USDA Forest Service Region 9

White Mountain N.F.

Flood Recovery Trip Report 2018

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Lincoln Woods Trail/Road

Assessment

Lincoln Woods trail along the Pemigewasset River was severely impacted by T.S. Irene and the most recent floods in July and October of 2017. Approximately 1 mile upstream from the Lincoln woods trail and the Kancamagus Highway (NH 112), river position was redirected into the river right bank along the trail/road. A large point bar and log jam formed during T.S. Irene forcing the river to be directed at a 90 degree angle to the river right bank (See Figure 1&2). The trail is in close proximity to the river bank. Since T.S. Irene, a 500ft section of bank has been eroding. During the last 2 flood events in 2017, the river now threatens to close the trail due to trail tread loss along a steep hillslope section.

Figure 1 - View upstream of the impacted trail/road section looking downstream at the depositional bar and log jam forcing the river into the river right bank along the trail

The river runs along a bank composed predominately of sand and weather granitic material with a minor component of gravel, cobble and boulders. The toe of the bank is slightly armored however the materials along the toe of the bank are mobile during elevated flows. Very few large stable boulders exist in the bank material. The right bank will continue to erode and close off access. ~100ft of trail is of immediate concern with the remaining 400ft becoming problematic in the coming years or the next large flood.

There is a bedrock exposure for the first 100ft of the eroded section then it disappears beneath the hill slope and glacial alluvium. It appears the trail was blasted thru a short bedrock section (<100ft). There visible bedrock along the bottom of the bank (See Figure 3) in the eroded section.

Figure 2 View looking upstream along the river bank adjacent to the trail/road. Note the fine grained materials and lack of large boulders along the toe of the bank. Yellow line designates the toe of the proposed riprap revetment

Figure 3 – Bed rock toe of bank. Looking upstream

Geotech Investigation

A 305 CAT excavator was used to trench 5 soil pits along the first 250ft of the project area at the greatest risk of loss. Bedrock was found to be less than 2 ft along the edge of the trail/road at stations 0+00, 0+35, and 1+00. At these stations bedrock was in fairly good conditions with minor joints / fractures ranging from 2 "to 12" plus apart. The joints were tight with no dirt or accumulation in between them. Rock is competent in this section and could be benched or used as anchor point for trail structures. (See Figure 4)

Figure 4 - Bedrock exposure at Station 0+35. A continuous fractured backwall most likely from railroad construction

Two additional trenches were dug at stations 1+60 and 2+50. Each were excavated to 9ft deep below the existing trail grade. At station 1+60, a large flat slab was encountered at the bottom of the excavation. It appears to be of similar character to the bedrock outcrop but I cannot be assured it wasn't a very large boulder. At station 2+50, no bedrock was encountered. (See Figure 5) All material above the bottom of the trench had the same composition as is observed in the eroding stream bank. If an elevated trail/road structure or benching is considered, additional geotech work will need to occur. Either ground penetrating radar or wireline core sampling will be needed to determine the depth to competent bedrock from station 1+60 to 2+50 and beyond.

Figure 5- Station 2+50 trench. No bedrock observed , material was primarily sand with gravels, cobbles, and boulders

Recommendations

Repair at the site must occur sooner than later since equipment access will be cutoff soon. Several options are viable:

Option 1 – Riprap bank revetment

A 500ft long riprap revetment will be installed to handle flood flows and mitigate lateral migration of the river into the road/trail prism. Road/Trail width will be brought back to pre-existing width (~14ft). A short section of bedrock is exposed along 100ft section of the road/trail. A 4ft high concrete toe wall will be constructed to stabilize and buttress the riprap toe to prevent sliding and revetment failure. The bedrock changes to alluvial bottom at about station 1+15. Along the alluvial section, the riprap toe will be embedded ~5ft below streambed elevation.

A separation geotextile will be used to prevent fine grained material loss behind the riprap. Figure 6 shows a schematic of the cross sections.

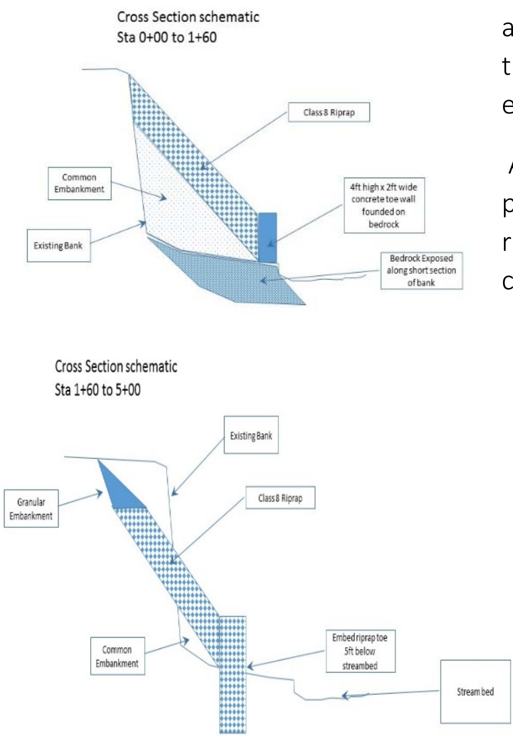

Figure 6 - Cross section schematics for riprap revetment along the eroding section of trail/roadway.

Option 2 – Bedrock bench and elevated trail structures.

This option would construct bridge type elevated structures on piling anchored into bedrock toe, and /or bench cut into the hill slope and anchored into the bedrock. At this point feasibility to span the entire section at risk is uncertain. Bedrock was not encountered to a depth of 9ft for about the last 300ft of the trail/road. Additional geotechnical investigation is required to determine feasibility of this option.

Option 3 – Trail relocation

Because of the material composition of the river banks, any sections adjacent to the river is subject to loss from lateral migration of the river. Along the trail at least 1000ft (or more) before the trouble spot, there were lower sloping valley walls with ample room to construct an ADA level trail / roadway to upper benches. Once on the upper bench or suitable hill slope is located, partial or full bench construction would utilized to construct ADA level trail/road that would have UTV access for administrative and rescue operations.

Option 4 – Modify trail difficulty level designation

A more difficult section of trail could be relocated to access the wilderness trails further up the Lincoln Woods trail. If longer ADA sections were desired then the east road could be improved and used for that trail purpose.

Each option will work, the problem is the long term outlook for the river. It is recommended that all potential erosion areas that can affect the trail within the next decade be identified. What should be avoided is putting band aids on small sections when the location of the trail and its proximity to the river is the principal problem. Some additional erosion relief may be gained by channel modification such as reopening old flood relief channel blocked by large wood and sediment from T.S. Irene. This may help relieve some of the flow depth during storms and the erosional forces on the banks.

Rocky Branch Road

Assessment

Rocky Branch road system sustained numerous road washouts and flanking of both abutments on the bridge crossing Rocky Branch. During T.S. Irene numerous slope failures occurred in the system providing a huge sediment supply to the river. During recent floods these sediment sources continual add more sediment to the system from undercutting the toe of the bank and then causing a block failure of the hill slope. The combination of large wood and excess sediment is aggrading the branch channel bed. The channel was filled almost to the top of the bank in a number of sections causing any elevated flow to go overbank and erode the roadway.

During the overbank flooding more erosion occurs adding more sediment to downstream reaches. Local recruitment of large wood occurs more frequently since the river can gain access to the banks and root systems easier than in normal conditions. All this produce a negative feedback of channel infilling and avulsing to a new channel position which will be the road since it is the waters path of least resistance. Figure 7 shows one section where the river avulsed on the flood plain and cut a 4ft deep channel thru the road prism.

Figure 7 - Road washout area. The channel bed is almost as high as the floodplain in this section. The channel has aggraded and the river goes overbank during lower than normal flood levels. The river cut down thru the road bed about 4.5 ft. in depth for several hundred feet.

Recommendations

There are two principal options for this area:

Option 1 – Reconstruct the road way and bridge

The roadway can be reconstructed but will still be subject erosion and damage during floods. If the road is reconstructed it should be relocated in places, have a levee system added along sections imminently at risk, and the bridge on Rocky branch (See Figure 8) should be raised to allow more hydraulic capacity.

Whenever the roadway can be placed against the hill slope and raised in elevation it will be safer. The river facing fill slope can also be protected with riprap for flood survival. This will be an expensive fix and the road will still be subject to damage during floods.

Option 2 – Decommission or store road. (Preferred option)

Remove the Rocky Branch and Otis Creek bridges. Remove all culvert drainage structures and construct dips. Place large wood on the floodplain and decommissioned roadway to discourage the road from becoming a primary flow path.

The bridge can be decommissioned and removed. The concrete deck and abutments will be unusable and can be broken up and used as bank protection, buried, or hauled offsite. The girders can be reused at another road crossing.

The roadway would only need to be opened minimally to get the bridge structures out. This would involve contouring the road surface and possibly additional road fill to make the site assessable to excavators, front end loaders, and/or CAT dozers. Large wood structures should be installed on the floodplain and at locations where Rocky Branch may avulse and run long distances down the old road bed. Wood should be gathered on the adjacent hill slope and some log jams material in the channel may be used. Trees that are firmly rooted in the floodplain should not be used or disturbed.

Any trail development along the road to access the trail system should have minimal investment. Perhaps trail markers to designate the route could be installed on trees.

Figure 8 - Rocky Branch Bridge near road approach. Both abutment approaches were washed out and the abutment structure sustained damage to the concrete backwalls.

Tripoli and Livermore Road

Assessment

The River that flows under the Livermore road and parallels the Triipoli road is currently aggrading it’s channel. This aggradation is from sediment waves moving downstream from T.S. Irene and the recent storm events.

The sediment has stalled at this location and is causing more frequent overbank events. Trees along the banks are eroding and at risk of falling into the river causing further aggradation upstream (See Figure 9). With diminished hydraulic capacity of the old channel, likelihood of avulsing across the paved road is high and will continue to increase in time.

Figure 9 - Location of potential avulsion. Note the trees undermining upstream and the very low relief of the top of the bank to the stream bed elevation. Red line indicates the avulsion flow path.

Recent signs of overtopping was observed at the location. The Bridge hydraulic capacity is most likely undersized compared to current standards. The road approaches on the river right side will avulse frequently since bank height is only a foot or so above the active floodplain.

It was reported that this section of road has been a chronic problem and is much more active since the floods in 2011 and 2017 occurred. (See Figure 10)

Figure 10 - Triple I and Livermore Road junction at the avulsion location. This view is downstream looking upstream at the junction. Raise the road grade to ~ the yellow line. Install the largest pipe arch or elliptical pipe possible under the Livermore road while maintaining 18" of cover on top of pipe or to manufactures recommendations. Construct a flood channel to the river from the outlet of the pipe.

Recommendations

The solution for a relatively long period of time is to raise the road grade at the junction of the Tripoli and Livermore roads. The road elevation should be increased to the maximum extent possible at this location. The increase will be on the order of about 3ft. The increased roadway elevation should extend beyond Tripoli road junction then change grades to tie into the original road elevation. A large pipe arch, elliptical, or box culvert can be installed to handle increased flood flow from more frequent overbank events.

A flood channel should be constructed from the new culvert outlet to the river channel. Trees in the path should be removed and a small flood channel constructed. At the inlet construct a small riprap apron to protect the pipe against scour.

In the area upstream of the culvert, place large wood trees with root fans attached. Weave the logs into the trees on the floodplain. This is to help ensure that the river has flood access to the new culvert but the avulsion path doesn't become the primary flow path. See Figure 11 for schematic layout out of proposed repairs

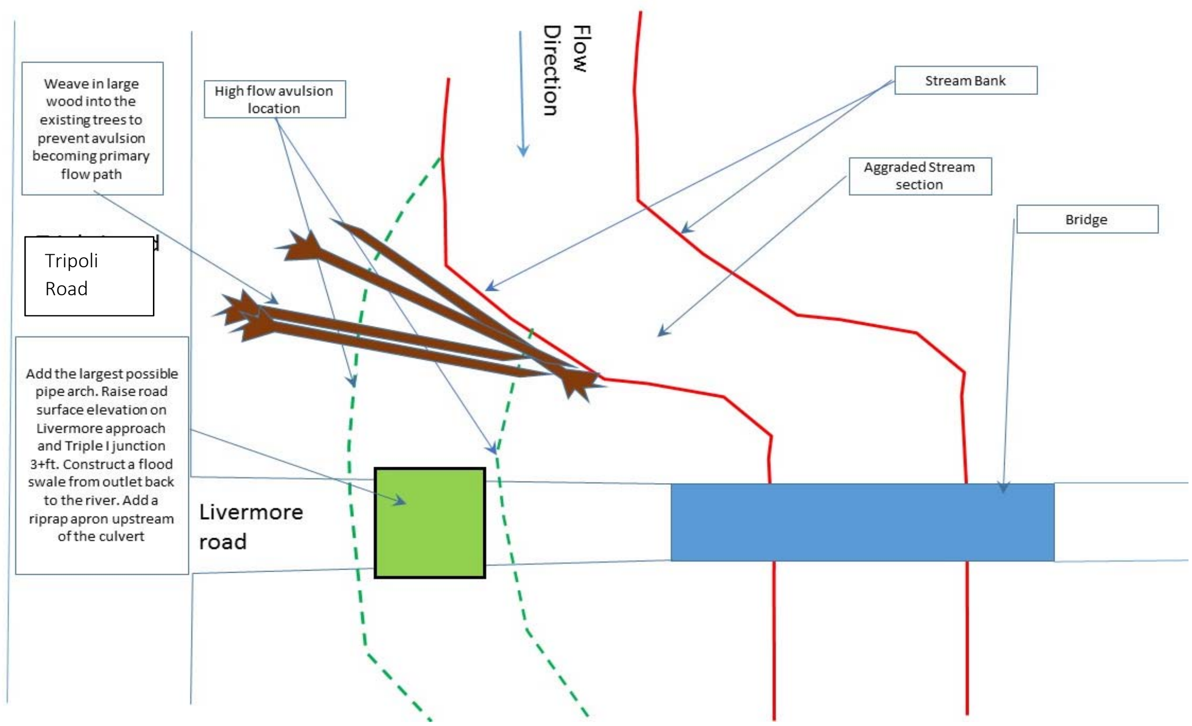

Figure 11 - Schematic plan view of conceptual proposed solution to overbank flooding the roadway at Triple I and Livermore road junction

Town Road (Tunnel Brook) Road

Assessment

A section of the upper Tunnel Brook road was decommissioned after T.S. Irene. The Brook in that section had aggraded, was jumping banks, and ran down the roadway at much smaller flood flows then usual. The confined valley and steep hill slopes made it difficult to re align that portion of the roadway. An alternative location was located to get back up on the hill side to gain access for timber acquisition. The new road is near completion. The Town road and the river aggradation continues to be a problem along the lower section of the Town (Tunnel Brook) road. We observed numerous areas where the flood water jumped the bank and came across the roadway. The Brook is very active in this section as sediment moves downstream. Numerous log jams were observed along this section of the Brook.

Figures 12, 13, and 14 show river sections that have aggraded up to the top of the river bank and large alluvial fan deposition zones in the section downstream from the decommissioned road and adjacent to the county road section.

Figure 12 - Panoramic view looking downstream on lower Tunnel Brook. Note no visible bank height exists. Possible 1 ft or so of relief at a maximum. This makes overbank flows common during lower than normal flood flows. Log jams are also visible in the photo.

Figure 13 - Sediment and log source area from mass wasting along Tunnel Brook caused by floods.

Figure 14 - Large alluvial fan has formed immediately upstream of the Town Bridge on Tunnel Brook. Sediment has built up 6 to 8ft in places and numerous cross valley log jams have formed helping to retain sediment on the alluvial fan.

Figure 15 shows the channel section between the large alluvial fan in Figure 14 and the Town Bridge.

Figure 15 - Channel section downstream of the large alluvial fan on Tunnel Brook. This section of channel is accumulating wood and aggrading sediment.

Recommendations

Access to Forest Roads – to maintain timber operations at Tunnel Brook, alternate routes that would tie into our existing road systems should be evaluated. During the brief site visit we explored a couple of routes which were both viable if private property owners would agree to allow a road to cross a small portion of their property. If access can be found further downstream, it would be even more beneficial.

The less Town road along Tunnel brook we don't need to rely on for haul the better. Any damage to the Town road will adversely affect our log haul. Hence if we minimize our utilization of the county road and get off the valley floor, the less risk to our timber haul.

The large alluvial fan growing and expanding downstream to the Tunnel Brook Town Bridge is a concern. On and upstream of the fan, log jam structures can be built that would catch trees moving downstream and help the channel to aggrade headward. This would help increase sediment storage time upstream and allow sediment getting to the bridge to be processed more readily. Figure 16 shows Lateral bar jams installed in Missouri used to recruit wood and store sediment upstream of sensitive habitat for Ozark hell bender. The same techniques can be employed on and upstream of the alluvial fan to store sediment.

Figure 16 - Left photo is a lateral bar jam constructed on the North Fork White River in Missouri to store sediment and recruit wood to control sedimentation from a campground. Left photo is the log jam structure pre-flood, the Right photo is post flood photo. Note the large accumulation of logs and sediment on and adjacent to the log jam. Accumulation was more than 3ft deep of sediment.

Log jams could be made from downed trees on the floodplain and from locations along the hill slope. Installation can be done by equipment rental for a reasonable price.

A typical configuration of the log structure would be similar to an apex jam (See Figure 17). Additional catching logs could be added so they stick out 5 or feet to recruit more wood flushing downstream.

Apex Log Jam Complex

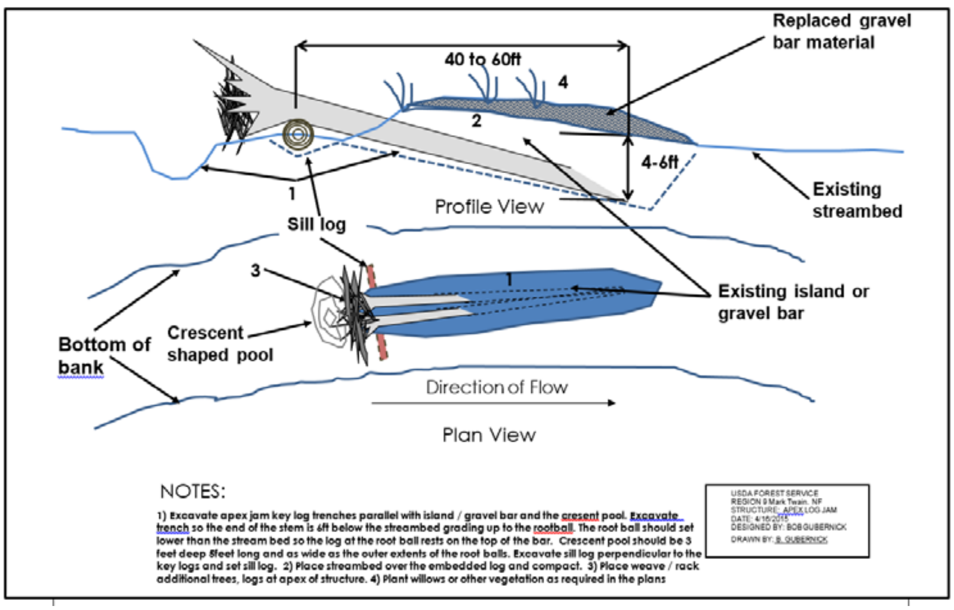

Figure 17 - Apex log jam complex. Additional logs can be added to catch more mobile wood moving thru the Tunnel Brook