Fluvial geomorphic and flood hazard assessment for the Wood-Pawcatuck Watershed

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Introduction

The Wood-Pawcatuck Watershed, located in Southern Rhode Island and Eastern Connecticut, is subject to periodic floods, but little data exists on the hydrological effects of the dams, culverts, and bridges it contains. Many of these structures are in disrepair or were never suitable for moving the amount of water they face during increased flow periods. Developing a flood resiliency management plan for the watershed will help to improve this infrastructure, reduce property damage, and maintain ecosystem balances in the event of storm events that bring heavy rains and flooding. With the help of a federal grant from Hurricane Sandy Coastal Resiliency Grant Program, the Wood-Pawcatuck Watershed Association engaged the engineering firm of Fuss and O'Neill to develop a Flood Resiliency Management Plan. As part of this plan a data set of accessible bridge, culvert, and dams will be created to rank their effectiveness and hydraulic capacity. Each site was surveyed to collect both qualitative data of the location, and quantitative measurements of the hydraulic capacities of the structures. This data, along with in-stream geomorphic data, will be used to develop recommended actions, such as green infrastructure and land use management. The plan will be made available to each town in the watershed, RIDEM, CT DEEP, and RIEMA and other interested parties.

Objective

Collect qualitative and quantitative data for each bridge, culvert and dam within the Wood-Pawcatuck Watershed to develop recommendations for infrastructure improvements that would most effectively improve flood resiliency within the watershed.

Methods

Field Data Acquisition

Vermont Geomorphic Assessment worksheets were used for each bridge and culvert inspected.

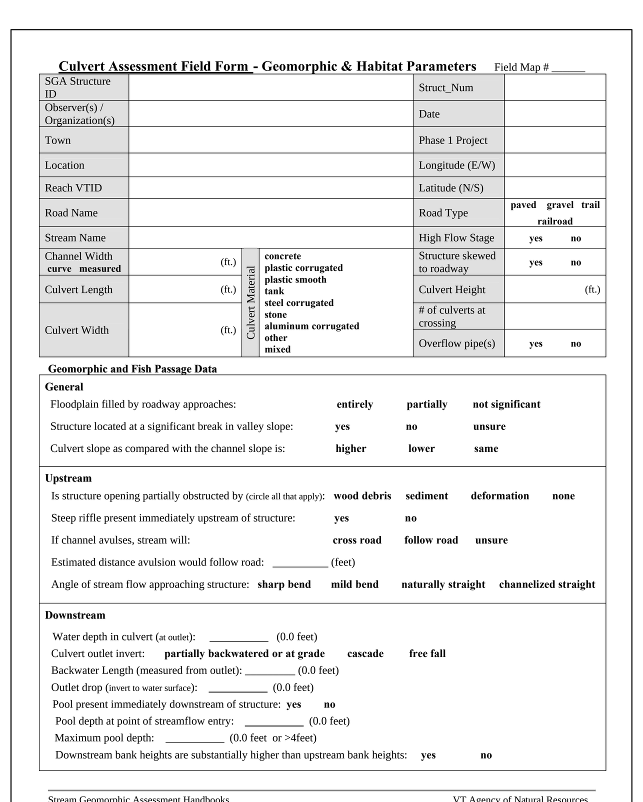


Figure 1: Culvert Assessment (page 1)

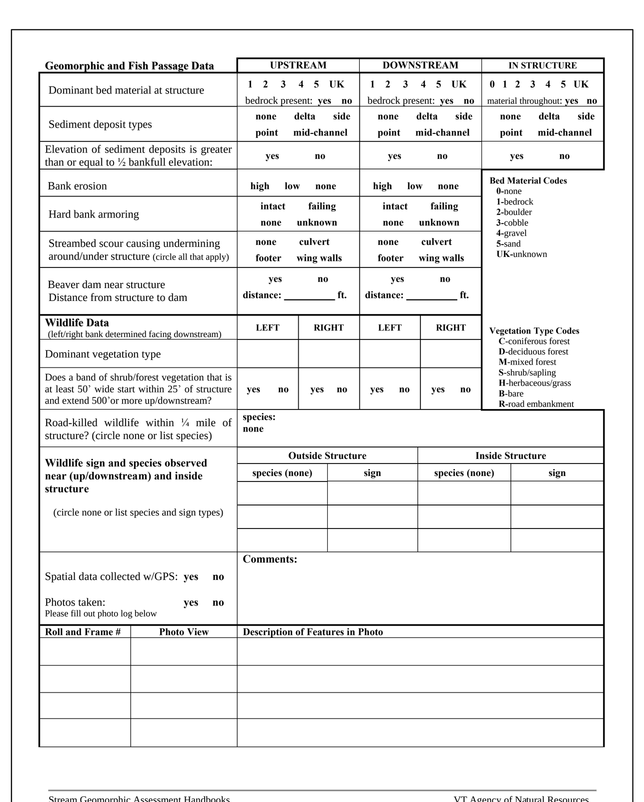


Figure 2: Geomorphic Assessment (page 2)

Data Assessment

- Use USGS Streamstats to define watershed delineations and peak flow data
- Use Culvert Master application to estimate hydraulic capacities and efficiencies of each structure
- Inputting data into Excel so that each structure could later be ranked and deficient structures could be determined

Materials Used

- Modified Vermont Geomorphic Assessment Sheets
- Dam Assessment forms
- Survey Equipment (scope, tripod, measurement rod)
- Laser measure & Tape measure
- Camera
- Waders

Figure 3: Maren, Zack and Rachel inspecting a culvert

Figure 4: Zack holding a survey rod

Figure 5: Nate using survey equipment

Results

442 out 594 structures were assessed and organized into a table comparing capacities and discharges at different sites (*figure 6)*, and then were ranked according to their potential impact on public safety (*figure 7)*.

Structure Name	Capacity (cfs)	Discharge (10-year)	Discharge (25-year)	Discharge (50-year)	Discharge (100-year)	25- Year Capacity Ratio	Future 25- Year Capacity Ratio
UWR-WOR-18-4	604.88	155	216	267	322	0.36	0.54
UWR-WOR-18-4-1	45.51	415	637	844	1030	14.00	21.14
UWR-WOR-18-5	122.55	41.2	56.6	69.3	84.1	0.46	0.70
UWR-WOR-19-2	7.47	78	112	142	172	14.99	22.64
UWR-WOR-19-3	36.50	53.5	76.6	96.6	118	2.10	3.17
UWR-WOR-22-2	126.96	16.1	22	26.8	32.6	0.17	0.26
UWR-WOR-24-2	23.12	10.7	13.9	16.4	18.6	0.60	0.91
UWR-WOR-25-2	4.22	18.4	23.9	28.3	32.2	5.66	8.55
WPB-FOUND-20150812	207.78	410	550	666	786	2.65	4.00
WPB-HET-0-2	93.52	144	190	228	265	2.03	3.07

Impact Rating	Upstream and Downstream Development[1]	In FEMA Flood Zone?	Type of Road
1	Little to no development, mostly forested land	No	Trail
2	Mostly open farm land, very low density residential area		Driveway
3	Low to moderate density residential area, little commercial/industrial development		Town Road
4	Moderate to high density residential area, some commercial/industrial development		State Road
5	High density residential area, significant commercial/industrial development	Yes	Highway or Railroad

Figure 6 (above): example of capacities table

Figure 7 (left): ranking scheme for potential impact

	High	Medium	Low	Total # of Structures
Arched Conduit	50%	38%	13%	8
Box Culvert	16%	49%	35%	68
Bridge	52%	30%	17%	128
Circular Conduit	12%	40%	48%	218

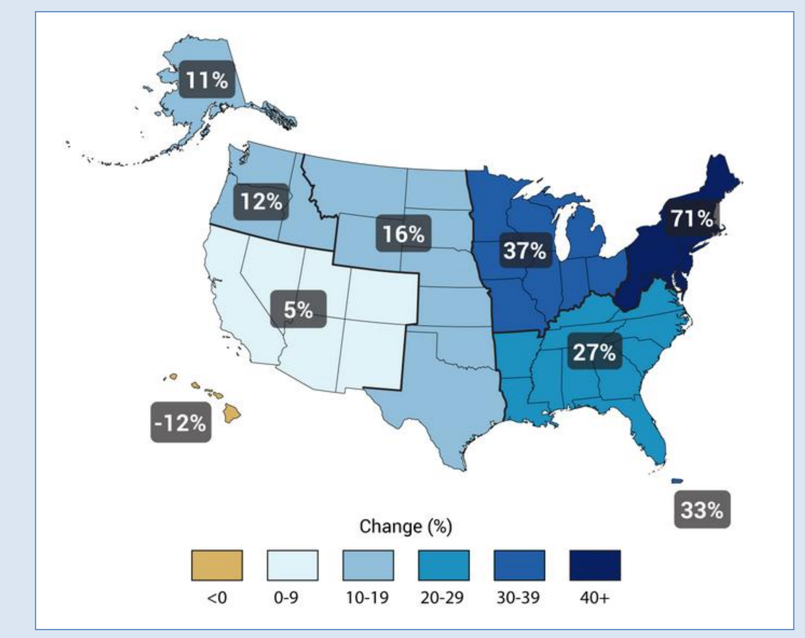
Figure 8 (above right): summary of all structures and their potential impact rating, organized by structure type

Figure 9 (below): example of table ranking structures based on their potential impact

Structure Name	Surrounding Area	FEMA Flood Zone?	Type of Road	Overall Ranking
AWR-GRE-0-6	Little Development/Forested	No	Town	Low
AWR-GRE-10-1-1	Little Development/Forested	Yes	Town	Medium
AWR-GRE-10-2-1	Little Development/Forested	No	Town	Low
AWR-GRE-1-2	Little Development/Forested	No	Town	Low
AWR-GRE-3-1	Low to Moderate Density Residential/Commercial	No	State	Medium
AWR-GRE-4-1	Little Development/Forested	No	Town	Low
AWR-GRE-5-1	Low Density Residential/No Commercial	No	Town	Low
AWR-GRE-5-2	Low Density Residential/No Commercial	No	Town	Low
AWR-GRE-6-1	Little Development/Forested	Yes	Town	Medium
AWR-GRE-7-1	Little Development/Forested	No	Town	Low
AWR-GRE-8-2-1	Little Development/Forested	No	Town	Low
AWR-GRE-8-2-2	Little Development/Forested	No	Town	Low

Discussion

Considering the effects of increased precipitation patterns in the New England area, and human urbanization influences, the impact for flooding is predicted to increase in magnitude into the near future. Applying the USGS flood magnification factor to our collected data, we can estimate that this factor of increased magnitude will result in greater discharges, therefore causing structures to be under greater stress.



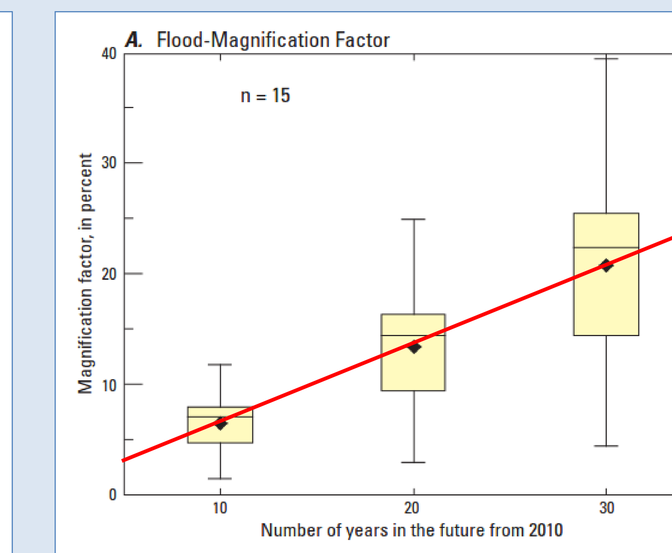
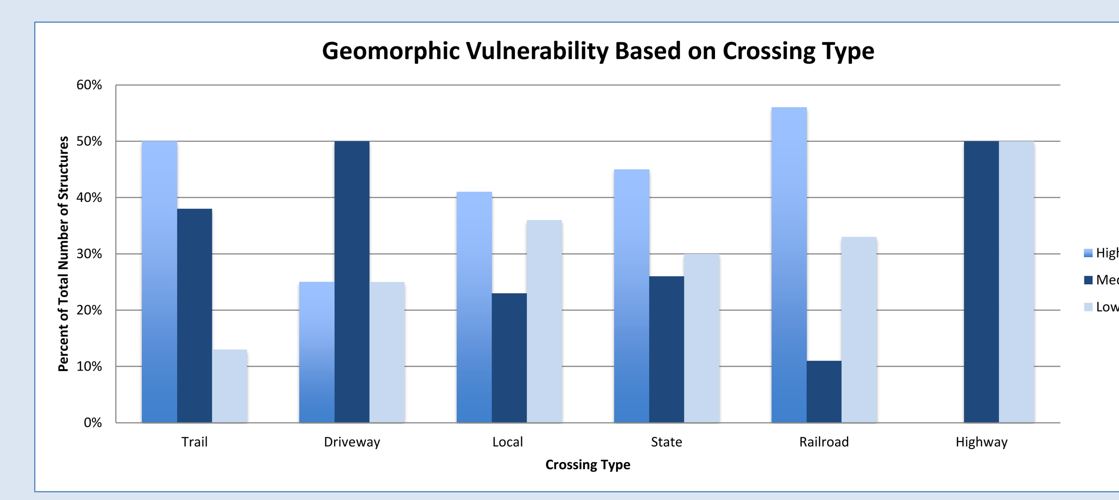


Figure 10 (left): observed change in very heavy precipitation throughout the United States from 2010-2015

Figure 11 (right): the magnification of flooding impacts over years in the future from 2010

Conclusion



Crossing Type	Total # of Structures
Trail	16
Driveway	8
Local	255
State	132
Railroad	9
Highway	2

Figure 12 (left): percent of structures vulnerable to increased flooding, and the ranking of this impact, which can be the basis for determining which structures may be modified. **Local crossing types are of the most concern, as there are a relatively high number of local crossing types, and nearly half are rated as being highly vulnerable to adverse flooding impacts.**
Figure 13 (right): total number of structures assessed within each crossing type.

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