Using Remote Data Collection to Identify Bridges and Culverts Susceptible to Blockage During Flooding Events

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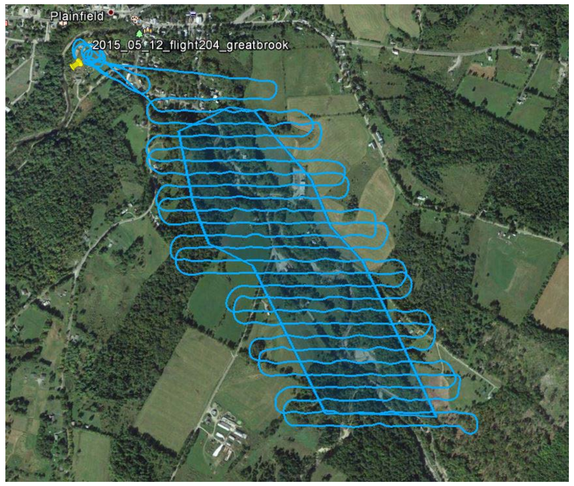
Introduction

Flooding occurs in Vermont when (1) rain falls over a prolonged period of time, (2) intense rain falls over a short period of time, or (3) an ice or debris jam reduces the capacity of a crossing structure and causes a river or stream to overflow onto the surrounding area. The third type of flooding, specifically due to large woody debris (LWD) jams at culverts and bridges contributed to the damage that was observed during both Tropical Storm Irene in 2011 and the heavy rainfall in the spring and summer of 2013. A new approach to mapping potential debris blockages - one that can produce actionable information in a timely manner at a reasonable cost would allow the identification of high-risk locations for this type of flooding.

Damage caused by debris blockage of a crossing structure



UAV flight log for Great Brook

Methodology

The objectives of this project were to pilot-test an unmanned aerial vehicle (UAV) to gather imagery of streambeds upstream of crossing structures, and to develop a process of rapidly transmitting data about high-risk locations with a high risk for debris blockage and flooding to stakeholders.

LWD pile identification in Great Brook

Results

The UAV imagery was used to identify the size of each LWD pile and its distance upstream from the crossing structure at each of the 5 test sites. The modified inverse distance upstream (MIDU) was then calculated to identify high-risk locations by weighting the inverses of the distances upstream for the LWD piles based on their size:

$$MIDU_x = \sum \frac{1}{d_s} + \sum \frac{3}{d_m} + \sum \frac{6}{d_l}$$

$MIDU_x$ is the MIDU at crossing x, and d_s, d_m, and d_l are the distances upstream of each small, medium, and large LWD pile, respectively. The results of the MIDU calculations for each test crossing are provided in the table below:

Water Body	Crossing	MIDU
Gunners Brk	Mitchell Rd	0.01
Unnamed Brk	Lower Rd	0.24
Gunners Brk	Harrington A	0.24
Gunners Brk	U.S Hwy 302	0.04
Honey Brook	U.S Hwy 302	0.06
Money Brook	VT100	0.04
Great Brook	Brook Rd 1	0.73
Great Brook	Brook Rd 2	0.21
Great Brook	Brook Rd 3	0.12
Great Brook	Brook Rd 4	0.04
Great Brook	Brook Rd 5	0.09
Great Brook	Mill Street	0.01

Conclusion

The new system was pilot-tested to identify LWD piles and output an extracted thumbnail image. The MIDU allows stakeholders to focus on the particular locations that are at the highest risk of blockage and flooding during the next significant rainfall event.

Several challenges were overcome to successfully complete this project. First, due to the resolution of the raw images and the need to check each identified LWD pile for accuracy, the fastest method of getting actionable results was found to be visually scanning the images for LWD piles, as opposed to automating the extraction in a GIS environment. Additionally, the file sizes of these images precluded their transmission in the field rapidly to stakeholders. Therefore, the team developed a procedure for extracting a thumbnail image of each LWD pile along with its size and location, reducing files to a size that can be transmitted as an attachment to an email or text message.

Acknowledgments

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