To: Alex Weinhagen, Director of Planning & Zoning, Town of Hinesburg

From: Mike Kline, River Ecologist, Fluvial Matters, LLC

Date: November 23, 2020

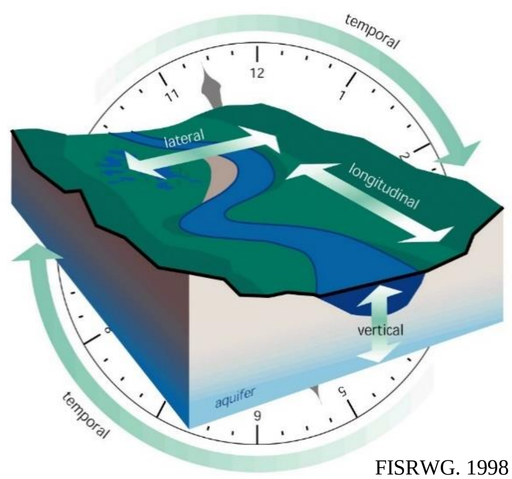
RE: Observations and recommendations for management of Patrick Brook and surrounding riparian area to promote the health and ecological function of the stream corridor.

Patrick Brook, from Route 116 to the LaPlatte River confluence (the lower reach), is evolving from a channelized condition to a more natural morphology and physical habitat condition, now that historic stream management practices on the lower reach have discontinued (LWP, 2007). The following short report will outline opportunities the Town of Hinesburg may have to promote natural stream processes and restored ecological functions in Patrick Brook. Attaining these conditions in the lower reach will, in part, be dependent on the health of upstream reaches to achieve near-natural inputs of water, sediment, and woody materials to the lower reach (VTANR, 2010[1]). Based on my field observations (11/20/2020) and previous studies, I will provide a description of channel evolution processes, and explain how achieving and maintaining natural connectivity in the stream, riparian area and floodplain, within the stream corridor, may achieve the highest ecological function in and along the lower reach.

Stream aquatic organisms require different types of cover for their survival, including slower-deeper currents, bank undercuts, vegetation, woody debris, and clean, sorted bed sediments (i.e., graded silts, sands, and gravels) for their resting, feeding, reproduction, and juvenile rearing (VTANR, 2008). The channel slope and depth, bed and bank sediment sizes, and riparian vegetation dictate the quality and quantity of cover types maintained in the stream corridor (Allen, 1995: Allouche, 2002). When a stream has historically been straightened, deepened, diverted, and starved of upstream sediments, as was the case on the lower Patrick Brook (LWP, 2007), the natural processes creating and maintaining cover habitats are significantly altered. If watershed inputs (i.e., flow and sediment regimes) are restored and the stream has room to move, it will evolve from its channelized condition, via the work performed during floods, to a connected, vertically stable, meandering stream morphology that maintains the cover types and ecological functions described above (Fitzgerald, 2007; Simon, A. and M. Rinaldi. 2006). In a village setting, a stream corridor filled with life is a tremendous scenic, aesthetic, and recreational asset.

Connectivity Analysis

I have examined components of Patrick Brook's stream and floodplain connectivity to describe existing and potential channel evolution and habitat forming processes. As defined by Vermont ANR[2], stream connectivity consists of longitudinal connectivity (i.e., the upstream and downstream movement of flows, sediment, debris, and organisms) and temporal connectivity (i.e., the quantity, timing, and duration of flows). Floodplain connectivity consists of lateral connectivity (i.e., open lands, side to side, within the stream corridor for meander development) and vertical connectivity (i.e., up and down access of annual flow events to groundwater and floodplain surfaces).



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[1] VT ANR assessment protocols referenced in this memorandum have extensive peer reviewed literature citations.
[2] See VT ANR Functioning Floodplains Initiative at https://dec.vermont.gov/rivers/ffi

Longitudinal Connectivity – watershed inputs to the lower reach and aquatic organism passage are altered by dams, diversions, and undersized crossings. Cross-channel structures causing high flow impoundments or backwater decrease the downstream movement of coarser sediments and debris. Disruptions to the sediment and wood regimes may have contributed to historic channel incision, which adversely impacts the development and replacement of cover habitat forms and substrates that are scoured away when a stream is starved and straightened. Longitudinal connectivity will improve as stream crossings are replaced with structures that match or exceed the bankfull width of the Brook. To restore the ecologic functions dependent on watershed inputs of sediment and debris in the lower reach, Hinesburg should consider seeking the removal of unused dam and diversion structures that still affect high flows.

Temporal Connectivity – The lower reach of Patrick Brook is affected by flow alterations that impact a range of ecologically important stream flows. Patrick Brook has 3 headwater reservoirs (Lake Iroquois, Sunset Lake and Cemetery Pond) and 2 diversion structures that have collectively reduced downstream flows. When a range of flows were historically diverted into the Patrick Brook Canal for industrial use, the quantity and quality of aquatic habitat in the lower reach was diminished. Any ongoing diversion of higher flows (i.e., those necessary to sort and distribute sediments and debris forming cover habitat), and drive channel evolution toward stream equilibrium[3], may still be impacting in the lower reach. Opportunities to further reduce temporal connectivity impacts and enhance ecological function include continued efforts to address untreated stormwater and the complete removal of one or both diversions to achieve a more natural frequency of high and low flows in the lower reach.

Lateral Connectivity – At present the lower straightened reach has the room within a protected corridor and is beginning the meandering processes that will maintain channel slope and riparian function. As the channel lengthens, different cover habitat will form in the new riffle, pool, bar, and undercut bank features of a sinuous channel. The lower reach has a narrow woody buffer, with some open breaks, comprised primarily of shrub species and a smattering of shade providing trees. The Town of Hinesburg has adopted protections for its stream corridors, which minimizes the placement of structures that would require bank armor and ongoing channelization to protect and maintain. Maintenance of an open, protected, and woody-vegetated stream corridor is the best way to ensure a lateral connectivity that promotes the formation of cover habitats in channel bed forms, bank undercuts, and tree canopy. A critical consideration is that when stream connectivity is improved and the lower reach begins to experience natural sediment inputs and flows, the rate of meander development will increase for a time and the Town and property owners should understand and accept that channel evolution means bank erosion and messiness. Establishing and maintaining a robust woody-vegetated buffer over the lateral extent of the stream corridor will moderate the rate of erosion over time and further add habitat value. Resisting channel management to arrest natural processes will ultimately achieve a least-erosive, equilibrium condition.

Vertical Connectivity – Lower Patrick Brook was observed during my assessment to be moderately to severely incised with some minor berming. The Brook does not have access to its floodplains, except during the very highest flood flows. When floods are concentrated and deepened within the channel, they have increased power to scour bed forms, coarser sediments, and debris that provide cover. Ecological function is lost when instream habitat becomes homogenized from the greater scour that occurs through the loss of vertical and lateral (floodplain) connectivity. Vertical connectivity will return as the lower reach continues to evolve, widening and depositing new sediment bars that develop into floodplain features.

[3] "equilibrium condition" means the width, depth, meander patter, and longitudinal slope of a stream channel that occurs when water flow, sediment, and woody debris are transported by the stream in such a manner that it generally maintains dimensions, pattern, and profile without unnaturally aggrading or degrading the channel bed elevation. 10 V.S.A. §1422(14)

Options for Promoting the Health and Ecological Function of the Lower Patrick Brook

Based on 30+ years of developing, designing, and implementing stream restoration plans and projects and the connectivity analysis above, I would suggest the following set of practices in the near and longer term. I am also providing estimates on the relative cost (i.e., low, medium, or high) for design and implementation. My recommendations are made acknowledging the lower Brook's existing and future village setting, however, they are based solely on a goal of promoting the health and ecological function of the Brook.

Near-term

1. Update lower Patrick Brook hydrology studies under different management scenarios to ensure new and replacement infrastructure and all the near and longer-term practices to restore ecological function are designed for future flow conditions in the Brook. It is beyond the scope of this assessment to ascertain the current and future impacts of the dams, stormwater and the historic canal diversions, but these hydrologic modifications have likely had profound effects on the morphology of the lower reach. If, over time, more natural flow and sediment regimes are actively or passively restored in the watershed, the town and permitting jurisdictions will want to know how the dimensions (width and depth) of the Brook will change in response. The most recent studies completed for the Town (Milone and MacBroom, Inc., 2010 and 2012a) identified some stormwater that was yet untreated and a "split" of flows between the Canal and the Brook. The flow volumes diverted into the canal have changed in the past 8 years, and may change even further[4]. Any design of practices within, over, under, or adjacent to the lower reach and its floodplain should be based on future hydrology and the resulting channel dimensions *(moderate engineering costs)*.
2. Where woody riparian vegetation is minimal or absent, consider removing berms and creating floodplain benches at the bankfull elevation (2-year recurrence interval flood elevation estimated at 2 feet below the current bank heights) in selected locations along the lower reach. In time, the Brook will evolve and create floodplain features on its own, however, jumpstarting this practice may have benefits. The town and adjacent landowners planning nearby developments may find these vegetated, inset features useful in further diffusing treated stormwater discharges (avoiding further gullying in the stream corridor) and create flood storage offsets for mitigating any planned floodplain fills[5] *(minor additional H&H modelling costs to guide restoration if updated hydraulic models described above in #1 are developed, moderate engineering / permitting costs, and moderate construction costs if completed in conjunction with other nearby construction activities).*
3. Add wood structures to the lower Patrick Brook channel to improve the hydraulic complexity that provides cover habitat, enhances organism movements, accelerates bar growth, and promotes meander development *(moderate H&H analysis and other engineering and permitting costs if updated hydraulic models are used; minimal construction costs if completed in conjunction with floodplain cuts and other nearby construction activities).*
4. Plant trees and shrubs in all open spaces within the width of the stream corridor (i.e., the Hinesburg FEH corridor) along the lower reach. This practice would follow practices 2 and 3 above, should they be considered and implemented. Consider extending this practice upstream of Rt 116 to ensure long-term temperature moderation and woody material inputs to the lower reach. *(minimal design and implementation costs, however, given the village setting, investment in a buffer design with aesthetic components may be desirable).*

[4] Structures that dam of divert streams usually, at some point, incur maintenance costs or they fail. If the benefits of completely removing the diversions were shown to exceed those costs, then funding could be obtained to remove them intentionally. In such a scenario, flows and channel morphology in the lower Brook would be further naturalized.

[5] If state jurisdiction is triggered under the State's Flood Hazard Area and River Corridor Rule and Protection Procedure.

5. Set up a long-term maintenance and protection program for the naturalized stream and its wooded corridor to ensure their establishment and ongoing ecological function, e.g., for the control of invasive plants. Assured access and management agreements may become important. The lower Patrick Brook will continue to evolve toward a natural, dynamic equilibrium condition. In a village setting, there will be a need for ongoing local involvement monitoring and protecting this process to the greatest extent possible, i.e., limiting new fixed encroachments within the stream and stream corridor that would require channelization practices to maintain. *(minimal to moderate legal costs and the assignment of buffer management responsibility, e.g., to the Hinesburg Conservation Commission).*
6. Design stormwater outlets with diffuse discharges into well vegetated areas of the stream corridor, to avoid gullying[6]. Other facilities that must enter the stream corridor (e.g., a recreational footpath), should be designed and managed under the assumption that siting and layout adjustments may be needed when the stream moves toward them within its meander belt width. While arresting lateral meander migration at or beyond the outer limit of the designed mender belt should have little effect on equilibrium conditions, keeping the channel in a straightened, steeper gradient to protect encroachments is likely to cause bed erosion and the loss of habitat.

Longer Term

7. Remove or restructure one or both of the historic industrial flow diversions on the Patrick Brook and its tributary. Getting all high flows, that may still enter the canal, back into the stream channel would address the temporal and longitudinal disconnection of water and sediment flows, and may be central to restoring the health and ecological function of the lower reach *(moderate to high engineering design, permitting, and construction costs depending on whether the defunct canal is partially filled or retrofitted for other stormwater uses)*
8. Ensure that new and replacement crossings over the lower reach are designed and constructed to meet state standards and minimize any backwater conditions that would disrupt sediment and debris transport. It is beyond the scope of this study to suggest the opening dimensions of new or replacement crossings, but I am concerned that the recommended 14'x8' box culvert (Milone and MacBroom, 2012b) may not be adequate under the current and future hydrologic conditions of the lower reach (see recommendation #1 above). Previous stream geomorphic assessments (LWP, 2006) measured the Canal bankfull width at 21 feet and the lower reach bankfull width at 10 feet[7]. This would imply that to pass the combined bankfull flows from the entire watershed (i.e., drainage area greater than 7 square miles) would require a bankfull span larger than 14 feet. The structure currently used to cross over the Patrick Brook Canal on Rt. 116 is a 16-foot bridge.

Recommended practices described above that restore and protect connectivity, stream equilibrium conditions, and floodplain functions (including phosphorus load reductions) would very likely be eligible and competitive for grants from the state ecosystem restoration (water quality) funds and Lake Champlain Basin Program (EPA) funds. USFWS Partners for Fish and Wildlife and VT Department of Fish and Wildlife programs also have funding and technical assistance to implement habitat restoration projects.

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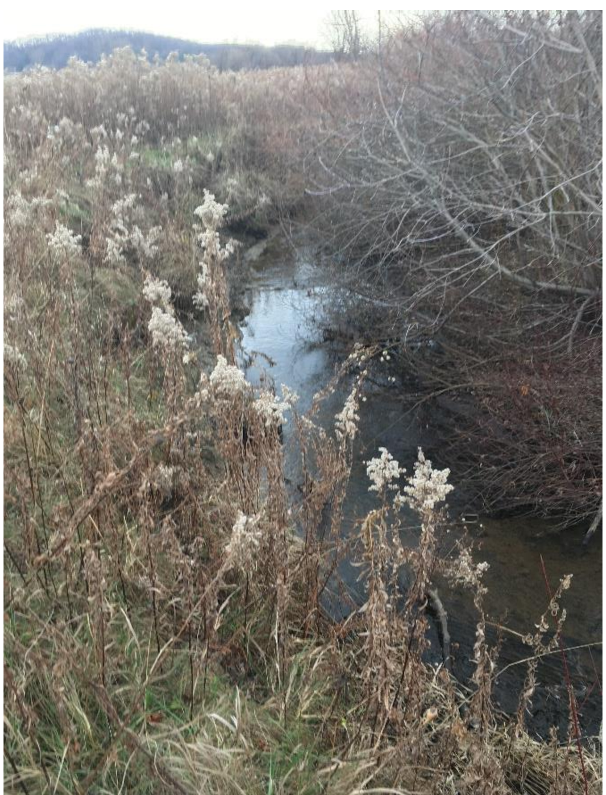
[6] I am not a stormwater engineer. My recommendation to Hinesburg is to require developers to design outfalls that minimize concentrated runoff (and resulting gullies and headcuts) and limit hardened, fixed structures to the outer margin of designed stream meander belt width and buffer.

[7] I measured a bankfull width on 11/20/2020 in the lower reach to be 12-13 feet at several locations just downstream of Rt. 116 and observed bank sloughing that indicates that a channel widening process may be underway. At the first downstream snowmobile bridge (upstream of Riggs Brook), a small floodplain feature has developed and bankfull width was measured at 21 feet.

Selected Pictures from 11-20-2020 Field Assessment of Lower Patrick Brook

Re-meandering section in the lower reach. This will be a slow process given the clayey banks and alter flow regimes.

Representative bank sloughing observed along the lower reach. Very little woody buffer vegetation in this section.



Lower reach is moderately to severely incised, and has interspersed stands of woody shrubs and grasses.

Patrick Brook Canal at a section with only stagnant water from local runoff or remnants of flood waters entering at diversion structure (no flowage when picture was taken). Sediments accumulating in the canal would otherwise have enter the lower reach and contributed to the beneficial re-meandering and channel evolution currently underway.

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