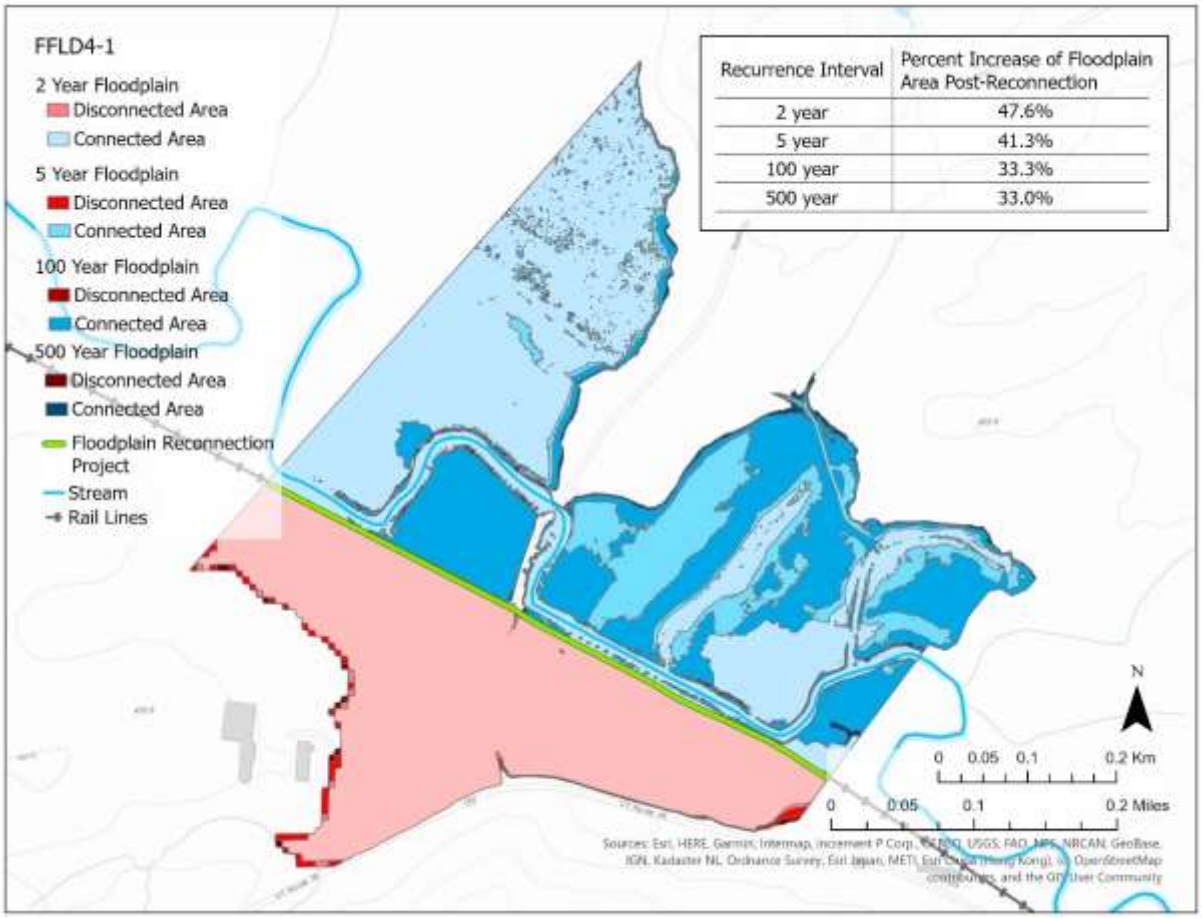
Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	50.9%
5 year	48.8%
100 year	51.5%
500 year	51.6%

Black Creek – Fairfield 3-1



Recurrence Interval	Percent Increase of Floodplain Area Post-Reconnection
2 year	16.0%
5 year	14.9%
100 year	13.0%
500 year	13.0%

Black Creek – Fairfield 4-1



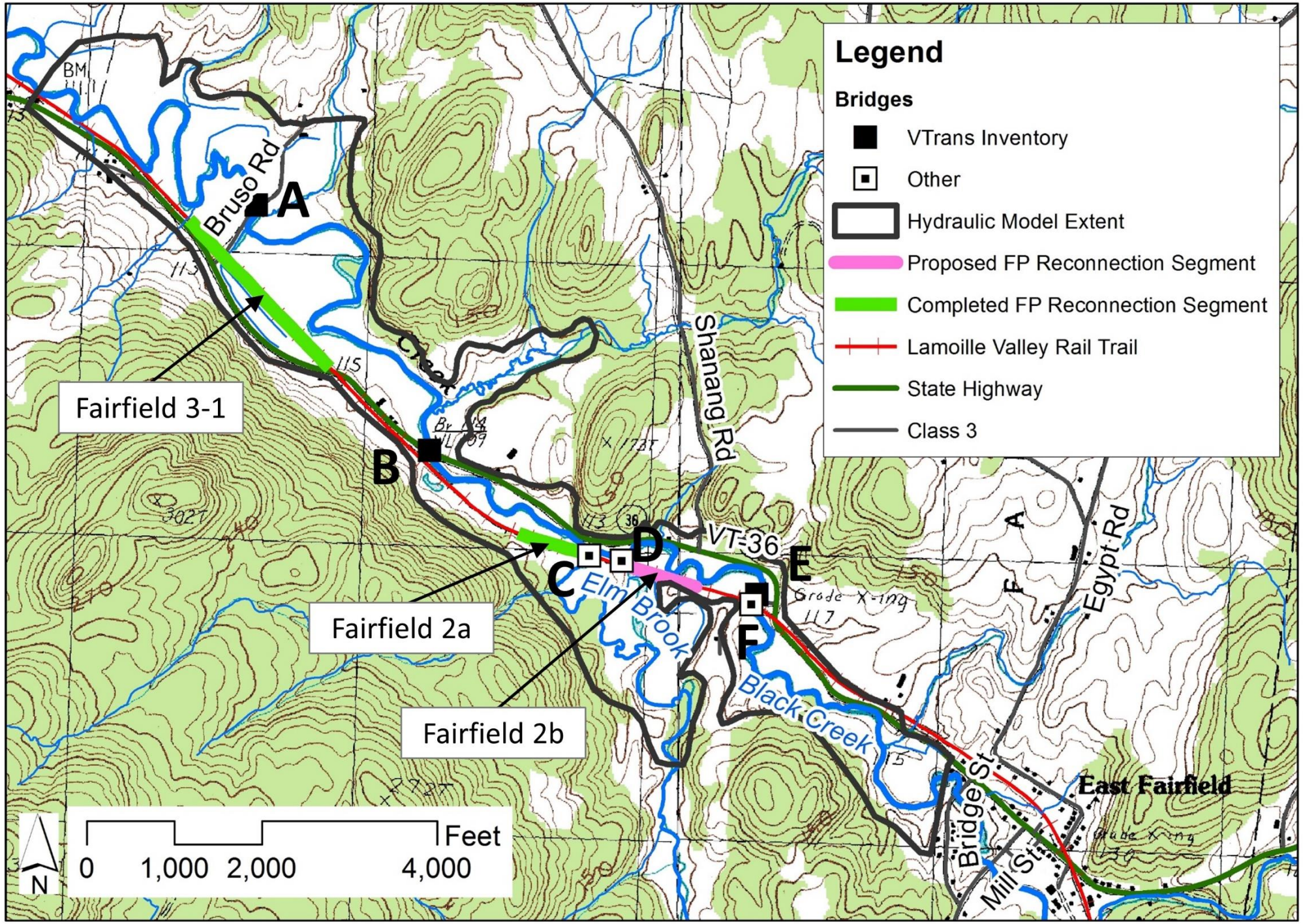
Bridges and Culverts on Black Creek and Major Tributaries

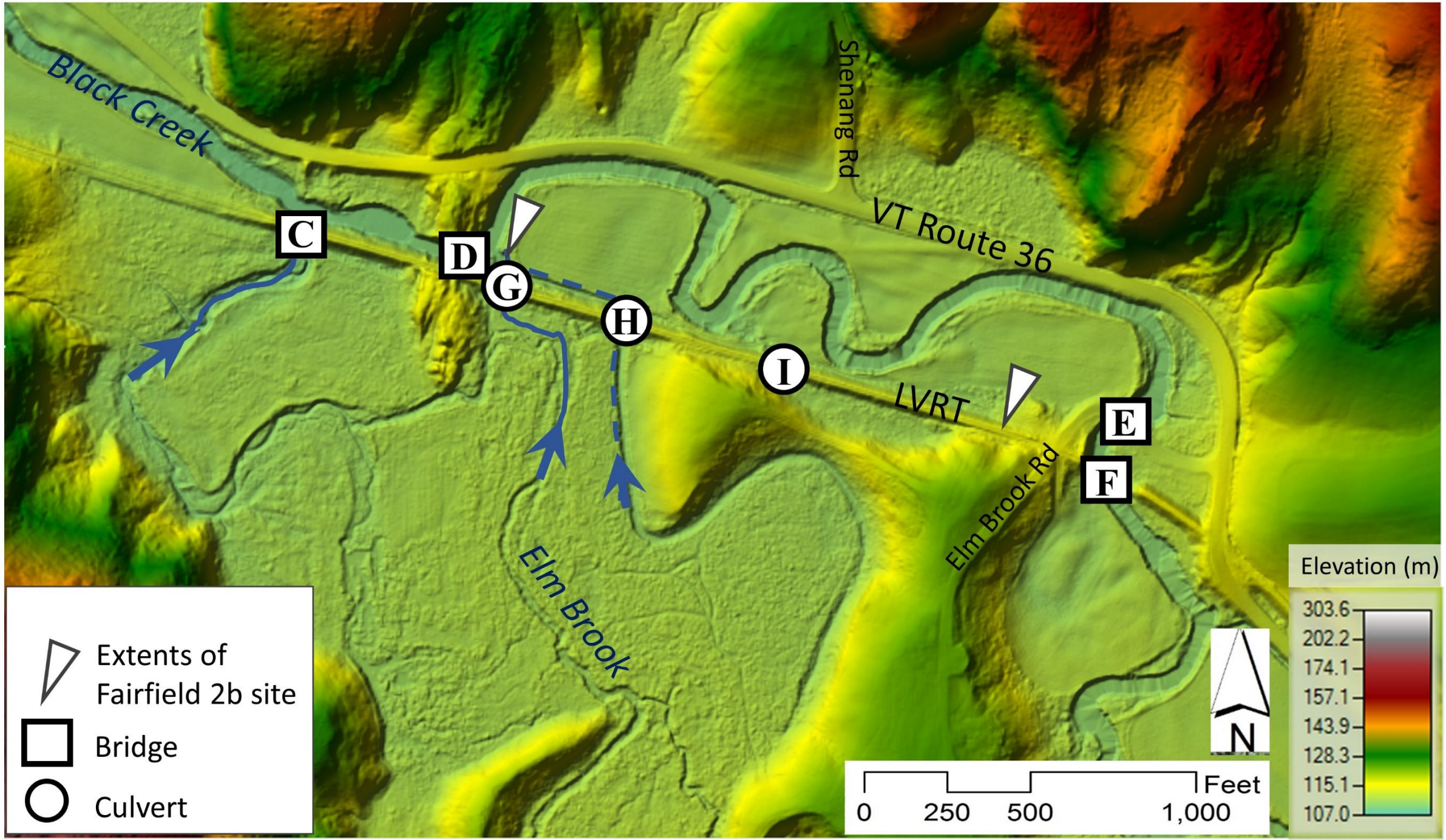
Black Creek Model Domain from East Fairfield village downstream below Bruso Road

Attachment E of VTrans Final Report 2018-02

EVALUATING EFFECTIVENESS OF FLOODPLAIN RECONNECTION SITES ALONG THE LAMOILLE VALLEY RAIL TRAIL: A BLUEPRINT FOR FUTURE RAIL-RIVER PROJECTS

August 31, 2020

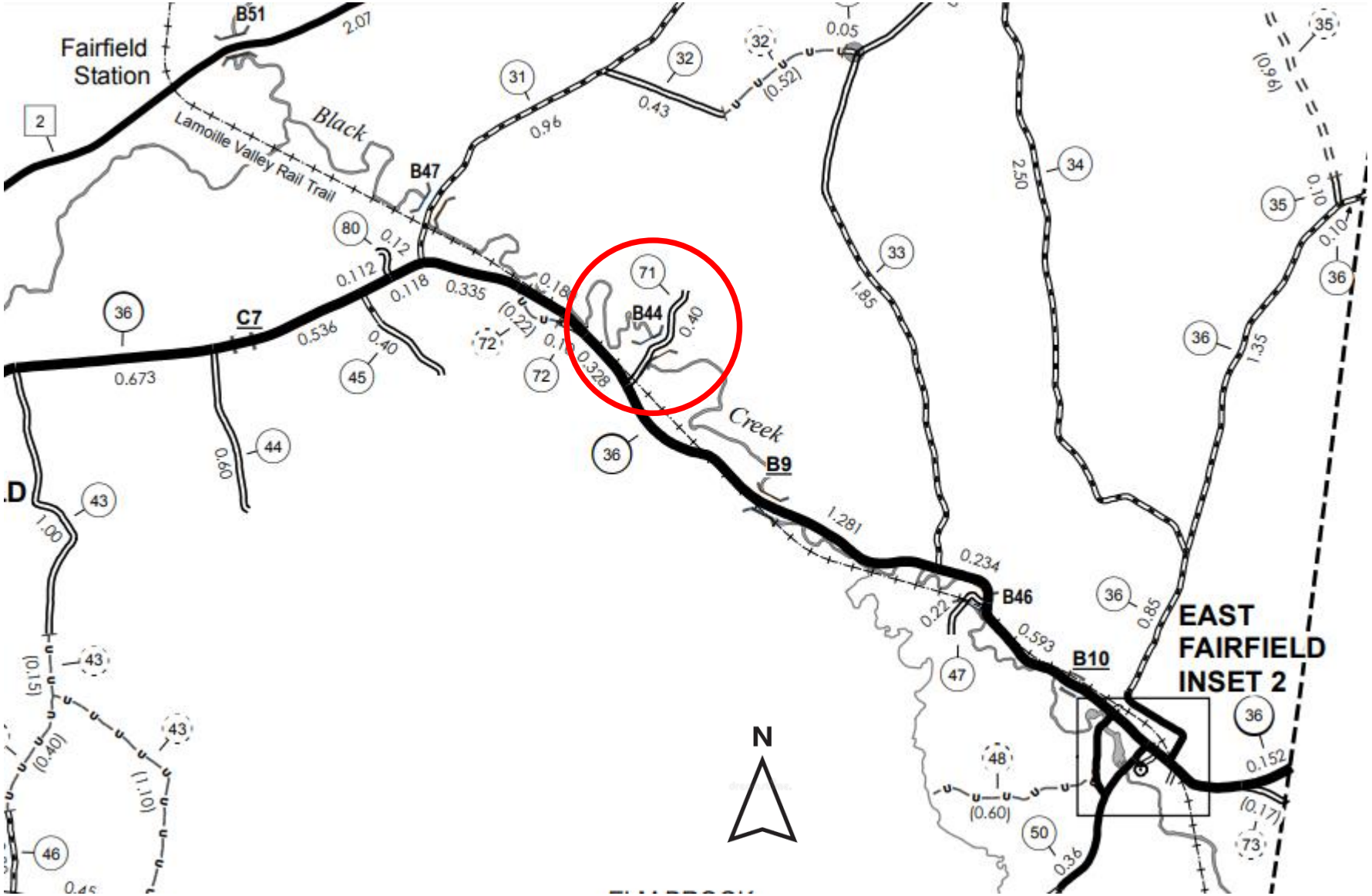

Legend
Bridges
VTrans Inventory
Other
Hydraulic Model Extent
Proposed FP Reconnection Segment
Completed FP Reconnection Segment
Lamoille Valley Rail Trail
State Highway
Class 3
A
B
C
D
E
F
Fairfield 3-1
Fairfield 2a
Fairfield 2b
Bruso Rd
Shanang Rd
VT-36
Egypt Rd
Elm Brook
Black Creek
Bridge St
Mill St
East Fairfield
N
0
1,000
2,000
4,000
Feet


Black Creek
Shenang Rd
VT Route 36
C
D
G
H
I
LVRT
E
F
Elm Brook Rd
Elm Brook
Extents of Fairfield 2b site
Bridge
Culvert
N
0
250
500
1,000
Feet
Elevation (m)
303.6
202.2
174.1
157.1
143.9
128.3
115.1
107.0

A – Bruso Road Bridge

VTRANS Town Highway Map, Fairfield, 2016

B44



http://vtransmap01.aot.state.vt.us/Maps/TownMapSeries/FRANKLIN_Co/FAIRFIELD/FAIRFIELD_MILEAGE_2016.pdf

A – Bruso Road Bridge

View to northeast from VT Route 36 down Bruso Rd, bridge at arrow, 12/22/2018

View to southwest to bridge outlet, from Bruso Rd, 12/22/2018

During ~Q5 flood

A – Bruso Road Bridge

Bridge inlet
During ~Q5 flood
12/22/2018

A – Bruso Road Bridge

View upstream from bridge during ~Q5 flood, 12/22/2018

A – Bruso Road Bridge

View upstream from bridge during baseflow conditions, 8/1/2019

A – Bruso Road Bridge

View downstream from bridge

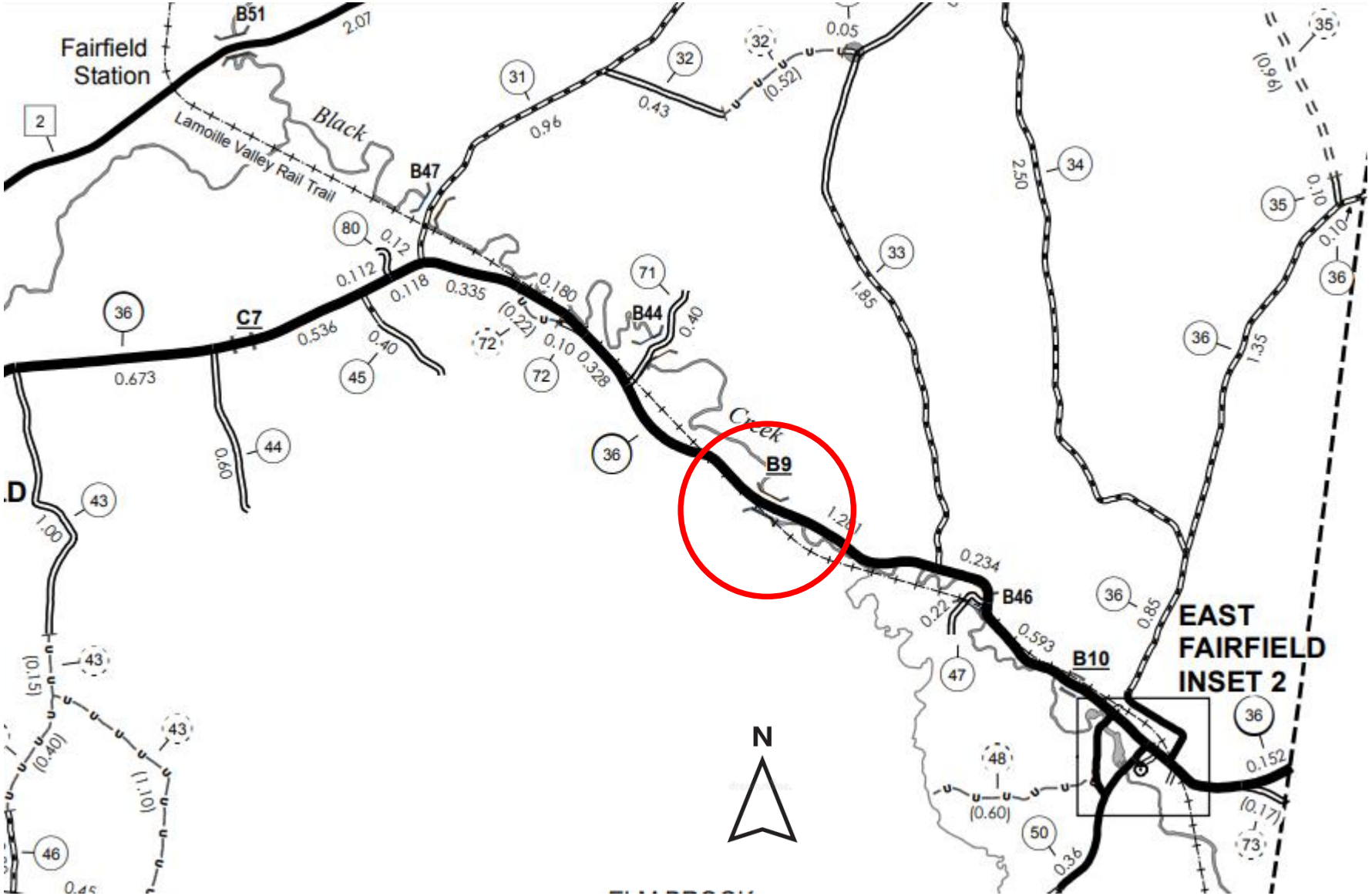
During ~Q5 flood, 12/22/2018

During baseflow conditions, 8/1/2019

B – VT Route 36 Bridge

B9

VTRANS Town Highway Map, Fairfield, 2016



http://vtransmap01.aot.state.vt.us/Maps/TownMapSeries/FRANKLIN_Co/FAIRFIELD/FAIRFIELD_MILEAGE_2016.pdf

B – VT Route 36 Bridge

B9

C – Lamoille Valley Rail Trail bridge over Elm Brook tributary

View to west from
bridge deck

Lowered rail segment,
Fairfield 2a, in distance.

July 24, 2020

C – Lamoille Valley Rail Trail bridge over Elm Brook tributary

View upstream in Elm Brook from bridge deck.

July 24, 2020

D – Sudol Farm Bridge

Constructed between 1941 and 1962 based on review of historic aerial photographs.

D – Sudol Farm Bridge

Farm bridge, view downstream to bridge inlet, 28 June 2019

D – Sudol Farm Bridge

View to south (toward rail trail) over bridge deck, 7/24/2019

View to north (from rail trail) over bridge deck, 7/24/2019. Note collapsed decking in foreground.

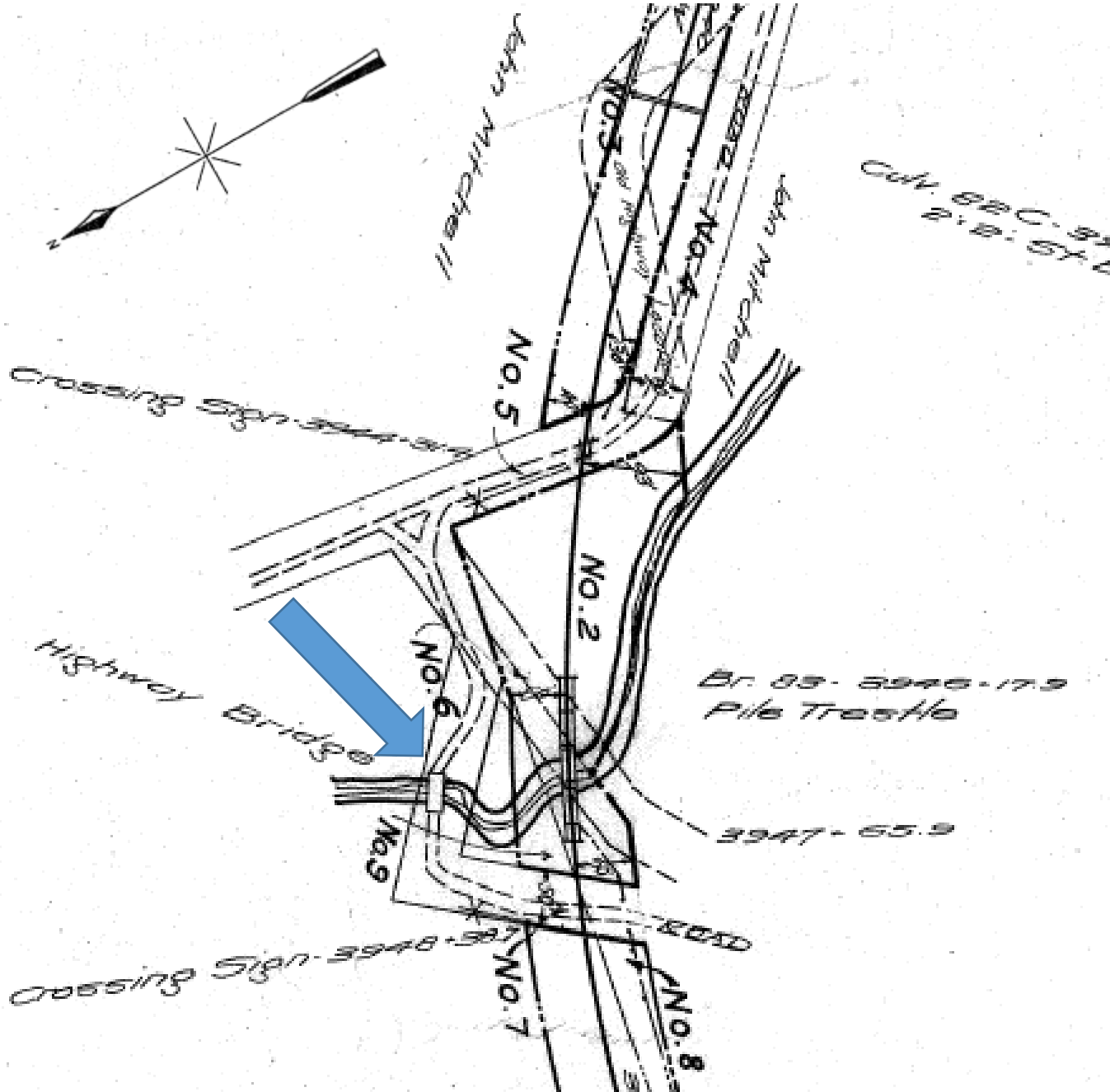
D – Sudol Farm Bridge

View upstream from bridge deck, 7/24/2019

View downstream from bridge deck, 7/24/2019, through blasted bedrock channel

E – Elm Brook Rd Bridge

Elm Brook Road crossing moved to present location during construction of railroad in 1870s. (1916 railroad valuation sheet)



RIGHT-OF-WAY AND TRACK MAP

THE ST. JOHNSBURY AND LAKE CHAMPLAIN R.R. CO.

Operated by

THE ST. JOHNSBURY AND LAKE CHAMPLAIN R.R. CO.

STATION 3922+80 TO STATION 3975+60

SCALE: 1-IN. = 100-FT. JUNE 30, 1916.

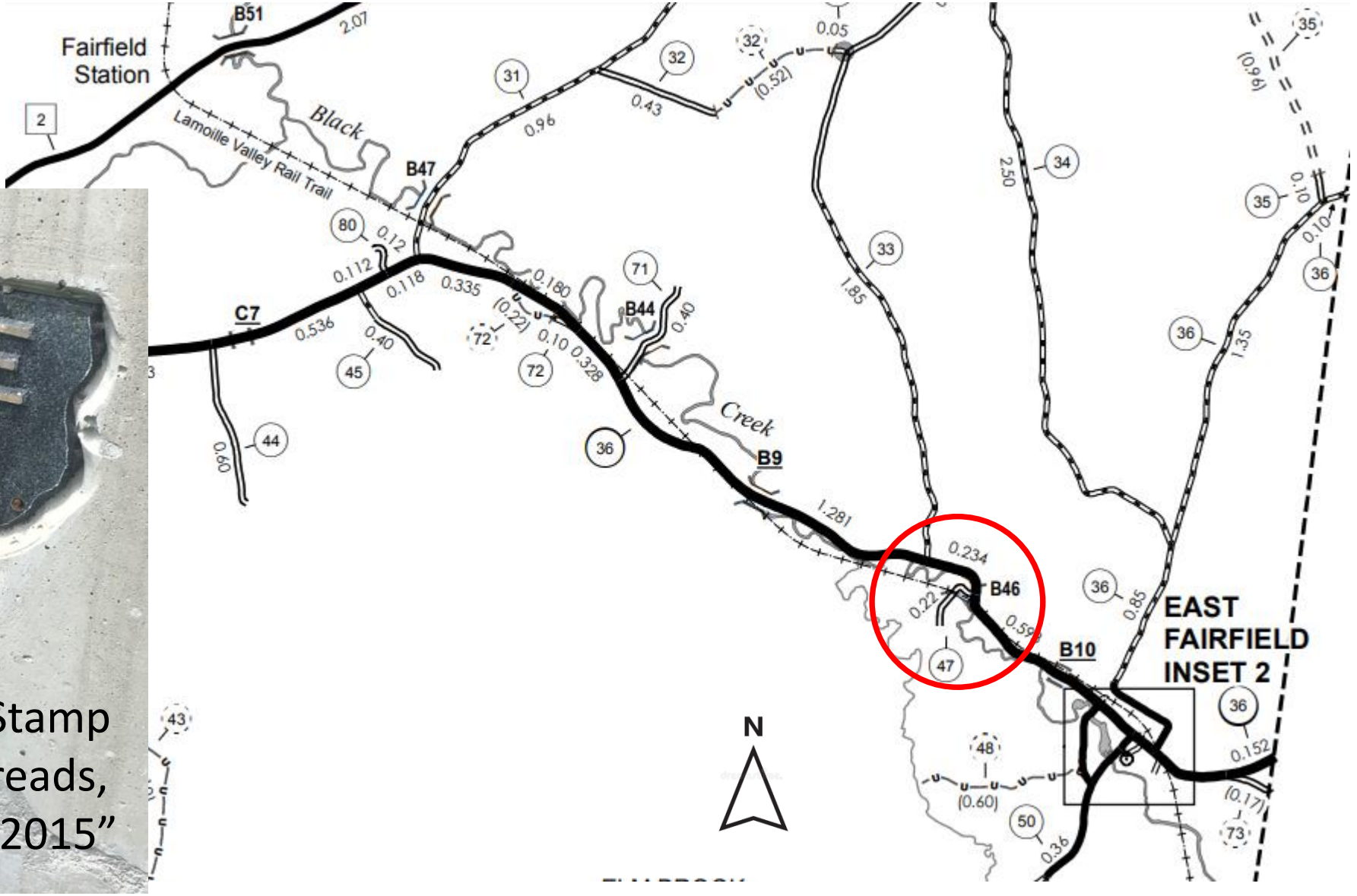
Office of Valuation Engineer,
Boston, Mass.

E – Elm Brook Rd Bridge

B46

Stamp reads, “2015”

VTRANS Town Highway Map, Fairfield, 2016



http://vtransmap01.aot.state.vt.us/Maps/TownMapSeries/FRANKLIN_Co/FAIRFIELD/FAIRFIELD_MILEAGE_2016.pdf

E – Elm Brook Rd Bridge

View to bridge outlet from Jct of Elm Brook Rd and VT Route 36, 12/22/2018

During a ~Q5 flood event.

During a ~Q25-Q50 flood event, 11/1/2019
Video from Susan Howe

E – Elm Brook Rd Bridge

6/19/2019
View downstream (north) to
Bridge inlet

E – Elm Brook Rd Bridge

6/19/2019
View downstream (north)
from bridge deck

F – Lamoille Valley Rail Trail Bridge near Elm Brook Rd

Railroad constructed between 1870 and 1877 (Aldrich, 1891)

Elm Brook Road crossing moved to present location during construction of railroad in 1870s. (1916 railroad valuation sheet)

RIGHT-OF-WAY AND TRACK MAP

THE ST. JOHNSBURY AND LAKE CHAMPLAIN R.R. CO.

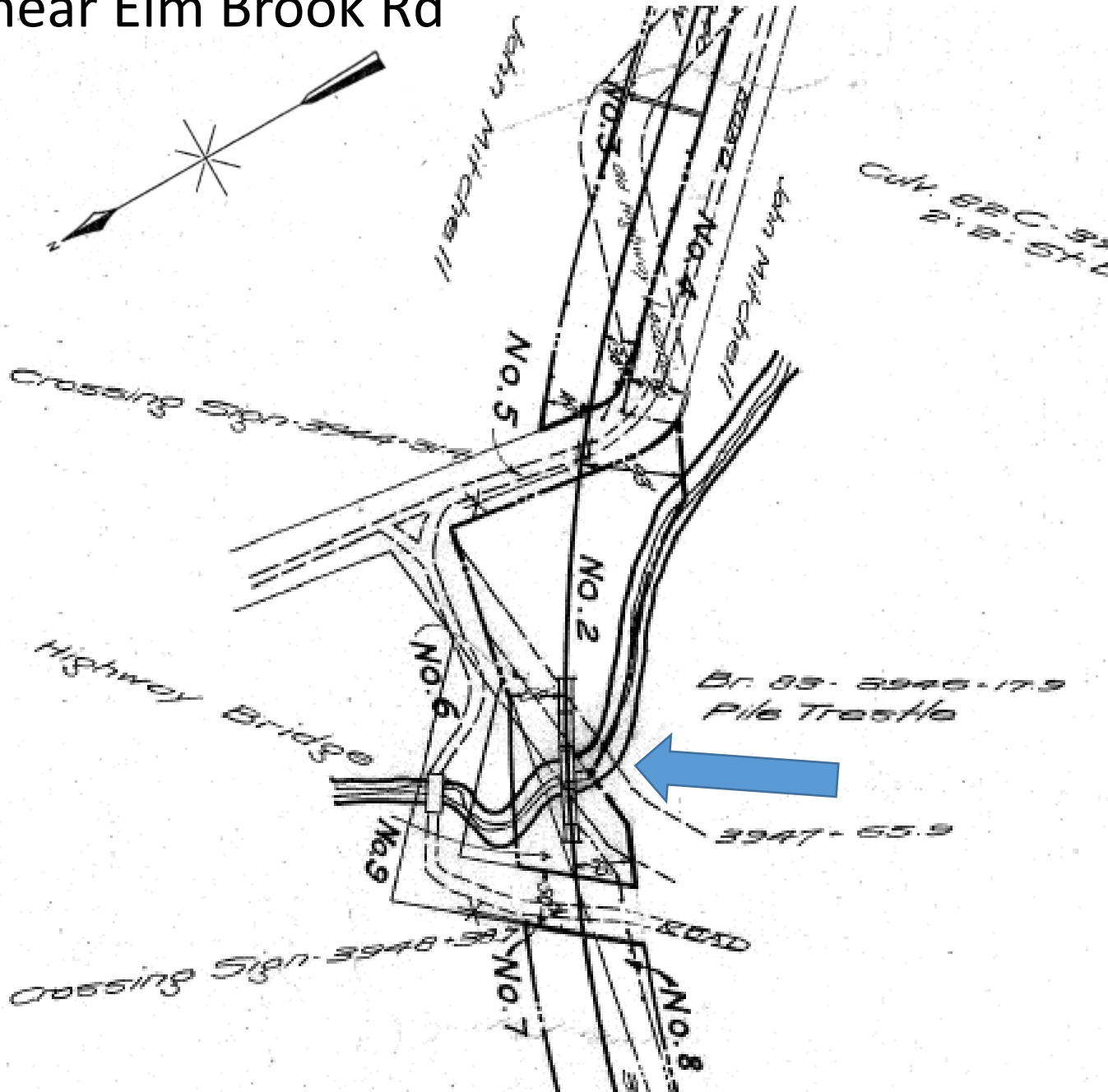
Operated by

THE ST. JOHNSBURY AND LAKE CHAMPLAIN R.R. CO.

STATION 3922+80 TO STATION 3975+60

SCALE: 1-IN. = 100-FT. JUNE 30, 1916.

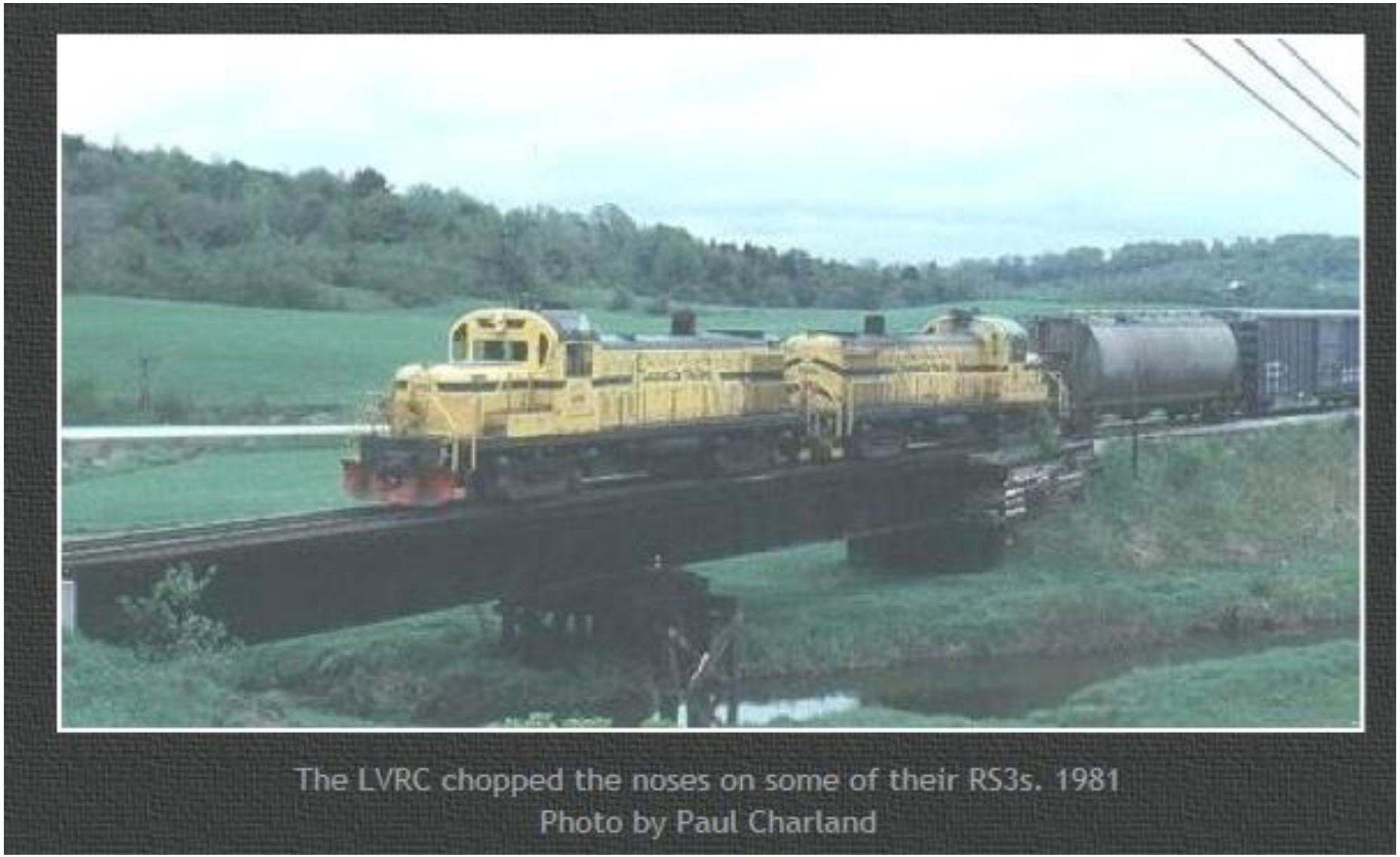
Office of Valuation Engineer, Boston, Mass.



F – Lamoille Valley Rail Trail Bridge near Elm Brook Rd

Last train on the Lamoille Valley rail line occurred in 1997, following substantial damages sustained in the floods of 1984, 1995, and 1997.

In 2005, "…the rail line was federally rail banked and the tracks and ties were removed."
(Schiff et al., 2008)



Source: http://nekrailroad.com/NEKOLD/Lamoille_Valley.html

View to northeast.

F – Lamoille Valley Rail Trail Bridge near Elm Brook Rd

4 April 2019, view to east of bridge decking

F – Lamoille Valley Rail Trail Bridge near Elm Brook Rd

View downstream to bridge inlet, 12/22/2018

View upstream to bridge outlet from Elm Brook Rd, 12/22/2018

During a ~Q5 flood event.

View to east down LVRT from Elm Brook Rd, 12/22/2018

F – Lamoille Valley Rail Trail Bridge near Elm Brook Rd

View upstream to bridge outlet, bedrock exposed in the channel.

6/19/2019

F – Lamoille Valley Rail Trail Bridge near Elm Brook Rd

View upstream to bridge outlet, wooden pile trestle in disrepair

6/19/2019

Surveying channel cross section, Bridger Banco, Lindsay Worley

F – Lamoille Valley Rail Trail Bridge near Elm Brook Rd

View upstream to bridge outlet, remnants of wooden pile trestle in mid-channel

6/19/2019

G – Cross culvert (west) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

From UVM Survey dated 19 June 2019:

Diameter: 1.044 m (3.43 ft, nominal 42”)
Length: 12.6 m (41.3 ft)
Slope: 0.0339 m/m
(Slopes downward toward the north)

Installed: (Upsized) between 2009 and 2012, based on review of aerial images, and as reported in interview with Mike Rainville (7/24/19).

Replaced former smaller culvert in Summer/Fall of **2009** based on photodocumentation by VAST (K. Brown, email, 2/13/2020)

View to south (upstream) from rail trail 19 June 2019; former path of Black Creek prior to 1870.

G – Cross culvert (west) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

View to north (downstream) from rail trail; confluence with Black Creek in distance.

Wide scour pool downstream of perched culvert outlet.

19 June 2019

G – Cross culvert (west) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

Site of former, smaller-diameter, pinched culvert.

Per Ken Brown, 2/13/20 email:
This “picture shows condition for the culvert nearest Elm Brook” in 2007

Photo caption: “1187- unidentified culvert, may be 36 inch cmp, sta 3961+50, blocked with debris from rains. Serious, needs cleaning”

View from south side of rail line in Elm Brook floodplain

2007 photo from Ken Brown, VAST – “1187…”

G – Cross culvert (west) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

Per Ken Brown, 2/13/20 email:
"In the summer/fall of 2009 the landowner(?) replaced that culvert so it would actually flow. Photos "IMG_0020 and 0023" are from spring 2010."

Spring 2010 Photo from Ken Brown, VAST – "IMG 0020"

Spring 2010 photo from Ken Brown, VAST – "IMG 0023"

Views from south side of rail line in Elm Brook floodplain

H – Cross culvert (east) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

From UVM Survey dated 19 June 2019:

Diameter: 0.81 m (2.65 ft, nom. 34”)
Length: 12.5 m (41 ft)
Slope: -0.00011 m/m
(Slopes very slightly downward to south; essentially level)

Installed: **Fall 2010** based on photodocumentation by VAST.

View to south (upstream) from rail trail
19 June 2019

H – Cross culvert (east) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

Per Ken Brown, 2/13/20 email:
“in fall of 2010 the [eastern] culvert and the ditch went in”.

View to southeast along south side of rail trail

Fall 2010 Photo from Ken Brown, VAST – “Inlet Bank East”

H – Cross culvert (east) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

Per Ken Brown, 2/13/20 email:
“in fall of 2010 the [eastern] culvert and the ditch went in”.

View to southeast from north side of rail trail

Fall 2010 Photo from Ken Brown, VAST – “Inlet 4”

H – Cross culvert (east) beneath Lamoille Valley Rail Trail at Fairfield 2b-1 site connecting Elm Brook and Black Creek floodplains

Per Ken Brown, 2/13/20 email:
“in fall of 2010 the [eastern] culvert and the ditch went in”.

Historic data from Rainville interview suggests the ditch along the north side of the rail line was constructed in 1998, therefore perhaps this work in 2010 involved improving a pre-existing ditch.
.

View to north from rail trail,
VT Route 36 in distance

Fall 2010 Photo from Ken Brown, VAST – “Outlet 3”

I – Cross Culvert under LVRT at Fairfield 2b-2 site

View to southeast from base of rail trail embankment to culvert inlet draining small isolated floodplain pocket blocked by segment 2 of the Fairfield 2b proposed rail line modification site. Inlet partially blocked by beaver-chewed small woody debris, 13 May 2020.