Better Roads
Clean Water You Can Afford

VTrans
VERMONT
AGENCY OF NATURAL RESOURCES

Vermont Better Roads Grant Program Application

Please complete one application per category and/or project you are applying for. You may make copies of the application for multiple applications per category and/or multiple categories.

Please check the Category you are applying for:

☐ B. Correction of a Road Related Erosion Problem and/or Stormwater Mitigation Retrofit for both gravel and paved roads

☒ C. Correction of a Stream Bank or Slope Related Problem

☐ D. Structure/culvert upgrades

Town/Organization: Town of Warren

Project Name: Brook Road Stabilization

Road Name: Brook RD TH #: 1 Structure # (if applicable): ______

Road Type: (Paved) or Unpaved (circle one) Curbed or (Uncurbed) (circle one)

(Class 1) Class 2 Class 3 Class 4 (circle one)

Watershed: Mad River

Please provide a thorough description of the problem (ex. Roadway has steep slope with no ditch which is causing roadway erosion):

Roadway has a steep slope down to Freeman Brook. Water runs down to low point causing undermining of Road.

Description of Project and how you plan to complete the work (ex. Stone line 500' of ditch by reshaping ditch and stone lining, working from the top of the project down to the bottom):

Installing Self-Drilling SuperNails and reinforced Shotcrete to Stabilize the slope along the roadway for a length of 92LF, Providing Curbing.

Expected Effects (+ & -) on water quality (ex. Erosion will be eliminated by placing the stone ditch):

Bank erosion would be eliminated from sliding into Freeman Brook by stabilizing the bank. Directing Water to ditch on opposite side.

Better Roads
Clean Water You Can Afford

VTrans
VERMONT
AGENCY OF NATURAL RESOURCES

Distance from end of project to nearest water (stream, lake, or stormwater system that outlets directly to water). Please circle one: (0-50') [circled] 50-250' 250'+

Progress to Date:

GeoStabilization International Representative has been to the site.

Is there an emergency reason this project must be completed quickly? If yes, please explain:

Class 1 Road from 2 Towns - Waitsfield, Roxbury. As much traffic as RT 100.

Has this project been identified through a municipal road inventory, capital budget plan, tactical basin plan, culvert inventory, or other management plan? If yes, please list which.

Yes: RSM / Roads Committee No

Please list any professionals you may have contacted for assistance with this project (ANR River Management Engineer, Army Corps of Engineers, VTrans District Technical staff, Basin Planner etc.):

Jaron Borg, A.N.R
Perry Kairis - GeoStabilization International

Is the project located in the town "Right of Way?" Yes, No, Both (if "Both" please explain further).

Yes

Will the town road crew complete this work? (Yes,) [circled] No, Some (if "some" please explain further).

Better Roads
Clean Water You Can Afford

VTrans
VERMONT
AGENCY OF NATURAL RESOURCES

Describe how the grant funds will be spent and/or attach a project budget: Attached is GSI Proposal, Contractor is an additional $12,000 + Permitting of 4,000 Engineering

How do you plan to meet the required 20% match on this grant?:
Budgeted in highway budget and in Capital Reserve fund

Requested Grant Amount ($20,000 max Category B, $40,000 max Categories C & D): 30,000
Estimated Total Project Cost (including 20% local match): $63,035
Estimated Completion Date: 9/30/16

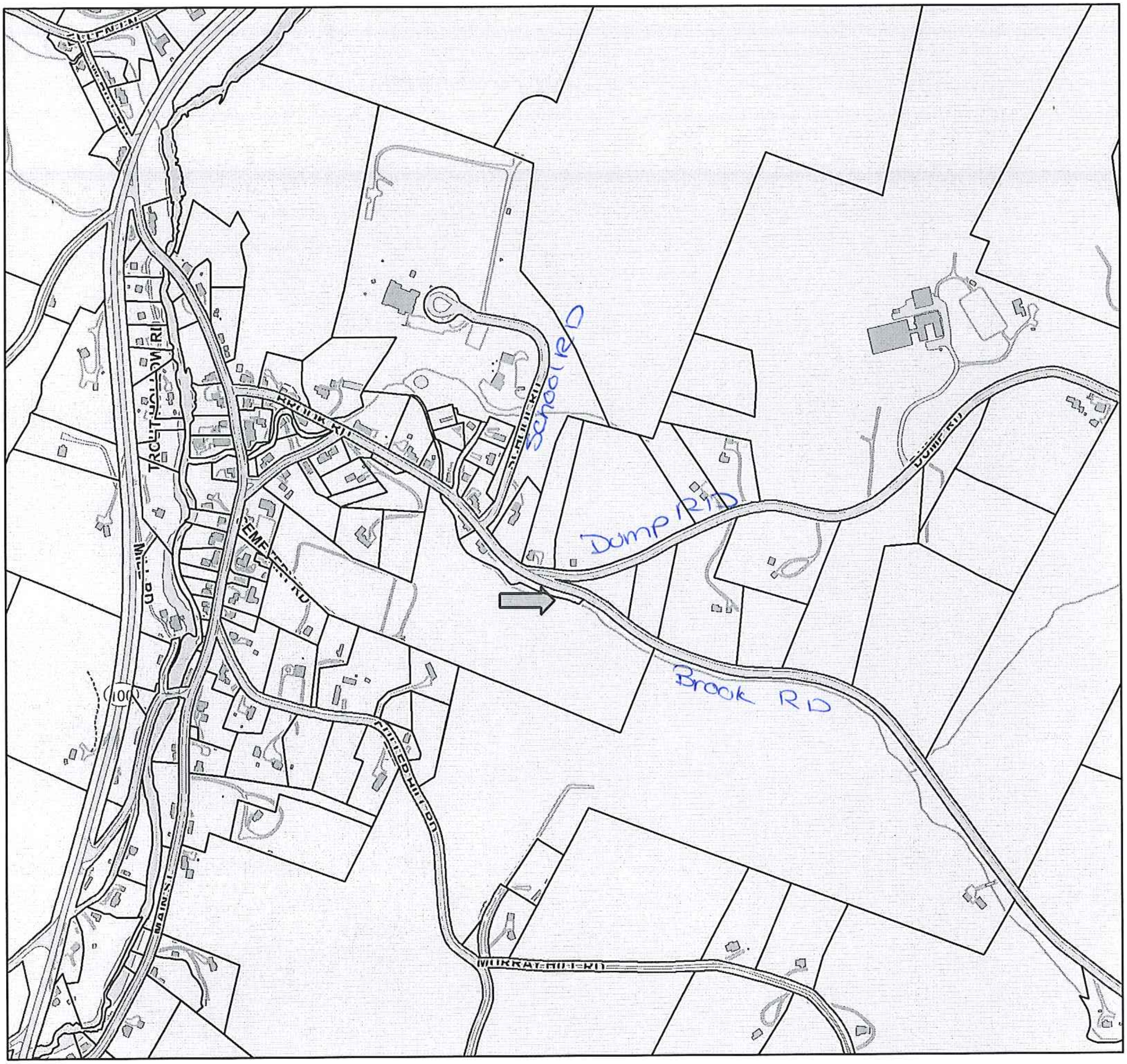
REQUIRED ATTACHMENTS:

- ☒ Itemized Cost Estimate (labor, equipment, materials)
  (For assistance, call Better Backroads at 802-828-4585)
- ☒ Project Location Map
  (Please show location of affected water; 1:12,000 USGS map, if possible)
- ☒ Sketch of proposed erosion control measures, including:
  - ☐ Distances (ft.)
  - ☐ Estimate of waste & borrow quantities
  - ☐ Approx. location of town/other right-of-way and/or property lines
- ☐ Photo(s) of the project area.
- N/A - ☐ Agreement for Entry and/or Deed of Easement (if project is outside Town ROW).
- ☒ If project involves stream or river/road conflict, include documentation of consultation with a River Management Engineer.
- ☐ Other appropriate supporting documents.

By signing this application I certify that all the information provided is accurate to the best of my knowledge. We will comply with all the requirements of the grant including making our books available for audit if required.

SIGNATURE OF APPLICANT: (Must be Town Administrator/Manager or Select Board Chair)

Name: [signature] Title: TA



Town of Warren, VT
Slide Brook Road

Disclaimer
This map is a public resource of general information.
The Town of Warren shall assume no liability for:
1. Any errors, omissions, or inaccuracies in the information provided regardless of how caused; or
2. Any decision made or action taken or not taken by the reader in reliance upon any information or data furnished hereunder.

Feet
0 380 760 1,520

N

1 inch:943 Feet

Legend
Trails
Other
Lot Line
Right Of Way

Bannon Engineering
Post Office Box 171
Randolph VT 05060-0171

Bannon ENGINEERING
www.bannonengineering.com

Town of Warren
Cindi Jones
PO Box 337
Warren VT 05674-0337

Estimate #	12102
Estimate Date	March 8, 2016
Estimate Total (USD)	**$3,980.00**

Nail + Grid
Saw Cut Hole
Crushed Gravel
Patch Pave

Item	Description	Unit Cost	Quantity	Line Total
Survey	Survey 92-ft roadway and 150-ft River corridor. Topographical Survey 2-ft contours. Survey ordinary high water.	1,000.00	1	1,000.00
Engineer	Prepare plans and typical sections to avoid of Stream impacts. Quantify impacts below ordinary high water. Impacts greater than 10-cy below ordinary high water require State Stream Alteration Permit.	2,480.00	1	2,480.00
Pre-con	Preconstruction meeting - Travel to site, meet with contractor to review project. Provide two additional visits to review progress and spot check compliance.	500.00	1	500.00
			Estimate Total (USD)	**$3,980.00**

Terms
This estimate is firm fixed fee. Invoice payable upon receipt. Credit cards accepted. Bannon Engineering standard terms and conditions apply.

Please "accept" Estimate at top right to schedule project. Given our current workload, completion of work for your project is estimated to be within 30-days from your acceptance of this estimate.

I look forward to assisting you with your project. Thank you!

BROOK ROAD

SLUMP CONDITION - GEOSTABILIZATION 2016

VIEW FROM EAST ▲ TEMPORARY STONE FILL

VIEW FROM WEST ▲ NOTE SLUMP FAULT LINES

CENTRAL VERMONT REGIONAL PLANNING COMMISSION

Cindi Jones
Town Administrator
P.O. Box 337
Warren, VT 05674

1/27/16

Dear Cindi,

The Central Vermont Regional Planning Commission supports your application to the 2017 VTrans Better Roads Program. The Brook Rd. Stream and Embankment work was identified in the Mad River Valley Flood Resilient Transportation Study, done last year.

The proposed application is also consistent with the following regional goals and policies:

> Support efforts to minimize negative environmental impacts associated with the transportation system (including air quality, noise levels, surface water, vegetation, agricultural land, fragile areas, and historical/archaeological sites).

Please call me if I can be of further assistance in the preparation of your grant application.

Sincerely,

Steve Gladczuk
Transportation Planner

29 MAIN STREET • SUITE 4 • MONTPELIER • VERMONT 05602
802-229-0389 • FAX: 802-223-1977 • E-MAIL: CVRPC@CVREGION.COM

GeoStabilization International®

GeoStabilization International

P: 855.579.0536 | F: 970.245.7737
PERRY@GSI.US Cell: 412.432.6047
www.geostabilization.com

May 18, 2015

Ms. Cindi Jones
Town of Warren Administrator
P.O. Box 337
Warren, VT 05674

Subject: Proposal for Roadway Stabilization on Brook Road, Town of Warren
Project Location: GPS Coordinates: 44.11173, -72.84765

Dear Cindi:

GeoStabilization International® (GSI®) is pleased to offer this proposal to stabilize the slope on Brook Road just above Dump Road in the Town of Warren.

Project Overview

This proposal addresses installing Self-Drilling SuperNails® and reinforced shotcrete to stabilize the slope along the roadway for a length of 92 LF.

CORPORATE ADDRESS: PO Box 4709, Grand Junction, CO 81502
BRANCH OFFICES: Arizona, British Columbia, California, Colorado, Kentucky, North Carolina, Ontario, Oregon, Tennessee, Utah, and Virginia

Slope Repairs

The Town of Warren forces, or your designated General Contractor, will conduct clearing, excavation, hauling, and reshaping of the working face to a slope steeper than a 0.5H:1V slope for about 6 feet measured along the slope. The bench at the bottom of the excavated slope will need to be day-lighted to allow positive drainage away from the repair. This site preparation will be directed by a representative of GSI to ensure a proper slope for the working face of the stabilization system. GSI will then install Self-Drilling SuperNails® per our design leaving the nail ends protruding through the soil. We will install a band of reinforced shotcrete tied to the nail tips. Installation and maintenance of guardrail will be by the Town of Warren after the slope stabilization is complete.

Resources

This proposal includes the Town of Warren, or your designated General Contractor, providing yard space to receive and unload materials shipped by GSI; site preparation as described above; utility locates (including depth to all utilities within the work zone); permits; easements; and traffic control (including signage, flaggers, and detours as appropriate).

Our equipment is mounted on a trackhoe allowing the work to be accomplished from the roadway. GSI can allow alternating traffic to pass in the opposite lane during working hours (roadway is 24 ft. wide). GSI can park the trackhoe off the road near the site at night to open the roadway for traffic during non-working hours.

Schedule

Barring any unforeseen delays, this repair should take approximately 5 days to complete.

Cost

LF	QTY	Unit	Item	Unit Price	Price
	1	EA	Mobilization*	$7,000.00	**$7,000.00**
92	47	EA	Up to 30-ft Self-Drilling SuperNails	$900.00	**$42,300.00**
92	552	SF	Reinforced Shotcrete	$30.00	**$16,560.00**
92	47	EA	Galvanized Steel Plates	$25.00	**$1,175.00**
			TOTAL		**$67,035.00**

*If multiple slides are repaired during the same visit, GSI will reduce mobilization charges.

Other

Our price also includes design and we will supply a P.E. stamped typical section. Our work also carries a five-year warranty commencing after GSI project completion. This warranty is void absent GSI receiving mutually agreed project payment. If at any point within the warranty period the repaired section becomes unstable, GSI will, in a timely manner, remedy the situation with a design/construction solution at no cost to the owner. This warranty does not cover work completed by others or shallow surface erosion problems that may develop in the future. Exceptions to the warranty include catastrophic seismic, weather, or other events outside reasonable accounting in design (including earthquakes and weather events exceeding expectation for the region) or further construction by third parties that destabilizes the repair (including utility trenches dug into or through any soil nails, deep excavations in the area, etc.). Extreme storm water volumes may cause erosion which could undermine the repaired areas which may void this warranty. After such an event these areas should be checked for erosion.

If you have any questions please feel free to contact me at the above number or via e-mail.

GeoStabilization International
Perry A. Kairis
By: Perry A. Kairis, P.E.
Northeast Region
Independent Project Development Representative
Cell (412) 432-6047
perry@gsi.us

Cindi Jones

From: Perry Kairis [pakairis@triad.rr.com]
Sent: Monday, May 18, 2015 11:28 PM
To: Cindi Jones
Cc: 'Nate Beard'; 'Matt Birchmier'; 'Eric List'; 'Chris Thompson'; 'Brent Leverett'; 'Neil Bullock'; 'Vinnie Antonette'; 'Zech Moriarty'; 'Rouse Slape'
Subject: GSI Proposals for Brook and West Hill 2
Attachments: Brook Rd. Final.pdf; West Hill Road Repair 2 Final.pdf

Follow Up Flag: Follow up
Flag Status: Completed

Hi Cindi:

Attached are the GSI Proposals for making the permanent stabilization repairs to Brook Rd. and to West Hill Road – Repair 2. We have been working to get Rouse and his crew to start the Sugarbush Access Road Repair after the VAOT job since he is familiar with Willie and working with the concrete supplier there in the Warren area. It looks like Rouse can make it over to Warren around 5/28 or 5/29. Please let Willie know that we are working towards that start date and will be in contact with you on Tuesday after Memorial Day to firm up the exact start date and time.

Please let me know about the attached proposals. I understand that you may only be able to fund 1-2 projects per year and we can have it on the pending list for next year if you prefer.

Thanks for your business and we look forward to working with you again.

Best,

Perry A. Kairis, P.E. Independent Project Development Representative

Cell: 412.432.6047 **Office:** 855.579.0536 **Fax:** 970.245.7737 **E-mail:** Perry@GSI.US

www.geostabilization.com

GeoStabilization International

GEOHAZARD MITIGATION EXPERTS

GSI® provides the most responsive and experienced geohazard mitigation services in North America and specializes in design/build/warranty landslide repair, rockfall mitigation, excavation shoring, and GRS-IBS abutment construction.

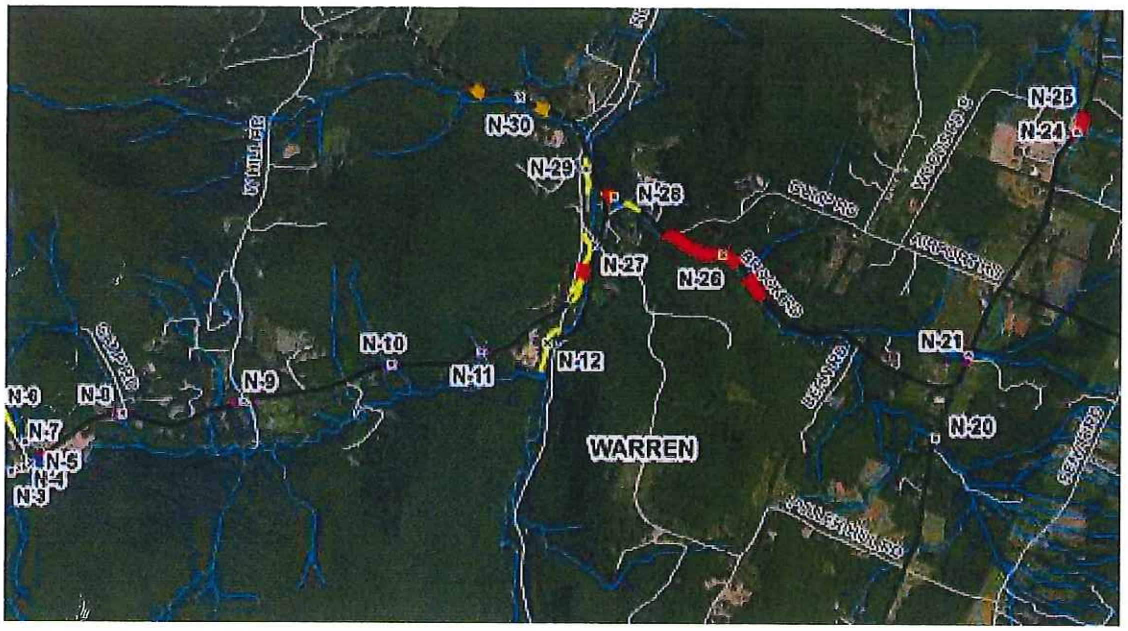
Branch offices in Arizona, British Columbia, California, Colorado, Florida, Idaho, Kentucky, North Carolina, Ohio, Ontario, Oregon, Tennessee, and Virginia.

Flood Resilient Transportation Pilot Study

Waitsfield, Warren, and Fayston
Vermont

Prepared for:

Central Vermont Regional Planning Commission



Prepared by:

DuBois & King inc.

Bear Creek Environmental

September 22, 2015

Flood Resilient Transportation Pilot Study

Waitsfield, Warren, and Fayston
Vermont

TABLE OF CONTENTS

ATTACHMENTS

1.0 Introduction

Tropical Storm Irene in August 2011 caused widespread damage in Vermont due to flooding and erosion. This has highlighted the need for communities to improve their transportation infrastructure to become more flood resilient. The Central Vermont Regional Planning Commission (CVRPC) is interested in promoting flood resiliency and assisting its member communities to improve the flood resiliency of their transportation infrastructure.

CVRPC contracted with river engineers and scientists from DuBois & King Inc (D&K) and Bear Creek Environmental LLC (BCE) to develop a systematic approach to identify sites on a Town's road network that are vulnerable to future flood damage and to recommend mitigation strategies to improve the flood resiliency of those sites. The study focused on the Towns of Waitsfield, Warren, and Fayston. This report summarizes the process that the documents the D&K/BCE/CVRPC approach and provides the results in the three subject towns.

There were four primary components of the project:

1. Identification and Conceptual Design of Strategies to Improve Flood Resiliency of Roadways
2. Guidance for Selecting Appropriate Strategy to Improve Flood Resiliency
3. GIS-Based Screening to Identify Roadway Segments Vulnerable to Flood Damage
4. Field Investigation of Potentially Vulnerable Sites

2.0 Strategies to Improve Flood Resiliency of Roadways

The project team identified nine strategies that could be used to improve the flood resiliency of vulnerable road segments:

Strategy 1. Relocate Road
Strategy 2. Raise Road
Strategy 3. Protect Road Embankment – Standard Rip Rap Slope
Strategy 4. Protect Road Embankment – Stacked Stone Toe Wall
Strategy 5. Raise and Protect Streambed
Strategy 6. Larger Culvert or Bridge
Strategy 7. Protect Road for Overtopping
Strategy 8. Create Low Point in Culvert/Bridge Approach
Strategy 9. Drainage Improvements

The strategies include those that have commonly been applied in Vermont following storm damage, as well as others that are less commonly applied. In some cases, such as using stone riprap to protect a vulnerable road embankment, the strategies are not new, but do include improvements on the traditional use of the strategies that are intended to improve resiliency. Each of the nine strategies is described below. Sketches of each are included in Attachment A.

2.1 Strategy 1. Relocate Road

Relocating a road is applicable in locations where the road parallels the channel in close proximity, and continued or future erosion of the roadway embankment is likely. Relocation usually entails a modest shifting of the most vulnerable segment of the roadway away from the channel rather than a wholesale relocation. The clear benefit of this strategy is that once the road is moved, the potential for damage is greatly reduced or eliminated.

In practice, roads are rarely relocated because it typically requires purchase of additional right of way, and that cost coupled with the cost of constructing the new length of road is frequently more than the cost of trying to protect the roadway in its current location. Thus, it is most applicable to sites where the cost of protecting the road via traditional methods is unusually expensive, or sites where traditional methods have proven unreliable.

2.2 Strategy 2. Raise Road

Raising a road would be done to reduce the frequency that the road gets inundated by floodwaters. It is applicable in limited settings meeting two criteria: the road is parallel to the stream and the road is located at the outer extent of the floodplain (typically against the valley wall).

Raising a road that does not meet these two criteria (e.g., the road crosses the stream or the road is next the stream with extensive floodplain on the back side) would prevent water from spilling into the floodplain and result in higher, more erosive flows in the channel.

2.3 Strategy 3. Protect Road Embankment – Standard Riprap Slope

Protecting roadway embankments with stone riprap is perhaps the most common strategy for improving the resiliency of roadways in Vermont adjacent to streams. It has been used for generations. As presented in Attachment A, the strategy includes three features that increase the resiliency of a riprap slope beyond the traditional approach:

1. Type IV or larger stone on the lower slope. It is well understood that larger stone is more resilient, but in practice considerably smaller stone has been used to protect and repair roadway embankments, with predictably poor results.
2. Scour Key, to prevent undermining of the riprap that would cause the embankment to slump and put the road at risk.
3. Grubbing material over the riprap, seeded to produce a hearty stand of grass and shrubs. The vegetation offers considerable protection from erosion that may be adequate during short-duration flood events to protect the roadway without relying on the underlying stone riprap.

2.4 Strategy 4. Protect Road Embankment – Stacked Stone Toe Wall

This strategy shares most features of the Standard Riprap Slope, except larger stone is stacked at the lower slope to avoid narrowing the active stream channel. This approach is applicable in settings where a standard slope would narrow the channel and result in deeper, faster flows that may cause the channel to incise (i.e., dig down) and undermine the roadway embankment.

2.5 Strategy 5. Raise and Protect Streambed

Many roadway embankment failures can be attributed to the down-cutting of the channel bottom that leaves the toe of the embankment unsupported causing the middle and upper embankment to slump and erode. Sometimes this down-cutting is transient; channel material can be scoured away during a storm only to be replaced by new material from upstream as flows recede. In most cases, however, the down-cutting is an ongoing, long-term process that often results in the perceived need to place additional riprap to stabilize the failing roadway embankment. Where a vertical channel stability issue is identified as the root cause of a failing roadway embankment, the vertical stability issue itself should be addressed. This is done by placing stone in the channel that is large enough to prevent additional down-cutting. Depending on site specifics, this material is either placed to raise the channel to a higher original elevation, or placed at existing grade to prevent additional down cutting. A related, but slightly different method to address head cutting and raise the streambed is to install a grade control structure (a.k.a. weir), made out of stone, timber logs or other local material. This weir is embedded into the channel bottom to develop stability and the top extends into the air to a height of the desired streambed. Over time, channel bed material will fill in behind the weir, effectively raising the streambed and reducing the potential for future head cutting and dedgration.

2.6 Strategy 6. Larger Culvert or Bridge

Culverts and bridges designed to pass major floodwaters, sediment, and debris significantly improves the resiliency of a road and reduces the potential for prolonged closures and costly repairs. Key features are a culvert or bridge span at least as wide as the natural channel- and adequate vertical height to pass floating debris. This strategy as shown in the sketch in Attachment A includes an aluminum pipe arch culvert recessed below the streambed. For the typical stream crossings in the study area, this approach is the most cost-effective way to meet current state and federal permit requirements and achieve the desired flood resiliency.

2.7 Strategy 7. Protect Road for Overtopping

At sites where floods overtop and damage roads – often in the approach to a bridge or culvert that is crossing a floodplain – the road can be constructed to minimize damage during overtopping events. As shown in Attachment A, this strategy entails placing stone riprap on the downstream roadway embankment where overtopping occurs. Ideally the riprap would be extended under the travel way so that the transition from the roadway to the embankment – where erosion and road damage usually originates is protected. This strategy does not typically eliminate roadway damage, but it can considerably lessen the extent and expense of damage.

2.8 Strategy 8. Create Low Point in Culvert/Bridge Approach

This strategy involves creating a low point in a roadway near a culvert or bridge so that floodwaters flow over this low point rather than being forced entirely through the culvert or bridge. This is a design feature of nearly all intact historic covered bridges and had played a primary role in their continued survival. The low point provides a "bleed-off" for high flows that keeps peak flood elevations lower and reduces the pressure on the culvert or bridge. The roadway at the low point may be damaged by erosion as flow overtops the road. Even so, this is generally a much better outcome than the loss of a culvert or bridge; roadways are inexpensive compared to culverts and bridges, and can be repaired much faster.

2.9 Strategy 9. Drainage Improvements

Drainage improvements are meant to improve the flood resiliency of a roadway segment where potential damage is due not to a parallel stream or a stream crossing, but rather due to runoff from the road itself or the surrounding hillside. Two common drainage improvements are included with this strategy, as shown in the sketch in Attachment A:

A. Additional Cross Culverts, designed to distribute collected runoff in a more dispersed manner away from the road.
B. Additional Ditch Turnouts, designed to reduce the volume and erosive potential of roadside ditches.

3.0 Guidance Flowcharts for Selecting Flood Resiliency Strategies

While the field evaluations for this study were done by experts who have the benefit of many years of experience and training, many sites could be reliably evaluated by town personnel with less river-specific experience. Exceptions, where an expert opinion would be strongly recommended, would be sites with unique challenges or severe space limitations, and sites that have suffered repeated cycles of damage and unsuccessful repair.

The Strategy Selection Flowcharts included in Attachment B are intended to provide guidance to Town staff or other personnel charged with identifying flood resiliency issues and selecting suitable solutions. The flowcharts lead the user to one of the nine Flood Resiliency Strategies and provide guidance for three common settings in which flood resiliency issues arise:

A. Road is parallel to stream channel (Flowchart 1)
B. Road is perpendicular to stream channel (Flowchart 2)
C. Local drainage issue (Flowchart 3)

4.0 GIS-Based Screening to Identify Roadway Segments Vulnerable to Flood Damage

D&K and BCE collaborated with the CVRPC to develop a method to use existing GIS data to identify sites that are vulnerable to flood damages. Once the approach was established, CVRPC conducted the analysis. A detailed technical description of the method has been prepared by CVRPC and is included in Attachment C. An overview is provided here.

The GIS analysis focused on Town roads categorized by CVRPC as High and Moderate Importance Roads. Low Importance roads were generally excluded in an effort to reduce the number of sites identified. The High and Moderate importance roads were divided into segments, and each segment was overlaid with available GIS data sets. Metrics considered in identifying sites included proximity to a stream (in the case where the stream and road are parallel), intersections of roads and streams (i.e., a bridge or culvert crossing), bankfull channel widths relative to bridge or culvert widths, height of road fill at crossings, stream channel incision ratios, location of road segments relative to mapped floodplain, and steep roadway slopes.

The GIS analysis identified 36 sites in Warren, 35 in Waitsfield, and 22 in Fayston, with potential flood resiliency issues. Sites where roads and streams were in close proximity were the most common, followed by stream crossing sites. The results are summarized for each of the three towns in the maps and tables of Attachments D.

The GIS phase concluded with meetings with staff in each Town familiar with the local road network and flood damage history. In general, feedback at the meetings suggested that the GIS analysis did a reasonable job of identifying sites that have the potential for flood resiliency issues, though frequently the towns reported that they did not believe many of the sites had *active* issues (i.e., either hadn't yet been damaged, or was repaired adequately). Town input is summarized in the Tables in Attachment D.

5.0 Field Investigation of Potentially Vulnerable Sites

A river scientist from BCE and an engineer from D&K visited each site identified by the previous GIS-based phase. The site visits typically lasted up to 15 minutes per site, with all sites in a Town visited in a single day. Field notes for each site are summarized in the tables in Attachment B, and photographs of each site are also included in Attachment D.
The intent of the site visits was three-fold:

1. Rate the success of the GIS analysis in identifying sites with potential for flood resiliency issues
2. Determine whether there was an active flood resiliency issue
3. Identify a strategy to mitigate the flood resiliency issue (if any)

Overall, the field evaluation suggested that the GIS analysis was successful in identifying sites with potential flood resiliency issues. For approximately 50% of the sites, the specific mitigation strategy suggested by the GIS analysis (e.g., protect roadway embankment with riprap) was confirmed during the field inspection to indeed be an appropriate strategy, and in some cased the strategy had already been implemented in response to previous flood damage. For approximately 40% of the sites, the field inspection confirmed that the site either has flood resiliency issues that need addressing or has a reasonable potential to develop flood resiliency issues in the future, though the GIS analysis did not identify the appropriate mitigation strategy. For the remaining 10% of the sites, the GIS analysis appeared to erroneously identify the site; no active or potential flood resiliency issues were observed.

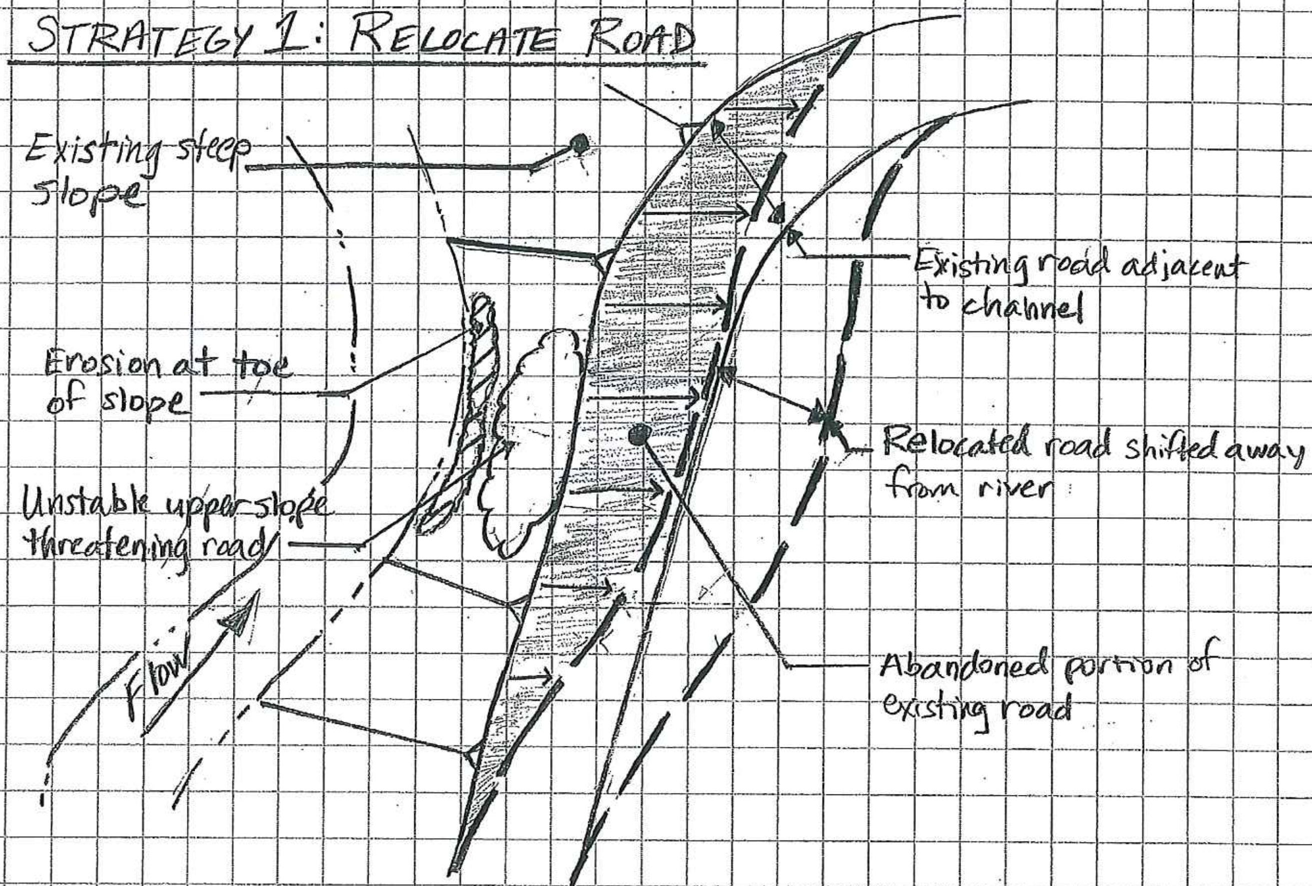
Active flood resiliency issues were identified at 18 of the 36 sites in Warren, 16 of the 35 in Waitsfield, and 16 of the 22 in Fayston. Protecting the roadway embankment and replacing undersized culverts at stream crossings are the two most common recommended mitigation strategies. Specific recommendations for each site as well as planning level cost estimates are included in the tables in Attachment D.

Attachment A

Conceptual Sketches of Strategies to Improve Flood Resiliency of Roadways

DUBOIS & KING, INC.
☐ Randolph, VT 05060 (802) 728-3376
☐ Williston, VT 05495 (802) 878-7661
☐ Bedford, NH 03110 (603) 883-0463
Engineering*Planning
Development*Management

JOB ______
SHEET NO. ______ OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

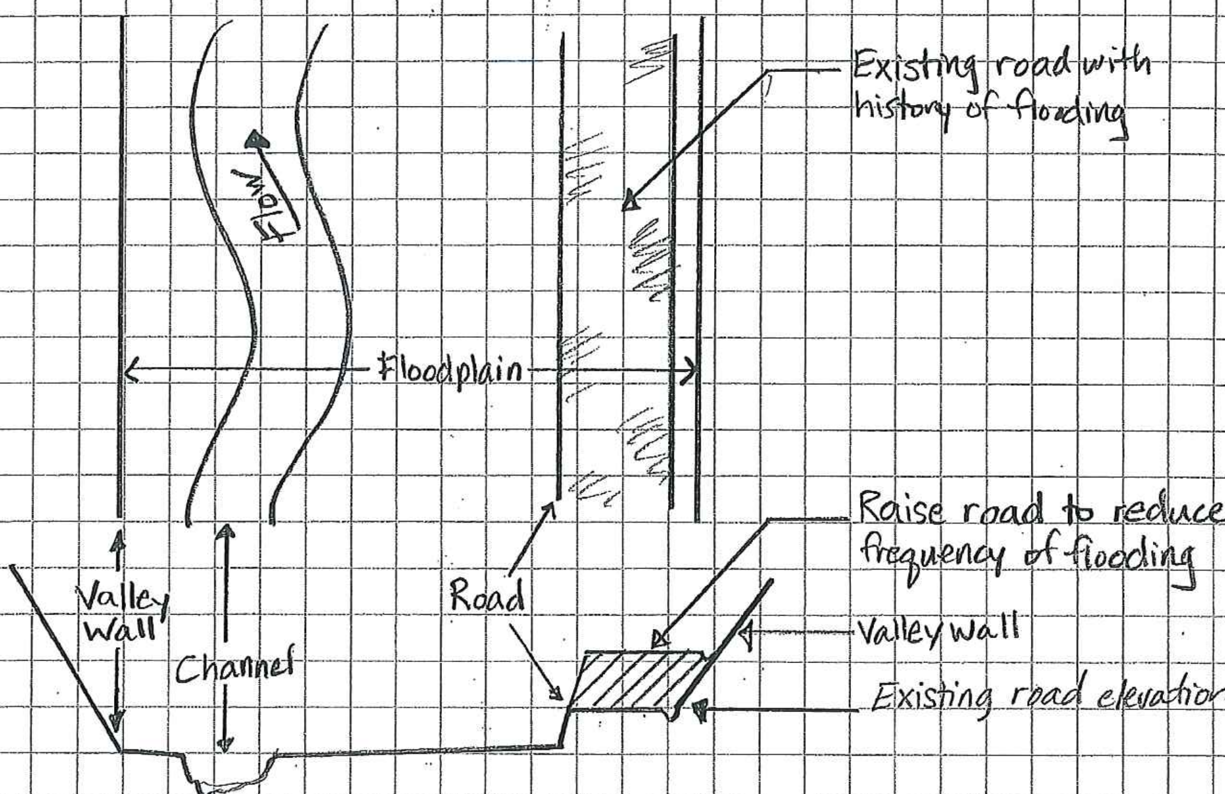


rev 1.1

DUBOIS & KING, INC.
☐ Randolph, VT 05060 (802) 728-3376
☐ Williston, VT 05495 (802) 878-7661
☐ Bedford, NH 03110 (603) 883-0463
Engineering*Planning
Development*Management

JOB ____________
SHEET NO. ________ OF ________
CALCULATED BY ________ DATE ________
CHECKED BY ________ DATE ________
SCALE ____________

STRATEGY 2: RAISE ROAD



General Notes:

1. Strategy is applicable to sites where road is parallel to channel and is against the valley wall.

rev 1.1

DUBOIS & KING, INC.

☐ Randolph, VT 05060 **(802) 728-3376**
☐ Williston, VT 05495 **(802) 878-7661**
☐ Bedford, NH 03110 **(603) 883-0463**

Engineering*Planning
Development*Management

JOB ______

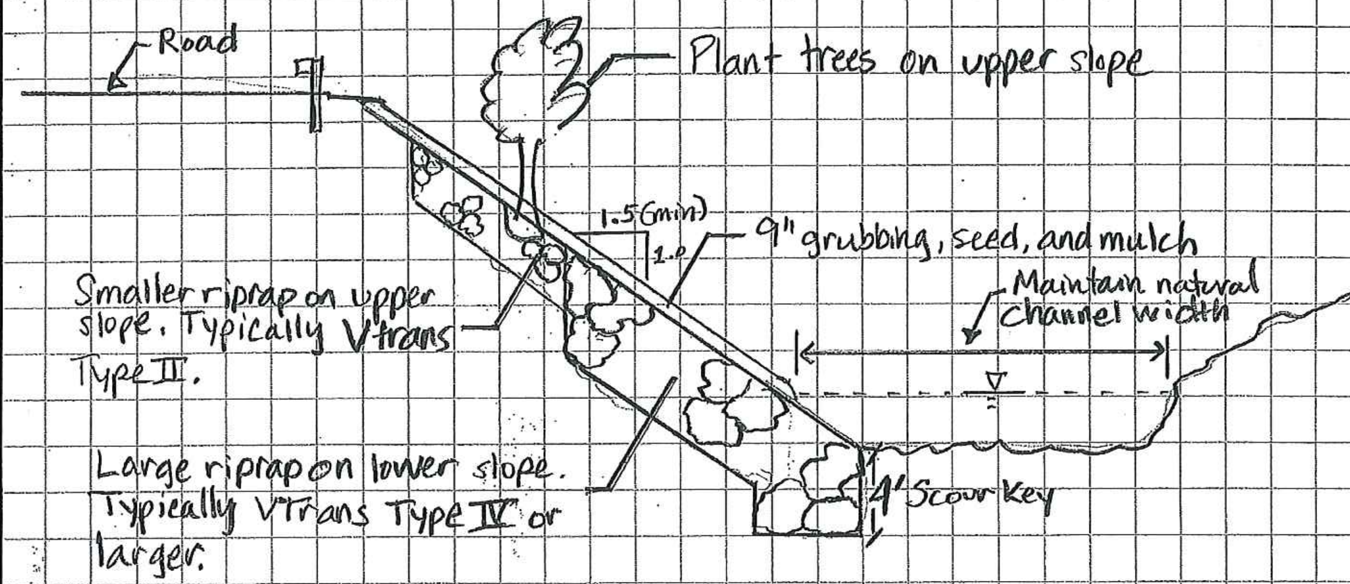
SHEET NO. ______ OF ______

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

SCALE ______

STRATEGY 3: PROTECT ROAD EMBANKMENT – STANDARD RIPRAP SLOPE



rev 1

DUBOIS & KING, INC.

☐ Randolph, VT 05060 (802) 728-3376
☐ Williston, VT 05495 (802) 878-7661
☐ Bedford, NH 03110 (603) 883-0463

Engineering*Planning
Development*Management

JOB ______

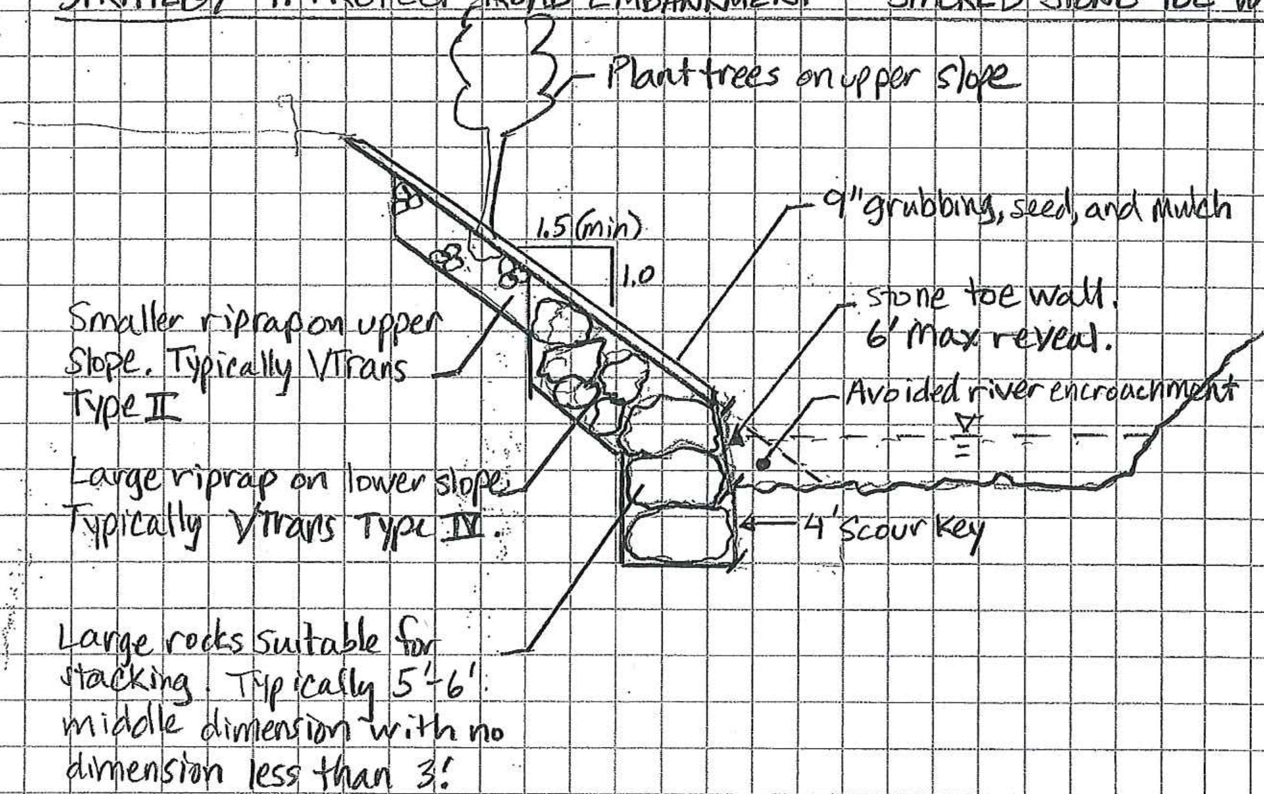
SHEET NO. ______ OF ______

CALCULATED BY ______ DATE ______

CHECKED BY ______ DATE ______

SCALE ______

STRATEGY 4: PROTECT ROAD EMBANKMENT — STACKED STONE TOE WALL



rev 1

DUBOIS & KING, INC.

☐ Randolph, VT 05060 **(802) 728-3376**
☐ Williston, VT 05495 **(802) 878-7661**
☐ Bedford, NH 03110 **(603) 883-0463**

Engineering*Planning
Development*Management

JOB

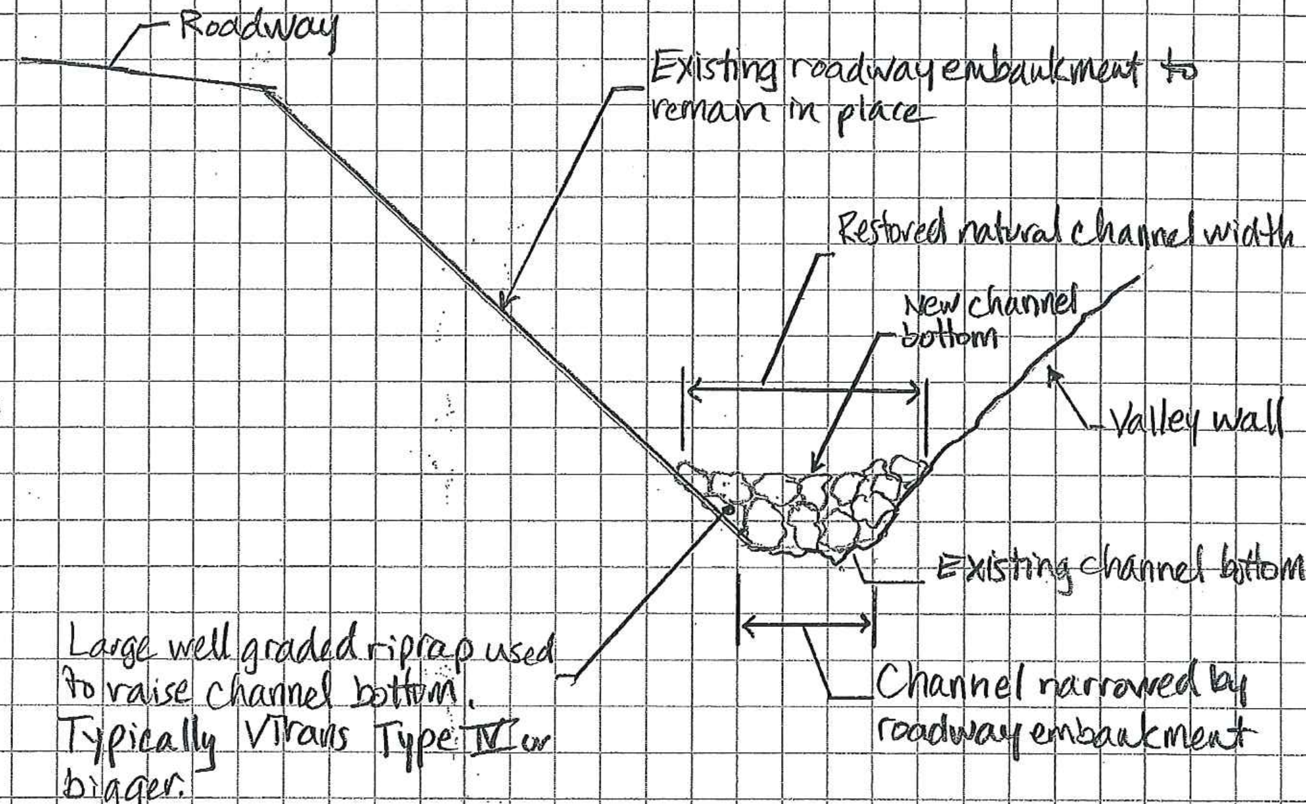
SHEET NO. OF

CALCULATED BY DATE

CHECKED BY DATE

SCALE

STRATEGY 5: RAISE AND PROTECT STREAMBED



rev 1

DUBOIS & KING, INC.

☐ Randolph, VT 05060 (802) 728-3376
☐ Williston, VT 05495 (802) 878-7661
☐ Bedford, NH 03110 (603) 883-0463

Engineering*Planning
Development*Management

JOB ____________________

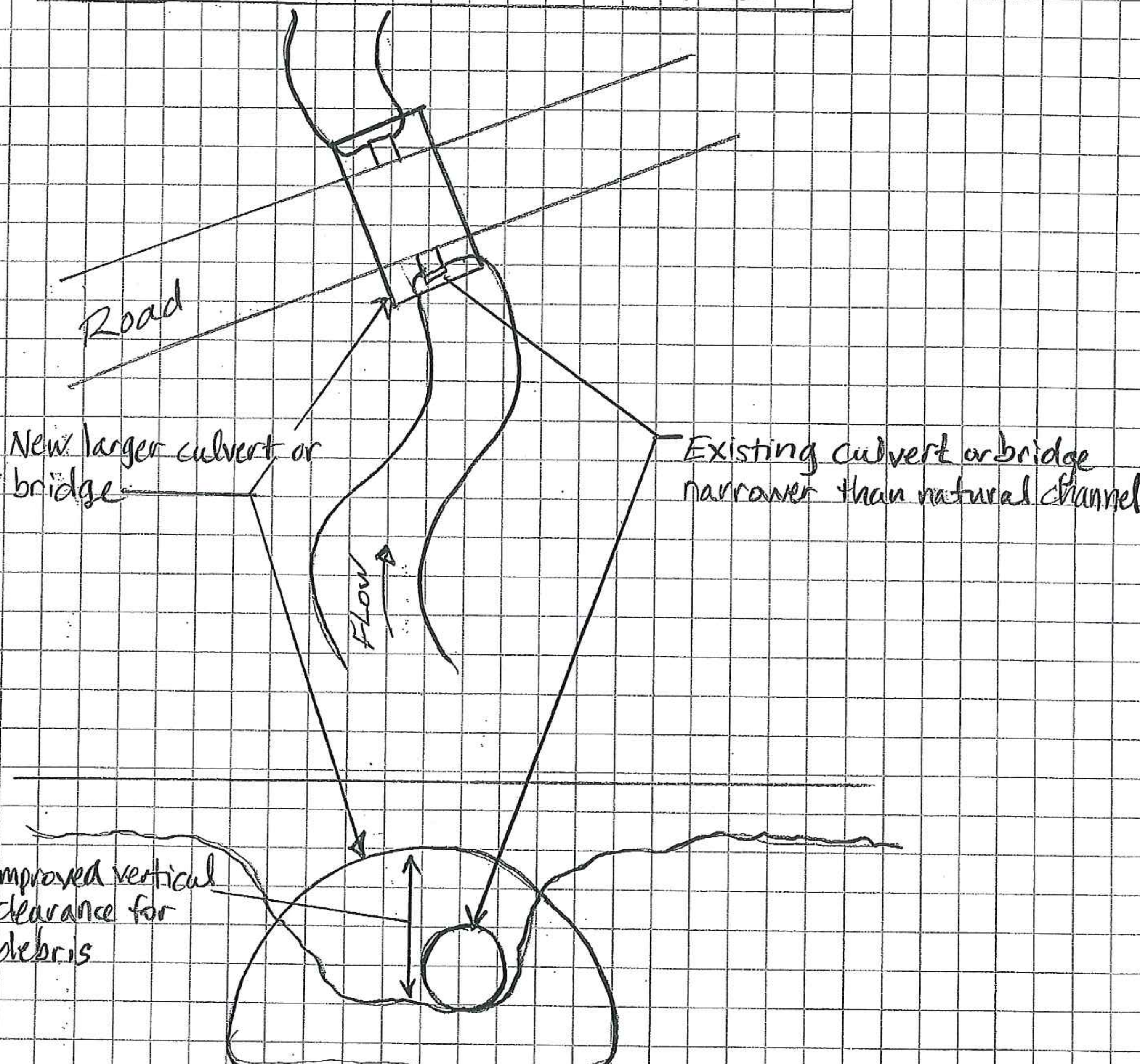
SHEET NO. ______________ OF ______

CALCULATED BY ______________ DATE ______

CHECKED BY ______________ DATE ______

SCALE ____________________

STRATEGY 6: LARGER CULVERT OR BRIDGE



General Notes:

1. Type of replacement structure will vary
2. In most cases, a pipe arch culvert as shown will be most cost-effective structure that meets state requirements

rev1

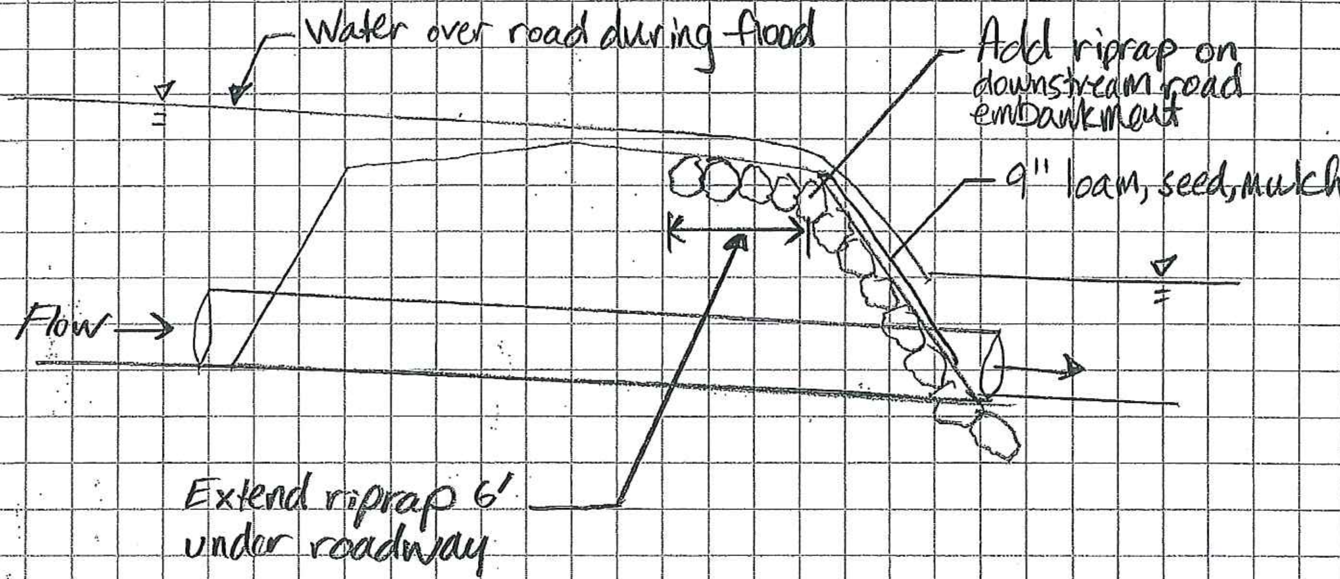
DUBOIS & KING, INC.

☐ Randolph, VT 05060 (802) 728-3376
☐ Williston, VT 05495 (802) 878-7661
☐ Bedford, NH 03110 (603) 883-0463

Engineering*Planning
Development*Management

JOB ______
SHEET NO. ______ OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

STRATEGY 7: PROTECT ROAD FOR OVERTOPPING



rev 1

DUBOIS & KING, INC.
☐ Randolph, VT 05060 (802) 728-3376
☐ Williston, VT 05495 (802) 878-7661
☐ Bedford, NH 03110 (603) 883-0463
Engineering*Planning
Development*Management

JOB

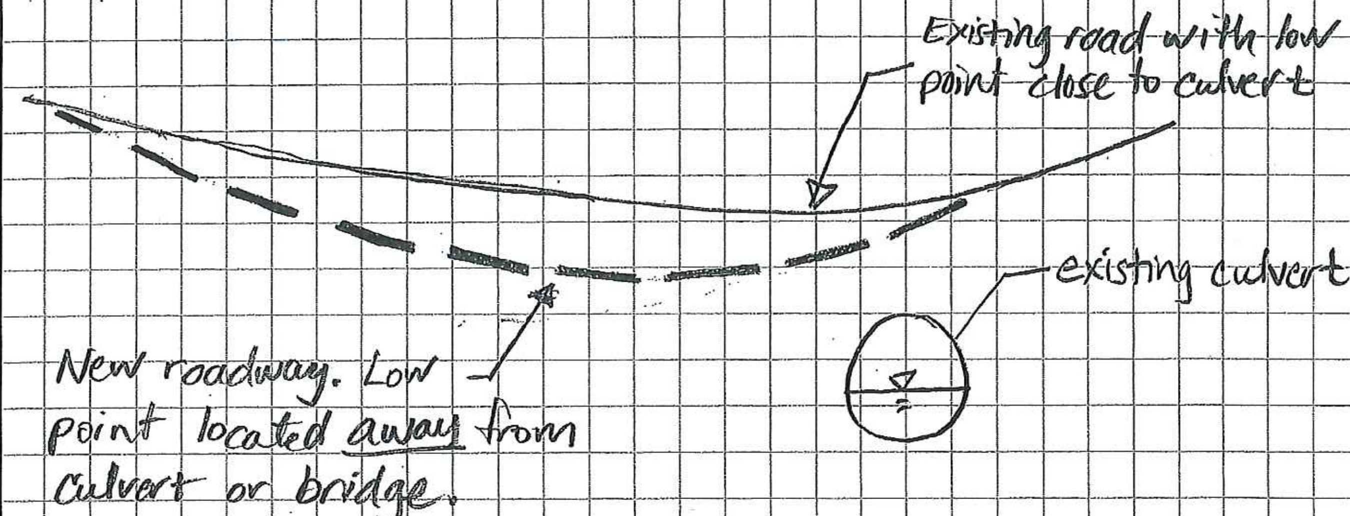
SHEET NO. OF

CALCULATED BY DATE

CHECKED BY DATE

SCALE

STRATEGY 8: LOW POINT IN CULVERT/BRIDGE APPROACH

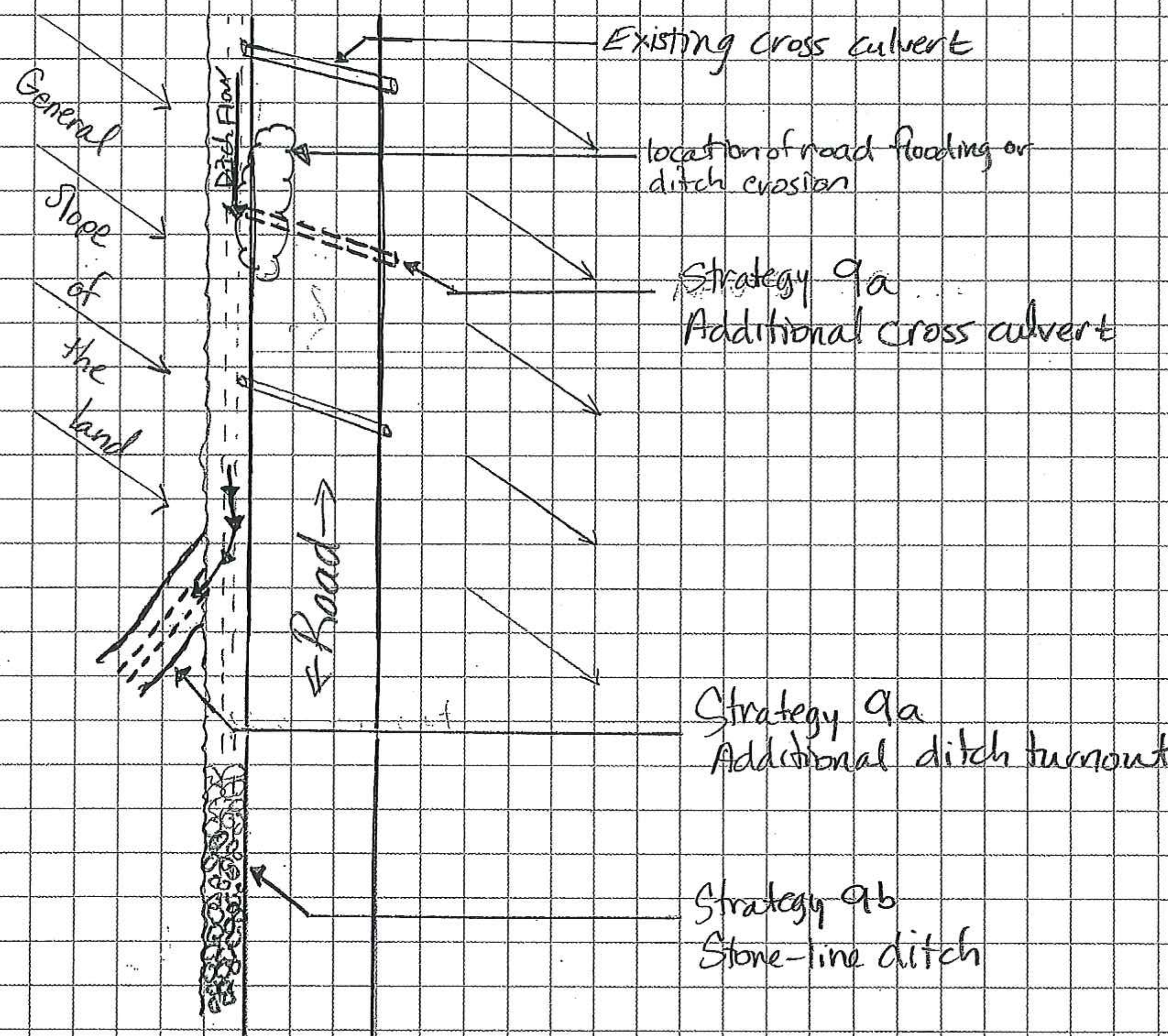


rev 1.1

DUBOIS & KING, INC.
www.dubois-king.com
Engineering * Planning
Development * Management

JOB ______
SHEET NO. ______ OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

STRATEGY 9: DRAINAGE IMPROVEMENTS



General Notes:

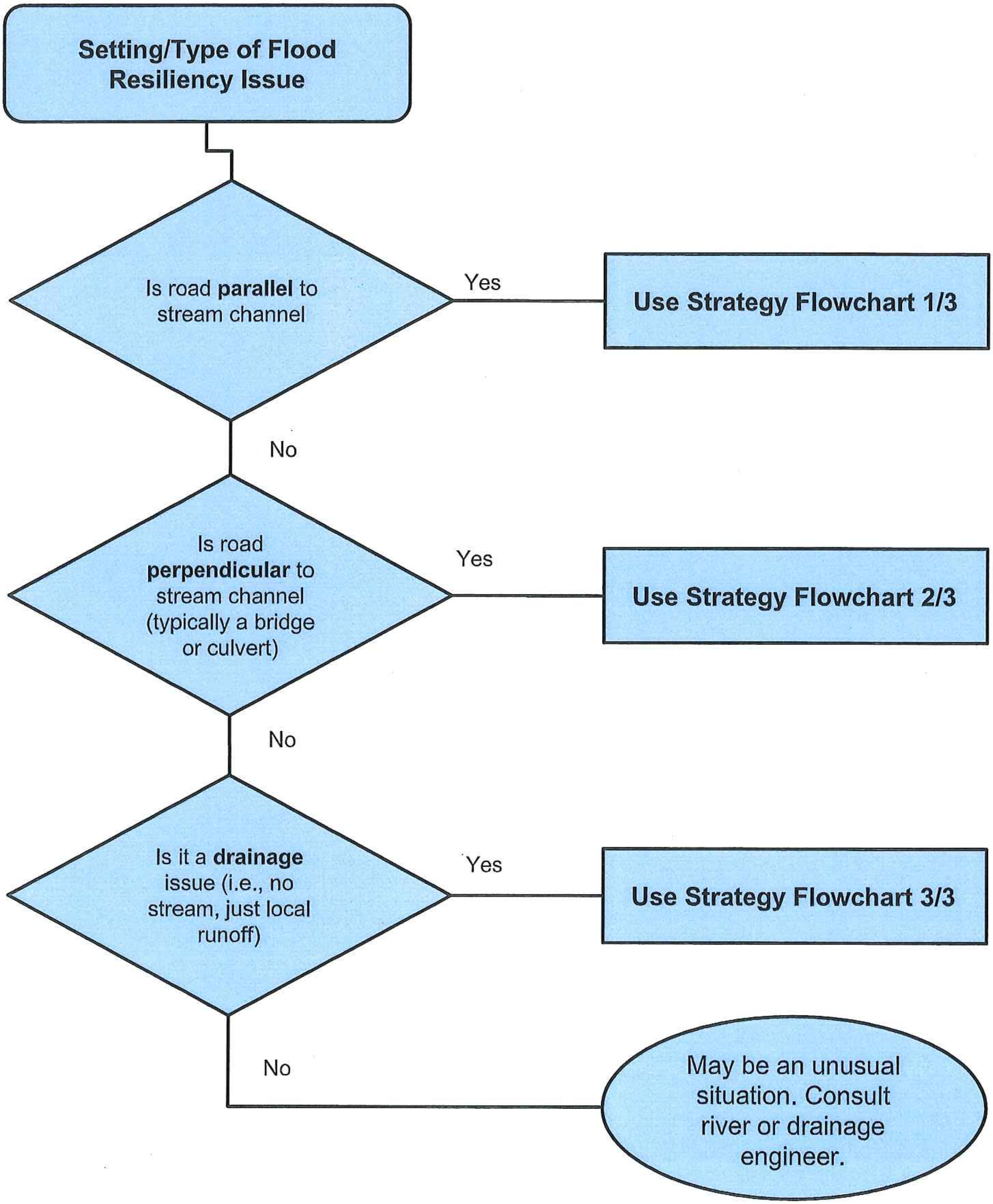
1. Additional cross culverts and turnouts reduce the amount of water in the ditch and distribute water closer to pre-road conditions.
2. Stone lining should be considered after additional cross culverts and turnouts have been evaluated.

rev 1.0

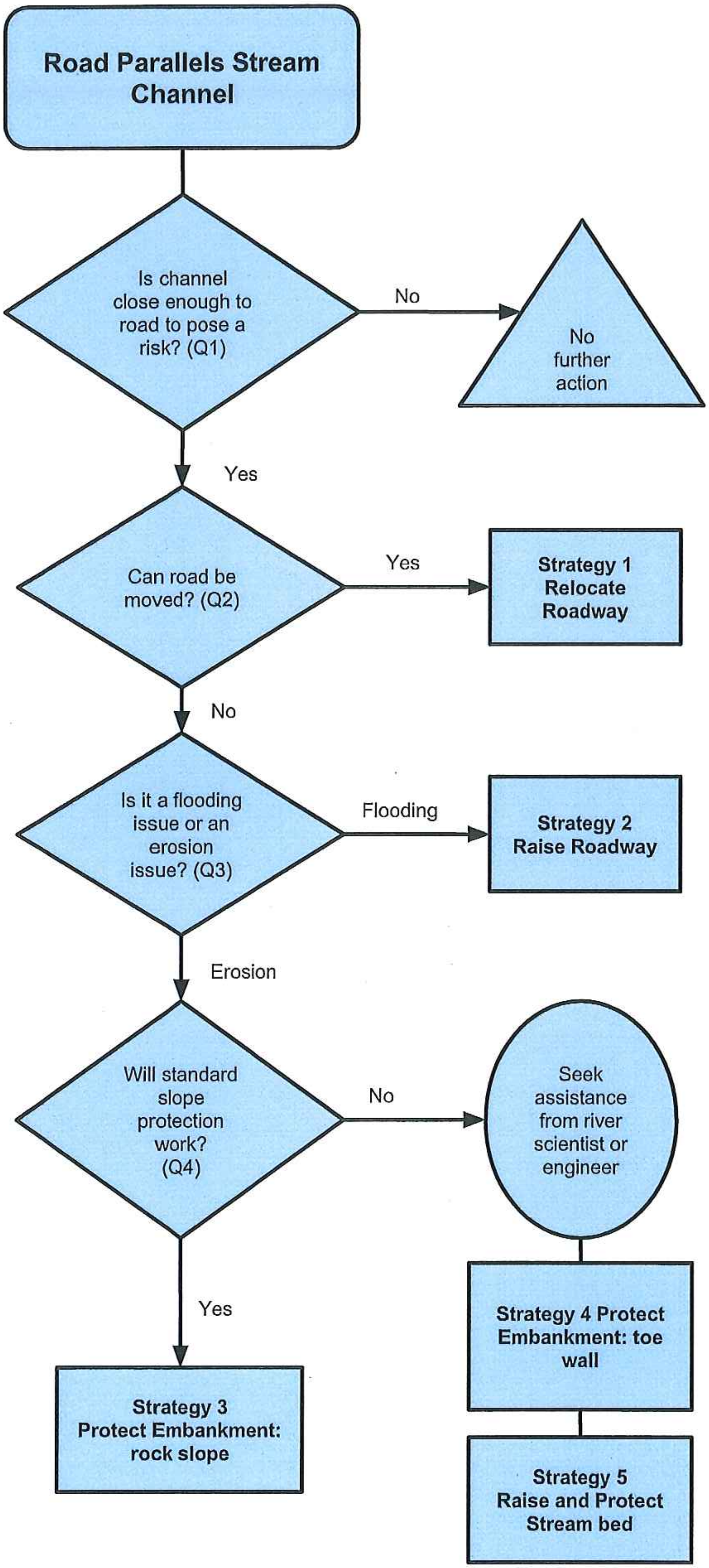
Attachment B

Guidance Flowcharts for Selecting Flood Resiliency Strategies

Strategy Selection Flowcharts for Flood Resiliency



Strategy Flowchart 1/3



GUIDANCE

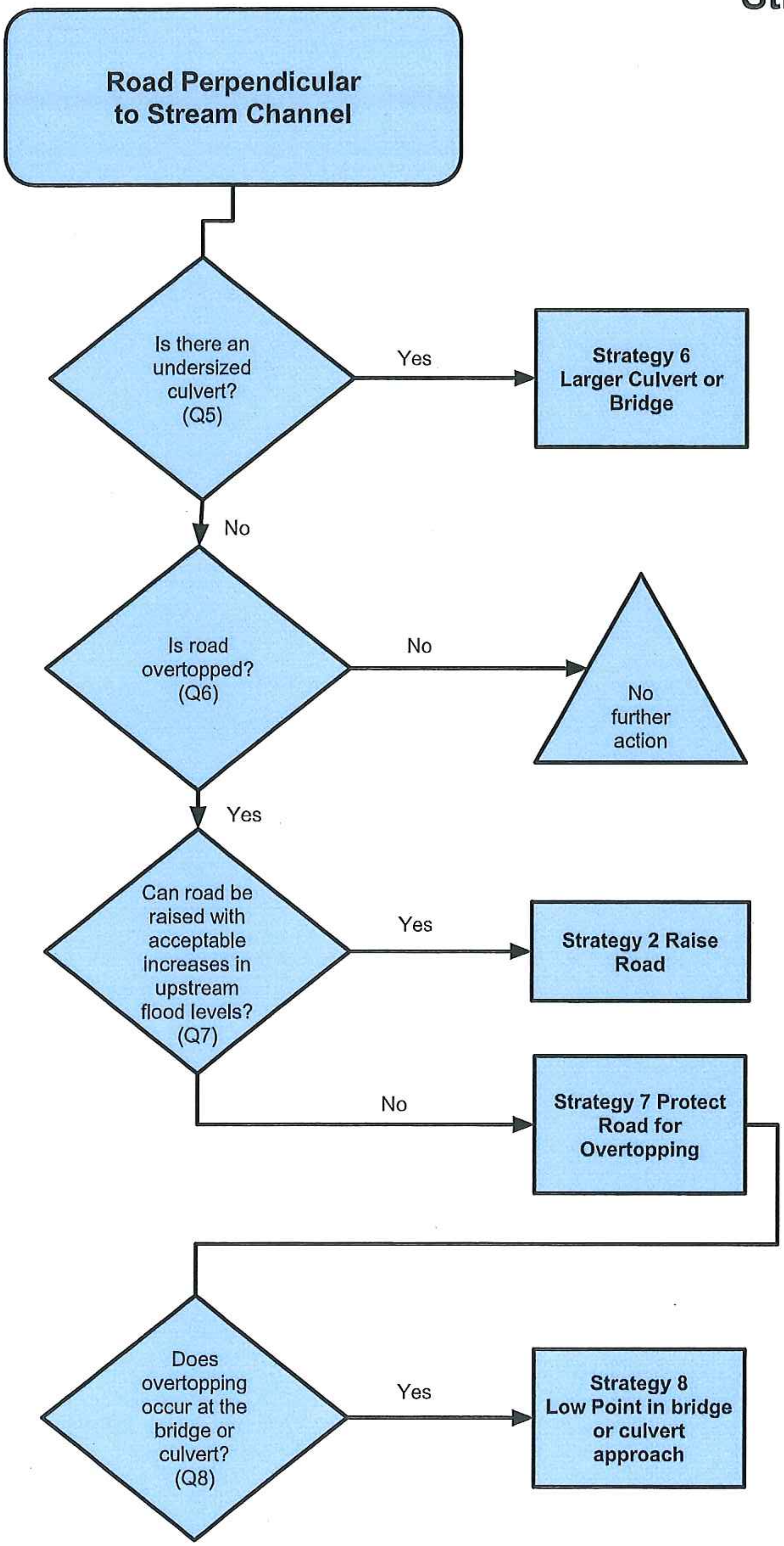
Q1. It can be a judgement call whether the road is at risk. Consider previous damage at the site (if any), damage to roads in similar settings, and presence of things like dense woody vegetation that might protect road.

Q2. It's rare, but sometimes a road can be shifted to sufficiently lower the risk. Right of way and financial considerations may steer you to answer No, but relocation may be the best long-term solution and should be given serious consideration.

Q3. Raising the road may keep floodwater off, but it is generally only acceptable in the road is close to or against a valley wall where raising it won't cut off floodplain on the other side.

Q4. If a slope of approximately 1.5H:1V will put the toe of slope into the river and make for a narrow channel, then a standard slope may not be a durable solution. Better fixes may include a stacked stone toe wall and/or raising the existing streambed to result in a wider channel.

Strategy Flowchart 2/3



GUIDANCE

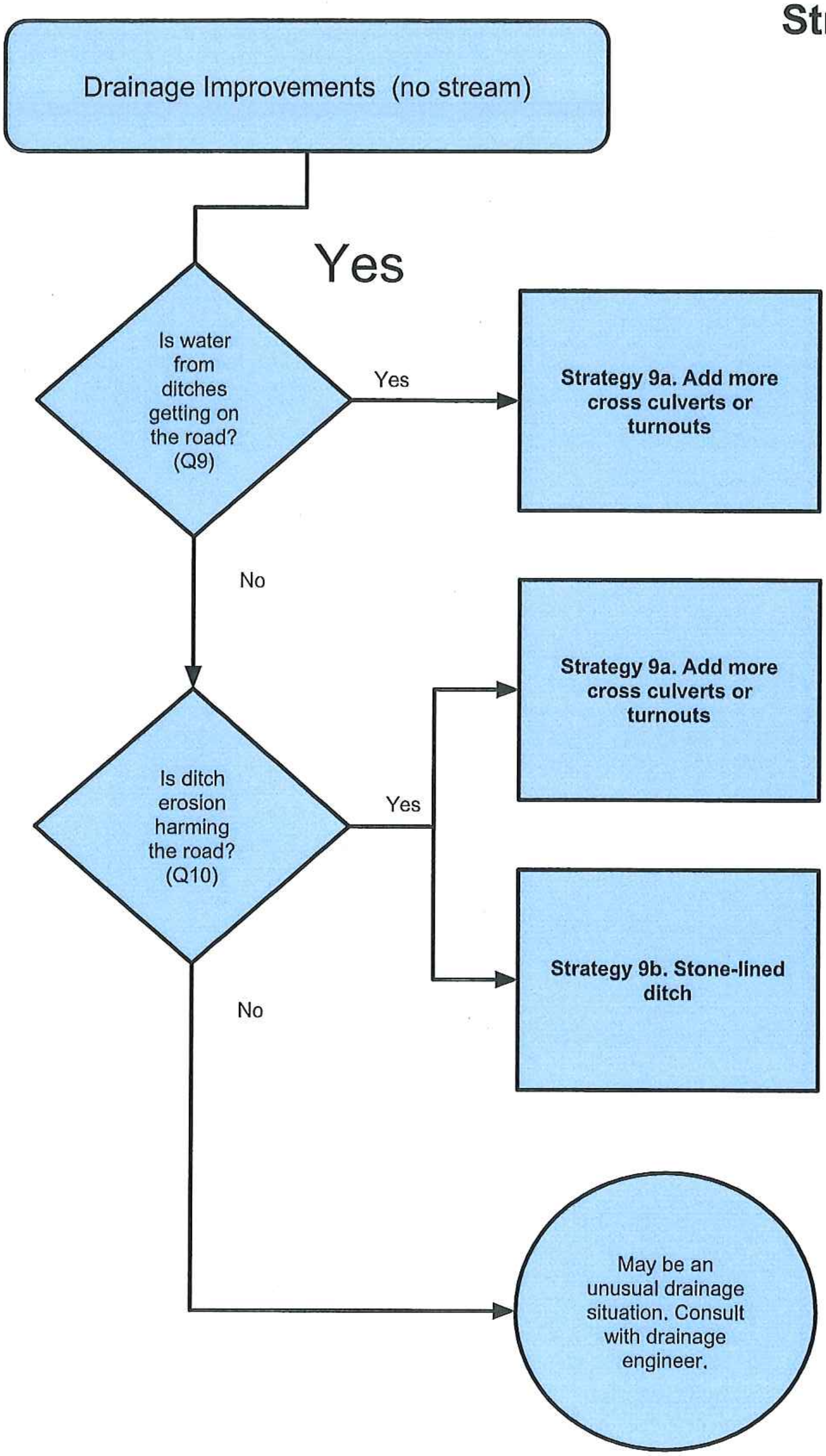
Q5. Is the existing culvert at least as wide as the natural channel? If it's significantly smaller, it may not be able to pass enough water and debris to survive the next major flood.

Q6. Is there a history of roadway overtopping during floods that leads to road damage and closure? Consider anecdotal reports and field evidence.

Q7. Raising a road typically increases upstream flood levels which may make flooding worse for upstream properties and which may put more pressure on a bridge or culvert. It is rarely an acceptable option. A better strategy is to reinforce the road to minimize damage when it does overtop.

Q8. If the bridge or culvert is at the lowest point in the road, the structure may be damaged when the road overtops. Regrading the road so that there is a low point on one bridge approach shifts the location of overtopping away from the structure. This low point on the approach may be damaged when it is overtopped, but the much more expensive structure is spared.

Strategy Flowchart 3/3



GUIDANCE

Q9. Is there a history of water exceeding the capacity of the ditch and flooding onto or over the road? Additional cross culverts and turnouts are generally more successful than increasing depth of ditch, which can lead to flows that are deeper and more erosive than the ditch can handle.

Q10. Is the ditch eroding into the travelway of the road? Ditches typically eroded downward first, and then laterally into the road, so be alert for signs of vertical erosion even if the road has yet to be damaged.

Attachment C

GIS-Based Screening Documentation (CVRPC)

GIS Analysis Methodology (Long)

Line features

Utilizing the most current VTrans road centerline data CVRPC staff did the following processing steps. Please note CVRPC utilizes an ArcGIS extension called ET GeoWizard for some of this processing.

1. Add VTrans road centerline data to project
2. Deleted all State roads from data leaving you with just town roads
3. In ET geowizard- use the split polyline tool to split the town roads into 100 meter segments (delete all extra fields from the data table except Route Number, Surface Type, Road Class, CTCode, and Road Name).
4. Add nine new fields to the split road data as follows:
    a. Attribute: Intersect Floodplain/Flood Hazard Data
       Field Name: Int_Flood
       Field: Type Short integer
    b. Attribute: Intersect River Corridor/Fluvial Erosion Hazard (FEH)Zone
       Field Name: Int_RC
       Field: Type Short integer
    c. Attribute: Intersect Stream Buffer
       Field Name: Int_Stream
       Field: Type Short integer
    d. Attribute: Intersect Road Slope
       Field Name: Int_RdSlp
       Field: Type Short integer
    e. Attribute: Valley Wall Distance
       Field Name: VW_D
       Field: Type Short integer
    f. Attribute: Stream Incision Ratio
       Field Name: Strm_Incsn
       Field: Type Short integer
    g. Attribute: Culvert Depth of Cover
       Field Name: Cvt_Dpth
       Field: Type Short integer
    h. Attribute: ANR Percent Bankfull Width
       Field Name: ANR_PrcBF
       Field: Type Short integer
    i. Attribute: RPC/VTrans Percent Bankfull Width
       Field Name: RPC_PrcBF
       Field: Type Short integer

    j. Attribute: Total of all Constraints
       Field Name: Con_Total
       Field: Type Short integer
5. Add floodplain/flood hazard data to project
6. Intersect Rdsplit_100m with floodplain (Rdsplit_100m_FP)
7. Select all road segments that intersected floodplain and calculate based on that selection Int_Flood equal to 1.
8. Add River Corridor/ FEH zone data
9. Intersected Rdsplit_100m_FP with River Corridor/ FEH (Rdsplit_100m_FP_RC)
10. Select all road segments that intersected River Corridor/ FEH and calculate based on that selection Int_RC equal to 1.
11. Add streams to project and buffer streams by 50ft (stream_buffer_50ft)
12. Intersect Rdsplit_100m_FP_RC to stream_buffer_50ft (Rdsplit_100m_FP_RC_SB50)
13. Select all road segments that intersected stream buffers and calculate based on that selection Int_Stream equal to 1.
14. Load best available Digital Elevation Model (DEM)
15. Calculate road slope using ET Geowizard tools
    a. Under surface tab click on feature to 3d tool and GO.
    b. Select Rdsplit_100m_FP_RC_SB50, DEM and output locations. Click finish. (Rdsplit_100m_FP_RC_SB50_3D)
    c. Under Polyline tab select Get Z Characteristics tool and Go.
    d. Select Rdsplit_100m_FP_RC_SB50_3D and hit next. Set target as same layer and click finished.
16. Road slopes need to be selected based on the following groups:
    Slopes 0-5% equal 0
    Slopes Greater than 5% to 15% equal 1
    Slopes Greater than 15% equal 2

Select all roads by slope groups and calculate based on that selection Int_RdSlp equal to value.

17. Load if available river/stream valley wall data. This data is typically collected during a Phase 1 and 2 Geomorphic Assessment and can be accessed from either the consultant who conducted the assessment or a VT DEC Rivers Program River Scientist.
18. Intersect Rdsplit_100m_FP_RC_SB50_3D to valley wall (Rdsplit_100m_FP_RC_SB50_3D_VW)
19. Run ET Geowizard tool near to feature between valley wall and Rdsplit_100m_FP_RC_SB50_3D_VW.(Rdsplit_100m_FP_RC_SB50_3D_VWN).
20. Valley wall distances need to be selected based on the following groups:
    Distance 0-10 meters equal 2
    Distance Greater than 10 to 30 meters equal 1
    Distance Greater than 30 meters equal 0

Select all roads by distance groups and calculate based on that selection Int_RdSlp equal to value.

21. Add if available existing Phase 2 stream geomorphic assessment data. You want to add in the stream line data that has been broken out into reaches and then segmented. This data is typically collected during a Phase 1 and 2 Geomorphic Assessment and can be accessed from either the consultant who conducted the assessment or a VT DEC Rivers Program River Scientist. To this stream data you will want to join a table exported out of the VT DEC online Stream Geomorphic Assessment Data Management System (DMS) – Web Link https://anrweb.vt.gov/DEC/SGA/Default.aspx. The table that you want to export is created by using the export Phase 2 data tool. Please follow this link to access the table export tool https://anrweb.vt.gov/DEC/SGA/projects/exports/phase2.aspx you need to have the following column attributes selected in your table numbers 0.101, 0.102, 0.103, 0.104, 0.105, 2.08a. You will need to select your project by river, and you will want to export out the table (I prefer a DBF table as it imports into ArcGIS very easily). You will want to do a table join use the RCHPTID in both the stream data and the exported table. Please note you may need to pick another field for this join based on your data. Once joined, you will be able to use the incision ratio values.
22. Intersect Rdsplit_100m_FP_RC_SB50_3DVWN to the join stream data to get the incision ratio (Rdsplit_100m_FP_RC_SB50_3D_VWN_I).
23. Incision ratio needs to be selected based on the following groups:
    Less than 1.4 (minor incision ratio) or not assessed equal 0
    1.4 - less than 2 (moderate incision ratio) equal 1
    Greater than and equal to 2 (sever incision ratio) equal 2
24. Join where available ANR SGA bridge and culvert data to your road data Rdsplit_100m_FP_RC_SB50_3D_VWN_I. If you don't have the point data already you can download a table from the online SGS DMS tool. Here is a link - https://anrweb.vt.gov/DEC/SGA/datasets/exports.aspx?rowFilter=Town you need to have the following column attributes selected in your table numbers 0.101, 0.104, 0.109, 1.01, 1.03, 1.05, 1.07, 1.08, 1.10, 1.11, 2.02, 2.06, 2.06a, and 2.10. You will need to select your filter by town, and you will want to export out the table (I prefer a DBF table as it imports into ArcGIS very easily).
25. Once the table is exported you will want to use the Latitude/Longitude values to covert the table to points. To do this you need to add the table to ArcGIS. Right click the table and select Display XY Data. Select the correct X and Y fields and your coordinate system and hit OK. A new point dataset will be added to the project. Check to be sure the data is displaying correctly.
26. XXXXXXX Rdsplit_100m_FP_RC_SB50_3DVWN_I to the ANR bridge and culvert join stream data to get the incision ratio (Rdsplit_100m_FP_RC_SB50_3D_VWN_I).

Point Features

Utilizing existing bridge and culvert points we will calculate bankfull width. Please Note this calculation is only necessary if you are using data not already loaded into VT ANR DMS or VTCulverts.org as those two sites already have bankfull width calculated where appropriate for existing bridge and culvert points.

1. Run and Intersect between roads and stream crossing exporting a point theme as the intersect.
2. Select all culverts greater than 18 inches with ("width" > 18 AND "width"< 999) and select by location all culverts that intersect a VHD stream/road intersect points (add a buffer of 10 meters). Export out as a new feature class.
3. Merge town culverts and bridges (Town Long and Short)
4. Add a new field for features crossed (feature_x)
5. Select by location, all bridges and culverts that are within 30 meters of a stream/road intersection.
6. Calculate for the selected features in the feature_x field “Stream Crossing”. Do a quick visual inspection of these selected sites to check for errors. Fix as needed. Switch selection and calculate “road crossing” to all other structures.
7. Select all stream crossing culverts and run the Snap tool between the selected stream crossing culverts and all Stream/road crossings. Use snap type of Vertex and a Distance of 30 meters.
8. Build Flow Direction Raster using Flow Direction tool in ArcGIS input is OrthoDEM
9. Run Flow accumulation model on flow direction raster switch output data type to integer
10. Select all stream crossing structures and run snap to pour point to the flow accumulation grid with 15 meter snapping. Select ObjectID as the Pour Point Field
11. Switch Selection and run snap to pour point on selected road crossing structures using the flow accumulation grid with 0 meters snapping. Select ObjectID as the Pour Point Field
12. Run the Append tool to add the Pour Point roads to the Pour Point streams.
13. Run Watershed tool in ArcGIS using new Flow DEM add selected culvert points as pour points use the value field as the pour point field so that the watershed data can be likened back up with the culvert points.
14. Convert Watershed raster to shapefile polygons remember to uncheck simplify polygons
15. Add a new field to the new watershed for acres and square miles and calculate using ArcGIS those area values
16. Run Dissolve on the watersheds selecting the gridcode as the dissolve field and sum on Sq miles
17. Add three new field to the culvert data for sq miles, bankfull width, and percent bankfull
18. Link the watershed data to the culvert data using the pour point field.
19. Calculate into the culvert data the acres and sq miles from the watershed and then remove the join
20. Calculate the Banks full width using he following equation Wbft=13.1 * Drainage Area(in sq miles)$^{0.44}$

21. Add a new field for the % bankfull and then calculate that by dividing the culvert width or the bridge span by the bankfull width and multiply by 100.

Depth of Cover

This value can be found in the bridge and culvert data loaded into VTCulverts.org if this is your original source for your bridge and culvert data, then the value may already exist. Otherwise you will have to measure it in the field.

Incision Ratio

1) Join existing Phase 2 stream geomorphic assessment data table to the stream geomorphic assessment stream segments.

2) Intersect bridge and culvert point and joined stream geomorphic assessment data to get incision ratio value.

Slope Stabilization Details

Brook Road

Town of Warren

Warren, VT

Sheet Index

Sheet Revision

Date:		By:

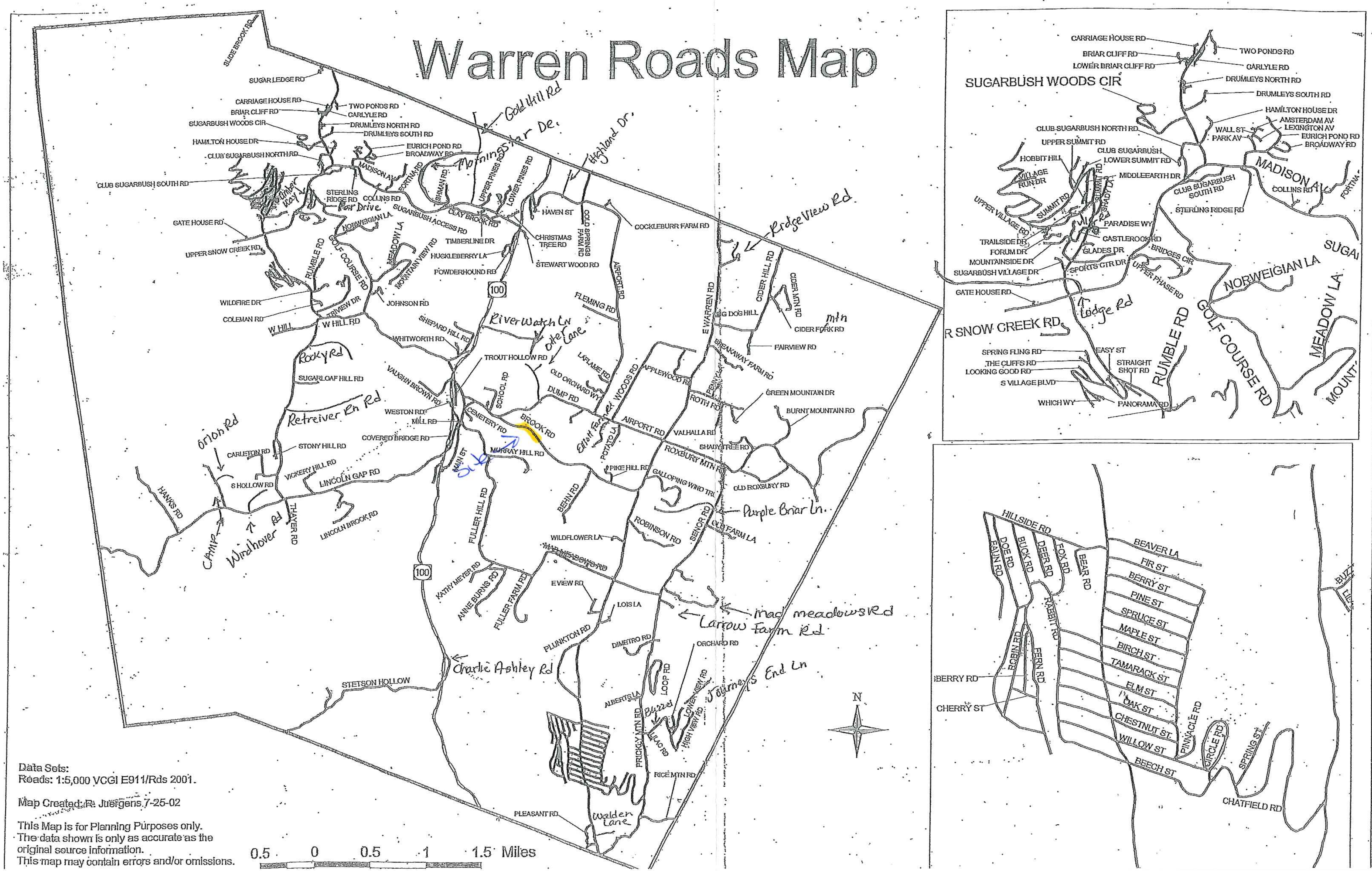
Cover Sheet

Project: Brook Road			Project No. ----
Date: March 14, 2016	Drawn By: EDL	Checked By: -	Sheet No.: 1

GSI GeoStabilization International

GeoStabilization International
Corporate Address: PO Box 4709
Grand Junction, CO 81502
P: 970.210.6170
F: 970.245.7737
www.geostabilization.com

Warren Roads Map

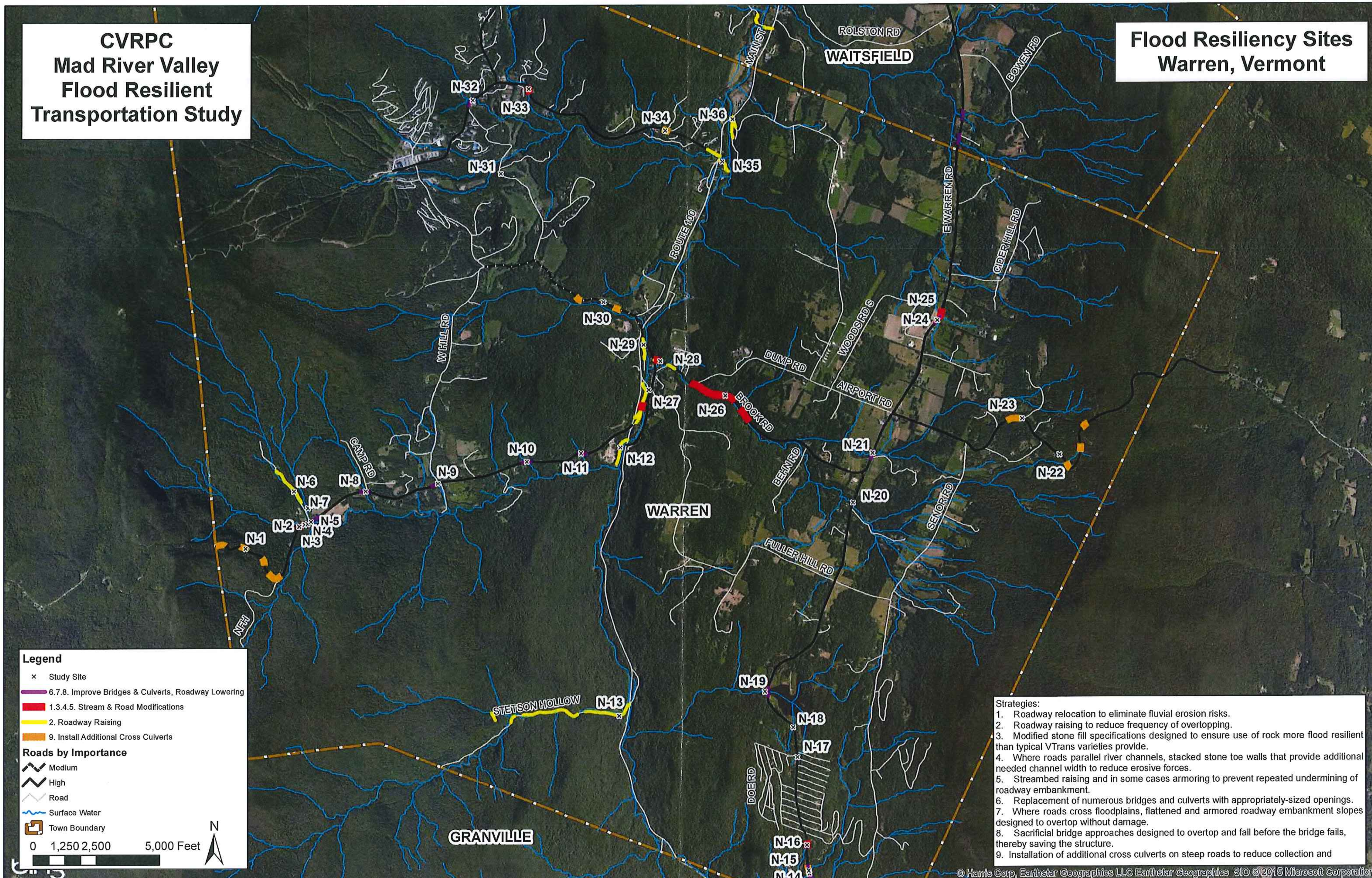


Data Sets:
Roads: 1:5,000 VCGI E911/Rds 2001.

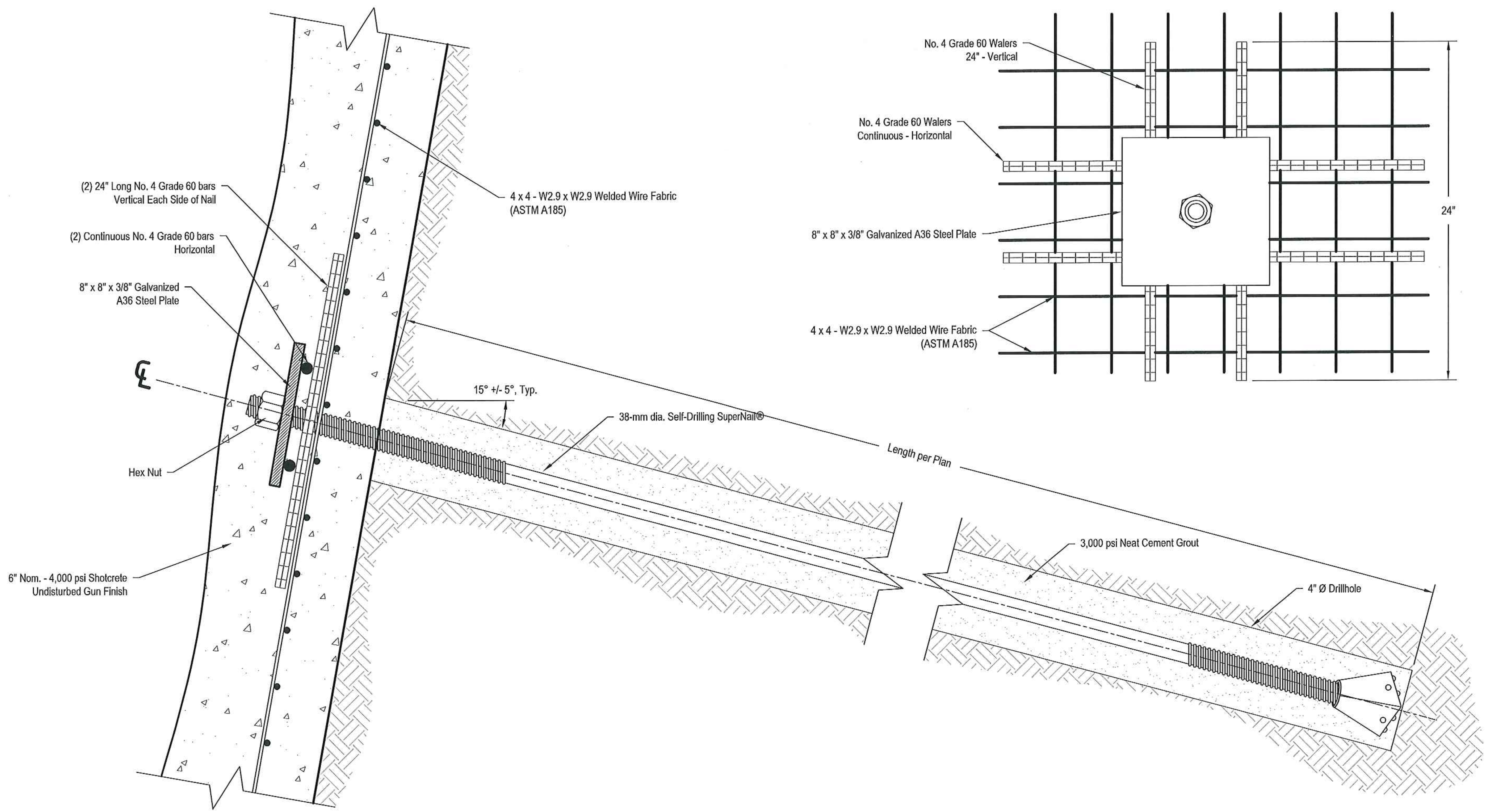
Map Created: R. Juergens 7-25-02

This Map is for Planning Purposes only.
The data shown is only as accurate as the original source information.
This map may contain errors and/or omissions.

0.5 0 0.5 1 1.5 Miles



Background is Bing Imagery.



This drawing is furnished solely for the use of or in connection with this project and the proprietary information shown hereon is not to be transmitted to any other organization without specific authorization by GeoStabilization International. (GSI). The design is only valid if constructed and supervised by GSI or its authorized subcontractor.

Sheet Revision

Date:		By:

Self–Drilling SuperNail® Detail

Project: Brook Road			Project No. ----
Date: March 14, 2016	Drawn By: EDL	Checked By: -	Sheet No.: 4

GeoStabilization International

GeoStabilization International
Corporate Address: PO Box 4709
Grand Junction, CO 81502
P: 970.210.6170
F: 970.245.7737
www.geostabilization.com

Construction Sequence/Work Schedule:

- The client will clear, excavate, haul off excavated material and provide traffic control.
- GSI will provide and install the specified soil nails and surface treatment per the construction documents..

Size and Spacing of Nails:

- GSI will mark the locations of the proposed soil nails with survey marking paint.
- The Soil Nails will be injected with grout. The grout will be a Type I,II,or III Portland Cement. The water/cement ratio will be 0.50 to 0.60. No additional aggregate or admixtures will be added to the grout.

Facing and Drainage System:

- Drain strips will be provided and installed between the soil nails every 6-feet along the face of the excavation. The drain strips shall be placed with the geotextile side against the ground. Drain strips will be continuous and any splices shall be made with a one-foot minimum overlap such that the flow of water is not impeded. Drain strips shall extend beyond the face of the shotcrete at the downhill face.

Reinforcing Steel Placement:

- Welded wire mesh will be placed along the face of the excavation with a separation of approximately 2 inches between the wire mesh and the soil.
- No. 4 Rebar will be tied to the wire mesh. Vertical bars will extend for approximately 24 inches and the horizontal bars will be continuous (with overlap splices) in the shotcrete.

Bearing Plate Placement:

8" x 8" x 3/8" galvanized steel bearing plates will be placed over the nails and attached with a hex nut to the nail to secure the wire mesh and rebar during shotcrete placement. If the soil nails extend beyond the hex nuts, they will be trimmed.

Shotcrete Application:

- Shotcrete will be placed from the lower part of the area upwards to prevent accumulation of rebound. The nozzle will be oriented a proper distance from and approximately perpendicular to the working face so that rebound will be minimal and compaction will be maximized. Care will be taken while encasing reinforcing steel and mesh to keep the front face of the reinforcement clean during placement operations, so that shotcrete builds up from behind, to encase the reinforcement and prevent voids or pockets from forming.

GSI Employee Certifications:

- ACI Shotcrete Nozzlemen Certification
- 10-hour Occupational Safety and Health Training Course in Construction Safety & Health
- American Red Cross Standard First Aid Training
- American Red Cross Bloodborne Pathogens Training: PDT
- Erosion Control Supervisor Training

House Keeping:

- The site will be organized and clear of any trash or debris. All trash will be placed in a proper container and removed at the end of each work day.

Safety:

- All safety plans for lifting, hearing, dust control, PPE etc. are in place and will be followed accordingly. PPE will include safety vest, steel toed shoes, hard hat, safety glasses, and gloves.

Shotcrete Mix Design:

Shotcrete shall comply with the requirements of ACI 506.2, "Specifications for Materials, Proportioning and Application of Shotcrete", except as otherwise specified. Shotcreting consists of applying one or more layers of concrete conveyed through a hose pneumatically projected at a high velocity against a prepared surface.

The wet-mix process consists of thoroughly mixing all the ingredients, introducing the mixture into the delivery equipment and delivering it, by positive displacement, to the nozzle. Air jet the wet-mix shotcrete from the nozzle at high velocity onto the surface.

Material	Weight per Cubic Yard
⅜" Rock	650 lbs
Sand	1800 lbs
Cement	750 lbs
Water	300 lbs
Fly Ash	150 lbs
Air Entrainment	6% (1.6 cubic feet)

0.40 to 0.50 water/cement ratio

Grout Mix Design:

Water/Cement Ratio= 0.5 to 0.6

(Batch Weight Per Cubic Yard)

Material	Weight	Volume	
Cement	2063 to 1837 lbs	10.4 to 9.3 Cubic Feet	22 to 19.5 bags (94#)
Water	1031.5 to 1102 lbs	16.6 to 17.7 Cubic Feet	123.5 to 132 gallons
Total		1 Cubic Yard	

(Per 94# Bag of Cement)

Material	Weight	Volume	
Cement	94 lbs	0.48 Cubic Feet	1 bag (94#)
Water	47 to 56.4 lbs	0.8 to 0.9 Cubic Feet	5.6 to 6.8 gallons

Sheet Revision

Date:		By:

General Notes

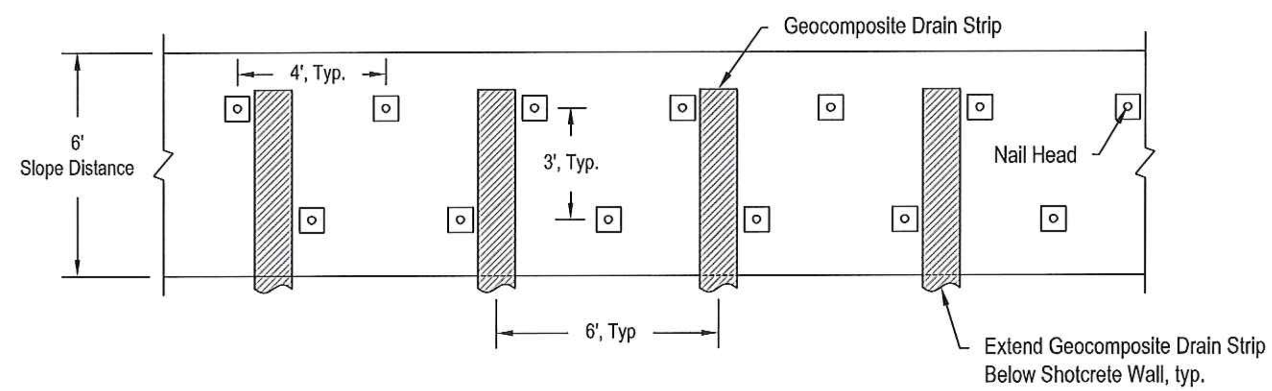
Project: Brook Road

Project No.: ----

Date: March 14, 2016 | Drawn By: EDL | Checked By: - | Sheet No.: 2

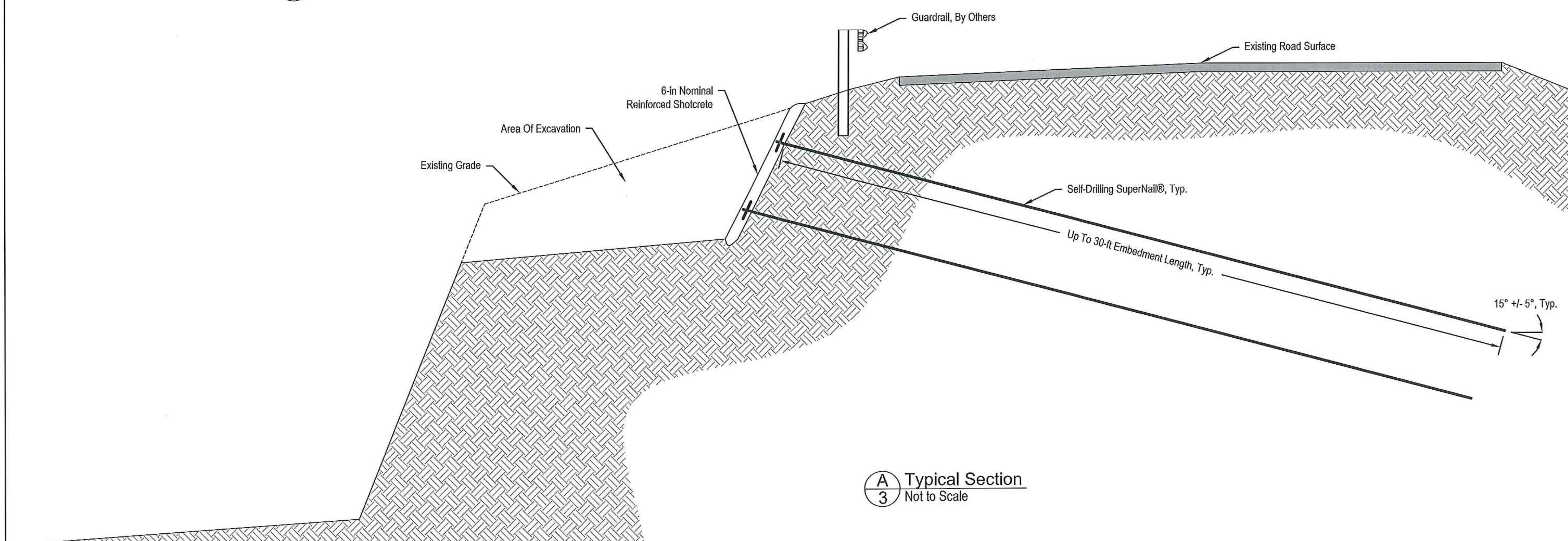
GeoStabilization International

GeoStabilization International
Corporate Address: PO Box 4709
Grand Junction, CO 81502
P: 970.210.6170
F: 970.245.7737
www.geostabilization.com



B/3 Elevation Detail
Not to Scale

Note: 92 L.F. of Stabilization As Shown



A/3 Typical Section
Not to Scale

Sheet Revision

Date:		By:

Typical Cross-Section & Elevation View

Project:			Project No.
Brook Road			----
Date: March 14, 2016	Drawn By: EDL	Checked By: -	Sheet No.: 3

GSI GeoStabilization International

GeoStabilization International
Corporate Address: PO Box 4709
Grand Junction, CO 81502
P: 970.210.6170
F: 970.245.7737
www.geostabilization.com