Fitzgerald Environmental Associates, LLC.

Applied Watershed Science & Ecology

MEMORANDUM

To: Chittenden County Regional Planning Commission

From: Evan Fitzgerald, Roy Schiff, and Evelyn Boardman

Re: Field Verification Memorandum and Refined Prioritization Methodology

Date: July 14, 2017

Introduction

Our team has developed, refined, and calibrated through field observations a road erosion prioritization methodology using Road Erosion Inventory (REI) data collected by CCRPC during 2016 in eight (8) towns in Chittenden County: Bolton, Essex, Jericho, Huntington, Richmond, St. George, Underhill, and Williston. As part of the methods development, we reviewed, updated and corrected REI data as needed following a thorough QA/QC process in conjunction with Chris Dubin. A summary of the QA/QC process and outcomes was previously summarized in a memorandum to CCRPC dated March 8, 2017. The draft screening methods and results were summarized in a memorandum to CCRPC dated April 12, 2017.

A recap of the key project objectives, as outlined in our scope of work, is provided below.

1. Develop and apply a road erosion prioritization method within each of the municipalities to identify priority sites for mitigation work.
2. Develop conceptual erosion mitigation designs for the highest priority sites in each municipality in support of Better Roads grants. Subsequent grants and restoration projects will in turn help municipalities meet the permit conditions of the VTDEC Municipal Roads General Permit (MRGP).

Outline of Prioritization Method

During our review and QA/QC of the REI dataset, we developed a concept for categorizing REI data based on each variable's potential impact on stormwater runoff, sedimentation, and overall water quality in adjacent waterways. We organized the data based on water quality processes that indicate sources of sedimentation and transport mechanisms. This approach is similar to other projects in the region to prioritize stormwater and water quality remediation projects (i.e., Critical Source Area analysis). This framework identifies areas with the greatest water quality impacts where there is 1) a source of pollution, and 2) a transport mechanism to move the pollution to nearby waterways, whereby road segments with both source and transport mechanisms have a higher impact rating than those lacking one.

Figure 1 outlines this concept using the REI data. Source and Transport are defined below in relation to our evaluation of road erosion:

Source: The roadway surface and/or right-of-way has areas of soil instability (i.e., rilling on gravel road surface, unstable ditches, gullies) that lead to sedimentation during runoff events.

Transport: The road segment has areas of direct discharge (i.e., conveyances) to adjacent or bisecting waterways.

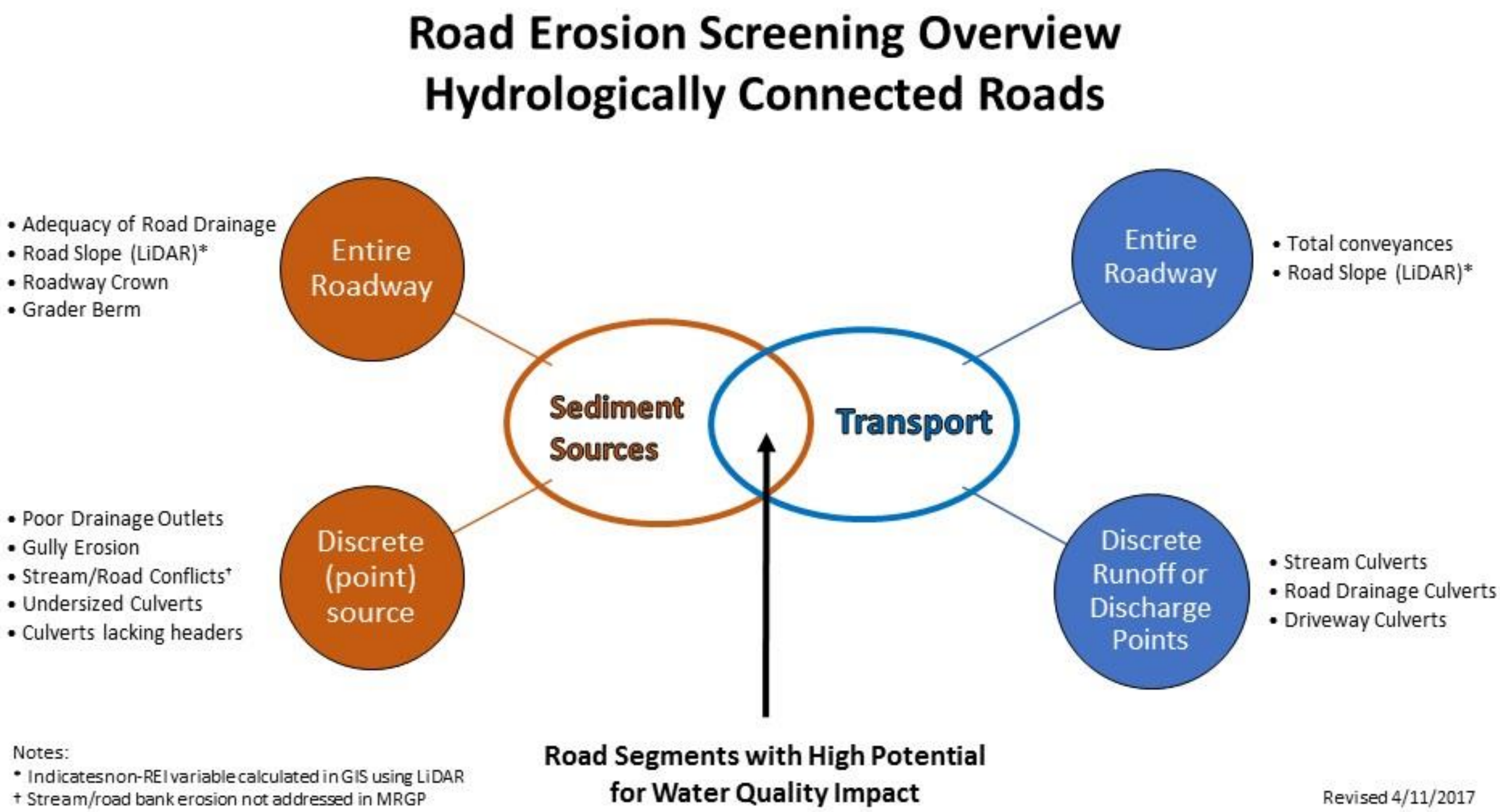

Figure 1. Draft Prioritization Concept

Draft Screening Results and Field Validation

Our initial screening method is described in detail in a memorandum to CCRPC dated April 12, 2017. Each of REI variables included in the screen was assigned a scoring value of 1 for low, 2 for medium, and 3 for high on each hydrologically connected road segment. The final scoring ranges for each road segment depend on whether the road is paved, gravel, or Class 4, as shown in **Table 1** for the Source and Transport scores. We reviewed the scoring distributions for the Source and Transport scores by road type, and applied breaks for high, medium, and low. The breaks in ranges were intended to call out the highest 10-15% of road segments as high, and about 50% as low. Final numeric scores were defined with a matrix using the scoring of high, medium, and low for Source and Transport where Source was weighted slightly higher than Transport.

Table 1. Ranges for Road Segment Scoring in Draft Screening

Road Type	Number of REI Variables by Type		Lowest Possible Score (all REI variables low or 1)		Highest Possible Score (all REI variables high or 3)	
	Source	Transport	Source	Transport	Source	Transport
Paved	9	5	9	5	27	15
Gravel	11	5	11	5	33	15
Class 4	9	5	9	5	27	15

Initial Round of Field Validation

We completed initial field validation work in April and early May 2017 to evaluate road segments in Underhill & Richmond (hilly) and Essex & Williston (flatter). We reviewed 60 road segments representing a range of scores in the high, medium, and low categories. Our process was to review both the individual Source and Transport scores, and the combined score, and compare this with our field observations of overall water quality impact potential of the road segment.

Overall, we found that the prioritization method did a decent job of distinguishing between high and medium categories, which will likely be the most important difference for assessing initial priorities for Towns to prioritize projects for water quality improvement, and ultimately meet the MRGP standards. However, we observed the following areas for improvement in the field, which we considered in developing the next iteration of screening refinement:

Overall Scoring

- Source variables appear to drive sediment losses more than transport variables. Source should be weighted higher.
- Segments receiving high scores in the steeper towns (Underhill & Richmond) tended to look worse than segments receiving high scores in flatter towns (Essex & Williston). This is likely related to road slope, and therefore slope should receive higher weight in the screening system (**Figure 2**).

Figure 2. Left: A high-scoring segment, low slope segment of Lost Nation Road in Essex. Right: A high-scoring, high slope segment of Lower English Settlement Road in Underhill, where a stream channel flows alongside the road with greater risk to water quality.

Variables to consider for higher weights

- Poor conveyances on segments with stream crossings almost always went straight into the stream. Poor conveyances and stream crossings should receive high weights in the screen.

Variables to consider for lower weights

- Roadway crown and grader berm variables are highly temporal, which was confirmed during field visits.
- Road drainage culverts lacking headers likely increase sediment source, but these should not be weighted as high as other Source categories. Similarly, small road drainage and driveway culverts did not appear to be large sources of sediment in the segments examined and should not be weighted as high as other source categories.

Other REI Data Observations

- The gully erosion variable tends to be related to low points in the road, where there is runoff along the shoulder and creates small eroded flow paths through the road shoulder. Where gully erosion locations were identified in the point file, the erosion tends to be of a larger magnitude (i.e. large erosion along a stream channel).

Scoring Revisions and Field Validation

After the initial round of field validation, we refined the overall scoring system before the second round of field validation. In this iteration of the screen, we pulled the slope parameter out of the Source and Transport components and included it as its own unique component to the score. **Figure 3** outlines the revised screening concept using the REI data. The Slope score was the raw slope value (0-10%) if the slope was less than or equal to 10% and received a score of 10 if the slope was greater than 10%. **Table 2** shows the ranges of the Slope, Source, and Transport scores with this new three-component screen.

Table 2. Ranges for Road Segment Scoring in Second Round Screening

Road Type	Number of REI Variables by Type			Lowest Possible Score (all REI variables low or 1)			Highest Possible Score (all REI variables high or 3)		
	Slope	Source	Transport	Slope	Source	Transport	Slope	Source	Transport
Paved	1	8	4	0	8	4	10	24	12
Gravel	1	10	4	0	10	4	10	30	12
Class 4	1	8	4	0	8	4	10	24	12

A composite score for each hydrologically connected road segment was calculated by weighting scaled Slope, Source, and Transport scores and summing the three components. Source and Transport were scaled from their ranges of 8 – 30 and 4 – 12 respectively to a range of 1 – 10 using the formula:

$$\frac{max_{scaled} - min_{scaled}}{max_{raw} - min_{raw}} \times (score - max_{raw}) + max_{scaled}$$

Or

$$\frac{10 - 1}{max_{raw} - min_{raw}} \times (score - max_{raw}) + 10$$

We tested different weights for the three components and compared the resulting scores to target scores we determined during the first rounds of field tours. We found the best results using a weighting scheme of 20% Slope, 20% Transport, and 60% Source. Conceptually, this agreed with our observations that Source mechanisms are the most importing factors in driving sediment losses and overall water quality impacts.

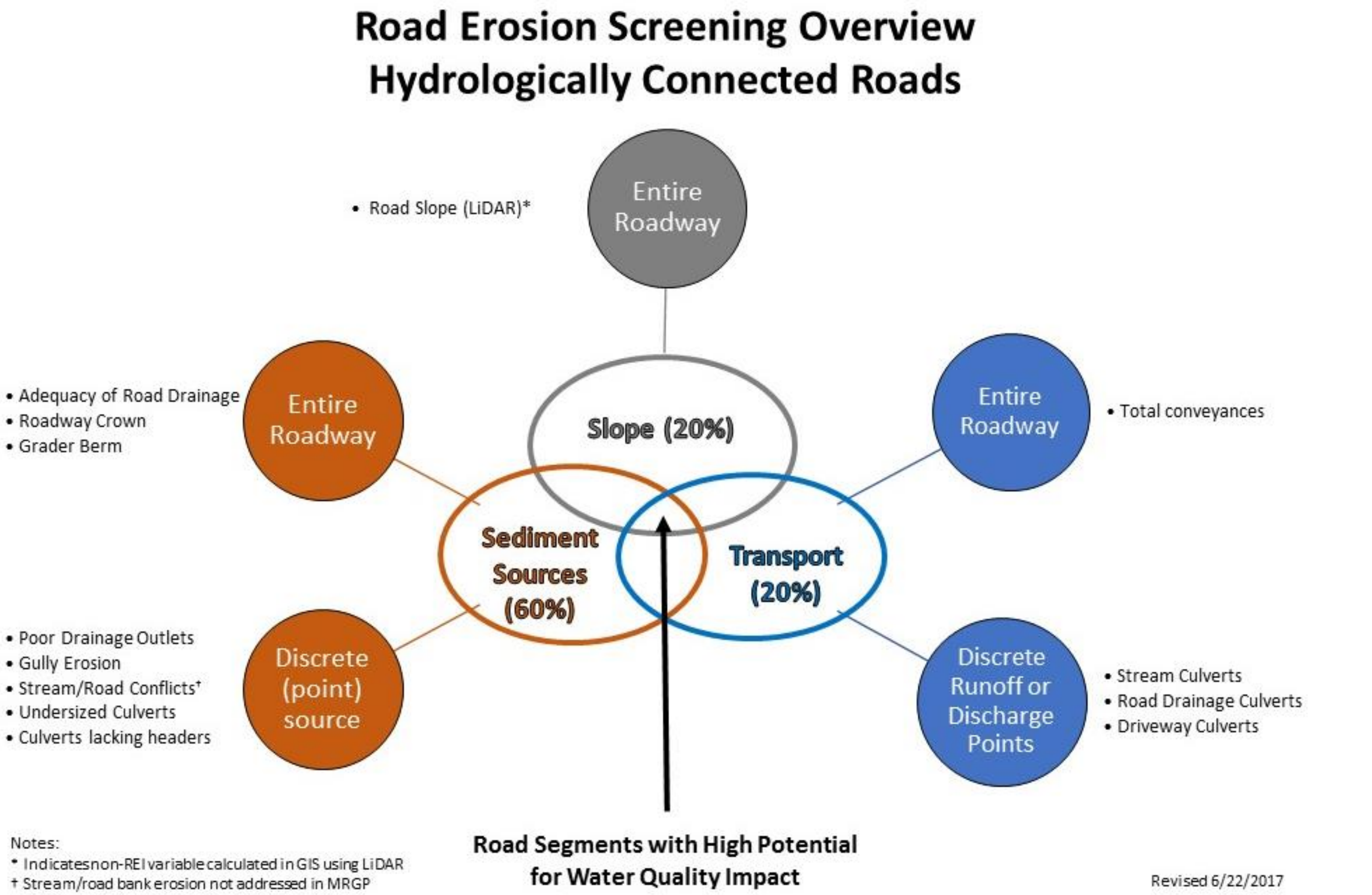

Figure 3. Revised Prioritization Concept

Second Round of Field Validation
We completed the second round of field validation in June to evaluate road segments in Richmond, Huntington, and Underhill. We reviewed 30 road segments representing a range of scores. Our process was to review both the individual Slope, Source, and Transport scores, and the combined score, and compare this with our field observations of overall water quality impact potential of the road segment.

Overall, we found that the prioritization method did an excellent job of distinguishing between high, medium, and low categories. The main discrepancies between the screen and our field validation occurred in the following situations:

- In areas where road or ditch instability had been addressed by the Town **after** the REI survey was completed in 2016, REI variables collected prior to the work tended to overestimate sediment source and transport potential.
- In areas where a stream was near the road segment but did not cross it and in areas with ditches and channels that had considerable flow but were not considered blue-line streams, the screen tended to underestimate sediment source and transport potential (**Figure 4**). Once again, we observed that segments with both poor conveyances and a stream crossing or stream nearby tended to generate and deliver more sediment than segments with one of these conditions but not both.

Figure 4. Repaired pavement on Wes White Road in Richmond where a channel with flowing water is alongside the road.

- In areas where the REI data on which the screens were based were different from what we observed in the field the screen tended to both under- and overestimate sediment source and transport potential. This included some areas where more permanent variables (e.g. adequacy of road drainage and poor conveyances) were reported to be worse in the REI data than what we observed in the field. However, most of the discrepancies were in the more temporally variable road crown and grader berm variables.

Final Scoring System
Following our June 2017 field validation tours, we made minor changes to the weights of the individual variables that make up the Source and Transport components of the overall screen. After assigning REI variables included in the screen a scoring value of 1 for low, 2 for medium, and 3 for high on each hydrologically connected road segment, we weighted the scores based on the importance of each variable to sediment and pollutant source and transport mechanisms. The determinations and weights shown in **Table 3** were made based on field observations, prior knowledge, and professional judgment of the permanence and magnitude of water quality impacts from problem areas. **Table 4** shows the ranges possible for Slope, Source, and Transport scores before scaling, weighting, and summing to determine an overall score as described in the previous section.

Table 3. Weighting of Individual Variables used in Road Segment Scoring in Final Screening

Component	Variable Description	Scoring Importance	Scoring Weight
Slope	Road Slope	High	1
Source	Adequacy of Road Drainage	High	1
	Roadway Crown	Low	0.33
	Grader Berm	Low	0.33
	Total Poor Conveyances (Road Drainage Outlets)	High	1
	Road Drainage Culvert Outlet Stability	Moderate	0.66
	Gully Erosion Locations	High	1
	Stream and Road Conflicts	High	1
	Total Road Drainage Culverts Less than 18 Inches in Diameter	Low	0.33
	Total Road Drainage Culverts Lacking Header(s)	Low	0.33
	Total Driveway Culverts Less Than 15 Inches in Diameter	Low	0.33
Transport	Total Conveyances (Road Drainage Outlets)	High	1
	Stream Culverts	High	1
	Total Road Drainage Culverts	Moderate	0.66
	Total Driveway Culverts	Moderate	0.66

Table 4. Weighting of Individual Variables used in Road Segment Scoring in Final Screening

Road Type	Number of REI Variables by Type			Lowest Possible Score (all REI variables low or 1)			Highest Possible Score (all REI variables high or 3)		
	Slope	Source	Transport	Slope	Source	Transport	Slope	Source	Transport
Paved	1	8	4	0	5.7	3.3	10	16.9	10
Gravel	1	10	4	0	7.7	3.3	10	18.9	10
Class 4	1	8	4	0	5.7	3.3	10	16.9	10

Attached is a table where we recorded our observations from both rounds of field validation, and two 24" x 36" maps. One map shows revised prioritization results for the Town of Underhill, and a second map shows the locations segments visited during the field validation. Between both field validation trips, we visited approximately 90 road segments representing 5% of the hydrologically connected road segments in the REI database for the 8 Towns in the study.