TOWN ROAD INFRASTRUCTURE FLOOD DAMAGE
SUSCEPTIBILITY
BELVIDERE, VERMONT

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INTRODUCTION

With the increasing frequency of flooding over the past few decades culminating with the devastating impacts of Tropical Storm Irene in 2011, Vermont communities are focusing planning efforts on flood resiliency. Last year Lamoille County Planning Commission (LCPC) developed a new flood resilience component for the Lamoille County Regional Plan. Complementing this, LCPC has been working with several towns in the region to strengthen infrastructure and better prepare for future floods.

This project targeted two towns (Stowe and Belvidere) in which to identify areas where road infrastructure is highly susceptible to future flood-related catastrophic failure and associated water quality concerns. LCPC conducted a GIS analysis for site identification and utilized a compilation of information from the following sources: river corridor layers, previous FEMA Community/Public Assistance grant site information, interviews with road foremen, BBR Category B grants completed projects list, culvert and bridge DMS/inventories, and river corridor plan/Phase 2 reports. The GIS analysis first involved determining which communities in Lamoille County have the most river road conflicts. LCPC then chose two towns including Belvidere with abundant river/road conflicts and applied varying constraints to town road segments that included the following: within 50 foot stream buffer, within 100 year floodplain, within the river corridor, at a bridge or culvert crossing that was significantly undersized, and steep road slope. The segments were then scored for total constraints to identify those sites that were highest priority for the town to pay attention to in helping the town to make their infrastructure more flood resilient. This report summarizes the findings for the Town of Belvidere. Included in the report are the methodology and results of the GIS analysis, maps, summaries of meetings with town officials, observations made during site visits by LCPC, and recommendations for protection of the Town’s infrastructure.

Belvidere is located in the northwest region of Lamoille County and prides itself in its beauty and its high quality water resources including Belvidere Bog and the North Branch of the Lamoille River. In fact the town’s name roughly translates to “beautiful to see” in Latin (bel, beautiful, and vedere, to see). The town has a low density of development, but 63 percent of the road infrastructure for that development is in conflict with the North Branch of the Lamoille River and its tributaries.

METHODOLOGY

LCPC first conducted a GIS analysis to determine what the percent of roads in each town were in conflict with rivers by intersection them with the river corridor layer. A subsequent GIS analysis was then conducted to determine the total constraints of town road sites in two towns (Stowe and Belvidere). The constraints placed on the road segments included the following:

- Within river corridor
- Within 50 foot buffer
- Within 100 year floodway
- Road slope
• Percent bankfull width of structures at stream crossings

A more detailed explanation of the methodology is presented in Appendix A. This method was based on one used by Central Vermont Regional Planning Commission (Dubois & King and Bear Creek Environmental, 2015). LCPC also reviewed areas where Better Back Roads road repairs or bridge/culverts replacements have been done and reviewed FEMA damage reports for each town to see where there has been historic damage to existing infrastructure.

RESULTS

Map 1 in Appendix B shows the sites within Lamoille County where Better Back Roads projects have been done and Map 2 depicts the various factors that are considered in the river/road conflict determination. For Belvidere, there have been six areas where Better Back Road grants were used to repair roads and culverts/bridges. Map 3 displays the number of constraints for each town road segment in Belvidere. LCPC came up with a total of 12 sites for the Town of Belvidere to prioritize in terms of flood vulnerability. Six sites shown on Map 3 that had four total constraints are also listed in Table 1 below.

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Road</th>
<th>Number of Constraints</th>
<th>Issues/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bog Road (east)</td>
<td>4</td>
<td>In floodway, river corridor and 50 foot stream buffer, road slope &gt;5%</td>
</tr>
<tr>
<td>2</td>
<td>Bog Road (west)</td>
<td>4</td>
<td>In floodway, river corridor and 50 foot stream buffer, road slope &gt;5%, structure recently replaced</td>
</tr>
<tr>
<td>3</td>
<td>Back Road and Boarding House Hill Road</td>
<td>4</td>
<td>In river corridor, road slope &gt; 15%, undersized structure</td>
</tr>
<tr>
<td>4</td>
<td>Back Road (east)</td>
<td>4</td>
<td>In floodway, river corridor and 50 foot buffer, undersized structure</td>
</tr>
<tr>
<td>5</td>
<td>Back Road (west)</td>
<td>4</td>
<td>In river corridor and 50 foot buffer, undersized structure</td>
</tr>
<tr>
<td>6</td>
<td>Laraway Mountain Road</td>
<td>4</td>
<td>In 50 foot buffer, road slope &gt;5%, undersized structure</td>
</tr>
<tr>
<td>7</td>
<td>Bog Road (north)</td>
<td>3</td>
<td>Identified by Town and LCPC transportation planner as water overtopping road during flood events</td>
</tr>
<tr>
<td>8</td>
<td>Back Road</td>
<td>1</td>
<td>Identified by selectman as a site where river eroded road embankment; riprap was placed after erosion event</td>
</tr>
<tr>
<td>Site Number</td>
<td>Road</td>
<td>Number of Constraints</td>
<td>Issues/Notes</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>9</td>
<td>Basin Road</td>
<td>2</td>
<td>Identified by selectman as a site where washout has occurred near bridge</td>
</tr>
<tr>
<td>10</td>
<td>Basin Road</td>
<td>1</td>
<td>Identified in FEMA damage reports</td>
</tr>
<tr>
<td>11</td>
<td>Bog Road</td>
<td>1</td>
<td>Identified in FEMA damage reports</td>
</tr>
<tr>
<td>12</td>
<td>Back Road</td>
<td>3</td>
<td>Field Observation of built up sediment and past gravel extraction indicating culvert may get plugged up with sediment</td>
</tr>
</tbody>
</table>

In April, 2016 LCPC visited those sites with three or more constraints as well as any sites listed on the FEMA damage reports or indicated as a problem for washouts according to the Town. Photos were taken at each site and observations of potential vulnerabilities to infrastructure damage from flooding were noted. In order to correlate river/road conflicts with historic damage in the Town, FEMA damage reports were obtained in November 2015. During the April 2016 site visit, LCPC was not able to confirm the location of one site on the damage reports (Smithville Road) since the description on the damage report was unclear. For the other sites listed on the damage reports, LCPC made several observations in terms of potential damage to infrastructure by either flooding or fluvial erosion hazard. The following photos and narrative are from sites listed above in Table 1, which include those town road sites with four constraints, town road sites identified by the Town as having flooding/fluvial erosion hazard concerns, and sites on the FEMA damage reports from 2015.

Two sites on Bog Road resulted in having four constraints. The most eastern site is located at a bridge where Bog Road crosses Belvidere Bog (Figure 1). This bridge may be vulnerable to inundation from possible rise of wetland waters (Figure 2) but energy of water flowing through would most likely not be high enough to cause substantial damage to road and structure. The other site on Bog Road is located just east of the intersection with Route 109. The bridge at this site has been recently replaced and is adequately sized (Figure 3). Given the constraints, damage in this area could occur to road and perhaps to nearby homes during a very high flow event. Depending on the elevation of the homes, implementing flood proofing measures would beneficial.
In 2002, the Selectboard improved Boardinghouse Hill Road with rock lined ditches and new culverts using funds supplied by the Better Backroads Program. This road had been experiencing routine washouts during heavy storm events. In 2015 FEMA damage reports noted that where Boardinghouse Hill Road intersects Back Road (Site 3), a cross culvert was damaged that conveys water from a small tributary to the North Branch of the Lamoille River.

LCPC flagged this area as a location in Belvidere where road encroachment, steep slopes, and undersized structures may lead to flood or fluvial erosion damage. A tributary that runs along Boardinghouse Hill Road, crosses Back Road, and enters the North Branch through an undersized culvert is out of alignment with the stream channel and the southern bank is inappropriately armored with tires (Figure 4). In a large flood event, these tires could be scoured out and block the culvert causing flooding and fluvial erosion hazards to both the road and the nearby buildings (Figure 5). In addition, the higher slope of Boardinghouse Hill Road (>15%) can result in eroded sediment entering the tributary (Figure 6). The building on the bank of the stream may also be at risk for flooding and fluvial erosion hazard.
The GIS analysis showed that two sites on Back Road have a total of four constraints. Both sites have undersized culverts crossing Back Road. The most eastern site is in the floodway and has a slightly perched culvert (Figure 7). The culvert at Site 5 is further west along Back Road and is also undersized. On the upstream side of the culvert, the water is ponded from wetland drainage, which if the water level rose high enough could cause some possible inundation and damage to the road (Figure 8).
The last site with the largest number of constraints (4), was located on Laraway Mountain Road. A small stream crosses this slightly steep road (>5% slope) through an undersized perch culvert and then enters the yard of a nearby home (Figure 9). There is some localized instability in the stream channel just downstream of the culvert which may be due to the inadequately sized culvert. The small culvert may make Laraway Road more susceptible to flood damage.

As part of this project, LCPC also reviewed areas of known inundation/washout problems. One site includes Bog Road at the intersection of Route 109 (Figures 10-12). The plan to replace the culvert at this location is in process with the Town, LCPC, and VTrans. The culvert has a very
low clearance and appears undersized (Figure 10). Water has overtopped the road in the past and areas of erosion caused by stormwater runoff can be seen on Bog Road (Figures 11-12).

Figure 10-Site 7: Undersized culvert at Bog Road

Figure 11-Site 7: Road erosion from Bog Road

Figure 12-Site 7: Bog Road at Route 109 intersection susceptible to inundation

LCPC also met with selectboard members Frank Machia and Earl Domina, Jr. to discuss the findings of the GIS analysis and to inquire about damage reports and town priorities for infrastructure impacted by flood washouts. Mr. Machia informed LCPC that although the GIS Analysis did not target two areas as vulnerable for flood damage, there has been some work to the roads and streambanks. One area was on Back Road where it encroaches upon the North Branch of the Lamoille River (Figure 13). The Town may want to explore alternatives to road placement to prevent further damage to the road. However, care should be taken so as not to make the nearby structures more susceptible to flooding (Figure 14).
Another site that town officials indicated as sometimes having localized erosion was around the bridge on Basin Road (Figure 15). This bridge is old and in poor condition but it is not heavily used as it is located at the beginning of a Class 4 road.

FEMA reports noted two other locations where damage had occurred in Belvidere. One was along Basin Road where 5 cross culvert inlets and outlets needed to be cleaned out. Figures 16 and 17 below shows the small stream through one of these culverts, which drains a steep area on the upstream end and then is down cutting on the downstream end.
The other location that needed repair in the recent past according to FEMA damage reports was along Bog Road just east of the intersection with Basin Road. A small stream crosses Bog Road at this location where it appears that some road material was washed down into stream.

Field Visit Identified Sites

LCPC identified two sites that may be vulnerable to future flooding or fluvial erosion during the site visit. One site (Site 12) was on Back Road, approximately 0.3 miles northeast of Morgan Bridge Road, where there is a poorly aligned cross culvert with excess sediment deposition on the upstream end (Figure 19). Just upstream of the deposition, there appears to have been some sediment excavated out of the stream channel and piled up on the western bank (Figure 20). Since excess sediment deposition is an issue here, it could potentially cause the culvert to clog...
and subsequently flood or washout the road at this location. A larger culvert could help to alleviate this damage risk.

Along Bog Road, LCPC observed another site (Site 13) about 0.7 miles east of the intersection with Basin Road that may be vulnerable to infrastructure damage. The future damage could be to the road and perhaps culvert from flooding and fluvial erosion as well as a potential water quality issue from road erosion runoff (Figures 21-23). There are a couple of issues making the road susceptible to damage at this location: 1) a stream runs parallel to Bog Road (Figure 21) and appears to overtop its banks and flow across the road (as shown in Figure 22 by sediment and water on the other side of road) and 2) culvert is undersized by approximately 48 percent (Figure 23).
BELVIDERE is challenged in managing its town roads due to the amount of surface water flowing through the town. Proper sizing of road crossings and other river management strategies that work with the rivers and not against them will help to avoid future damage to town infrastructure. Homes and businesses within the floodway, river corridor and within 50 feet of a stream would benefit from flood proofing measures to avoid financial damage. Additionally, one very vulnerable area in Belvidere is on Vermont Route 109, where the North Branch of the Lamoille River flows along the road and is nearby many buildings. As stated in the 2015
Belvidere Town Plan, “development near rivers and streams should be located in such a way as to minimize the number of stream crossings” and “no structures should be constructed within the flood hazard area” (Belvidere Planning Commission, 2015). Adhering to these principles will also help Belvidere remain more flood resilient into the future.

References
