MELVIN RIVER ASSESSMENT | REPORT

TO: Pat Tarpey and Bree Rossiter, Lake Winnipesaukee Association
FROM: Sarah Large, FB Environmental Associates (FBE)
SUBJECT: Melvin River Assessment
DATE: January 19, 2024; revised March 15, 2024
CC: Forrest Bell and Maggie Mills, FB Environmental Associates (FBE), James Woidt, Streamworks PPLC

I. INTRODUCTION & PROJECT BACKGROUND

FB Environmental (FBE) in partnership with Streamworks PLLC (Streamworks) completed assessments in response to the Lake Winnipesaukee Association's (LWA) request for a Habitat Suitability Assessment and Geomorphic Study of the Melvin River. The goal of the project was to investigate the condition and influences on the river that ultimately contribute to Moultonborough Bay's ecological health and to protect the Melvin River, its ecological characteristics and values, and geomorphic condition. The assessments were completed to provide a roadmap of next steps to restore the Melvin River and encourage conservation of its valuable riparian and forested habitat.

This project builds off previous studies and work completed by FBE and LWA. In 2020, FBE and LWA completed a Watershed Management Plan for Moultonborough Bay and Winter Harbor. This is part of a larger effort to complete planning documents across all of Lake Winnipesaukee's subwatersheds to provide a roadmap for individuals and communities to preserve ecosystem health and to "Keep Winni Blue" (find the full plans on the Lake Winnipesaukee Association's website, here). The Moultonborough Bay subwatershed includes six major embayments, one of which is Melvin Bay fed by the Melvin River. The direct drainage to Melvin Bay was identified as a priority subwatershed due to model results showing elevated total phosphorus load per unit area. Even though the larger Melvin River watershed had a low modeled total phosphorus load per area, residents have expressed concerns with elevated turbidity, detected visually, during and after storm events in the Melvin River. A small section of the Melvin River and its riparian landscape are designated as Highest Ranked Habitat in NH through the New Hampshire Wildlife Action Plan. Between County Road and Sodom Road, the river and its wetland habitat is all designated as Supporting Landscape, with a small portion included as Highest Ranked Habitat in the Region. Additionally, a segment of the Melvin River upstream of Sodom Road sustains a Wild Eastern Brook Trout *(Salvelinus fontinalis)* population. Records indicate good habitat and a large amount of both young and adult Eastern Brook Trout present. In addition to the populations of Brook Trout, the Melvin River is home to the annual "Salmon Sunday" where eggs and milt are harvested from landlocked salmon attempting to pass the Pope dam. The success of this event emphasizes the need to fully characterize native fish assemblages on the Melvin River for future habitat restoration prioritization. Furthermore, wild Eastern Brook Trout are a Species of Special Concern and are only found in flowing riverine habitats with high dissolved oxygen and cool water temperatures. Due to pollutant loading concerns in Melvin Bay, notable turbidity during storm events, as well as the intrinsic ecological value of the river and its landscape, this assessment was prioritized and completed in the summer of 2023.

The focus area of this study, designated as the 'study reach', includes the section of Melvin River beginning at the river's confluence with Moultonborough Bay extending upstream to Sodom Road. There are five (5) road-stream crossings, two (2) snowmobile trail-stream crossings, one (1) private trail-stream crossing, one (1) active dam, and two (2) locations of dam ruins in the study reach (Figure 1). The road-stream crossings are located along the Melvin River, from downstream to upstream, at its crossing with Route 109 in Melvin Village, High Street, County Road, New Road, and Sodom Road. The river is also crossed by two snowmobile recreational trails' bridges, one within the powerline corridor downstream of the New Road crossing and another immediately upstream. The Pope Dam, also known as the Melvin River Dam (D239001), is located upstream of the Route 109 crossing. Documented dam ruins (D239002) are noted in the state's database and located near the High Street crossing. Additional dam ruins were located near the Sodom Road crossing and a private residential bridge crossing south of the Sodom Road crossing.

This memorandum summarizes findings from assessment work along the study reach completed during July and September 2023. Three assessments were completed: FBE completed a rapid habitat assessment, Streamworks completed a rapid geomorphic assessment, and the New Hampshire Fish and Game Department (NHF&G) completed a native fish survey. In addition, NHF&G completed updated stream crossing assessments for the crossings along the study reach. This report also outlines recommendations, project ideas, and restoration actions based on the assessment findings.

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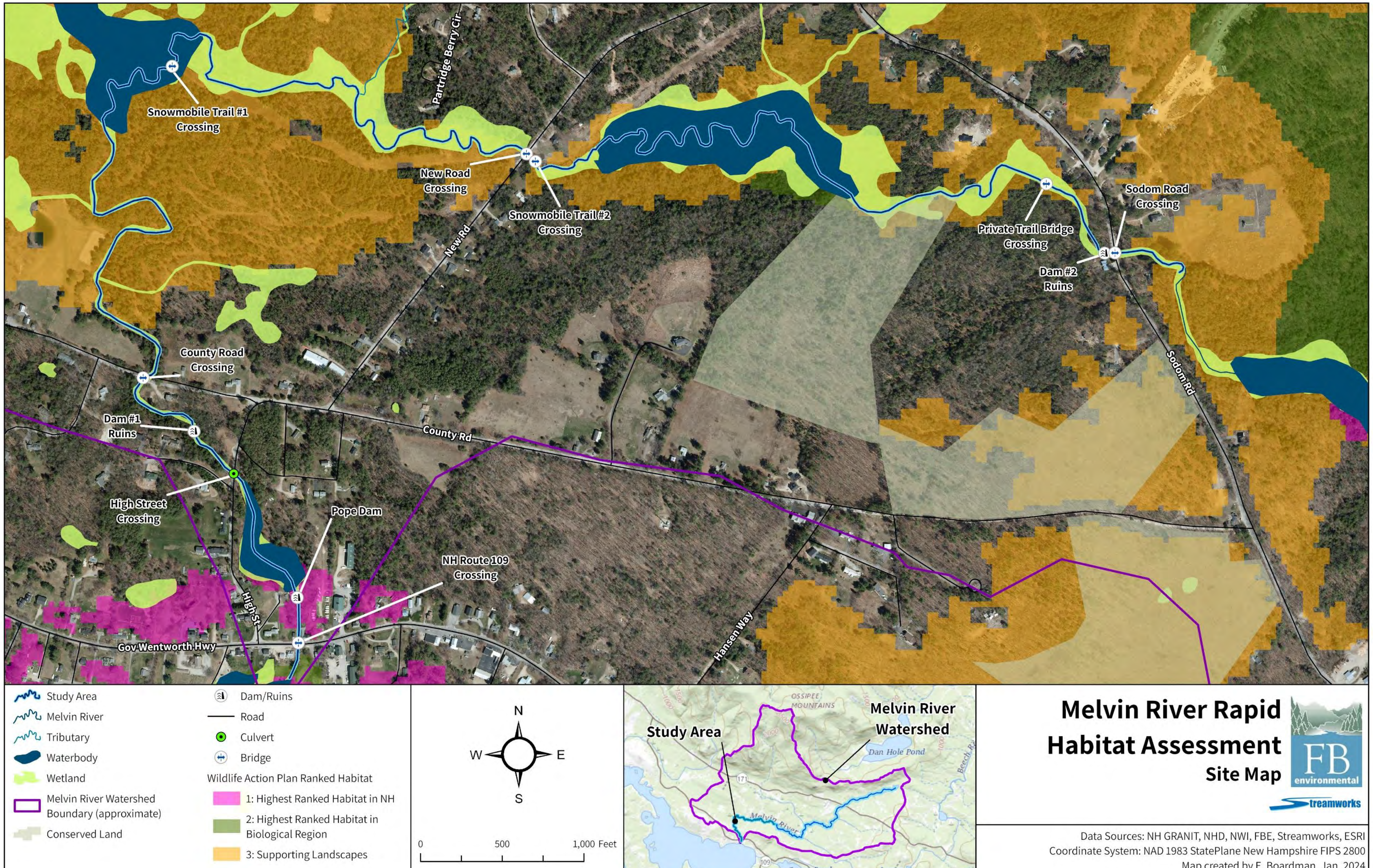

Figure 1. Site map of the habitat assessment study reach and Melvin River subwatershed located in Tuftonboro, NH.

II. MELVIN RIVER CHARACTERIZATION

METHODOLOGY

FBE and Streamworks conducted a joint rapid habitat and geomorphic assessment to identify and document the ecological condition of the Melvin River. The team broke the study area into sub-reaches based on geomorphic form and further categorized each sub-reach by stream type (riffle-pool, step-pool, plan bed, or braided). Six sub reaches were delineated within the study area, beginning at Melvin Village extending upstream to the Sodom Road crossing (Figure 1).

FBE's rapid habitat assessment methods of evaluation focused on identifying stream processes that influence habitat suitability for aquatic organisms to adequately carry out life cycle functions, in-stream and edge habitat suitability for aquatic and terrestrial wildlife, the overall stability and composition of the river and its adjacent riparian buffer, and the degree of anthropogenic impacts and modifications present. The assessment methods were selected to uncover potential stressors and issues directly within the watercourse that are affecting the overall health and ecosystem of the Melvin River watershed and Melvin Bay.

FBE's rapid habitat assessment consisted of identifying, describing, ranking, and quantifying the following criteria:

- the severity of erosion and bank scour,
- streambed substrate and composition,
- the presence/absence of in-stream aquatic organism habitat and refuge such as pools, bank undercutting, and the amount of woody material,
- vegetative riparian buffer composition and extent,
- canopy cover shading the stream,
- connectivity within the watercourse and through the reaches, as well as connectivity to the river's floodplain, and
- the degree of development along or within the watercourse.

These evaluation criteria were derived and adapted from river and stream assessment protocols such as the Vermont Agency of Natural Resources (VT ANR) Reach Habitat Assessment (RHA)[1] and the NH Stream Crossing Initiative's Stream Crossing Assessment Field Manual[2], among other resources, to target the goals of evaluating stream and habitat condition. Vermont's RHA method includes parameters, like the evaluation criteria bulleted above, that involve qualitative and quantitative measures. FBE utilized a similar approach of descriptive documentation supplemented by qualitative measurements, to determine a condition or rank for the habitat assessment criteria. More specifically, data was collected and characterized in the following ways.

FBE the severity of erosion and bank scour for each reach on a low, moderate, high/severe scale and noted potential causes. Locations where reference or natural levels of bank scour created by natural stream processes occurred were described and factored into low and moderate ratings. The locations of notable bank scour and areas of erosion concern were geolocated using a handheld GPS. Dominant streambed substrate was determined through visual characterization, whereas streambed composition was computed by conducting a pebble count utilizing a modified Wolman Pebble Count methodology.[3] Pebble counts occurred in the same location that bankfull width measurements were collected, and typically at a riffle. Locations of aquatic organism habitat, refuge, and woody material were geolocated using a handheld GPS to document abundance of in-stream habitat. FBE visually evaluated canopy cover by assigning an average or range of percent cover providing shade over the stream. Each reach's vegetative buffer was qualitatively described, capturing general plant composition and presence/absence of invasive plant species visible from the stream channel and categorized as being in reference - entirely natural, good - mostly intact, fair – partially degraded/fragmented, or poor - highly degraded/fragmented condition. Aerial imagery was evaluated to determine riparian extent and contiguity. Watercourse connectivity was evaluated based on the presence of barriers between reaches as well as the river's connectivity to its floodplain and qualitatively described. FBE also categorized the overall degree of development surrounding each sub-reach ranging from low, moderate, to highly developed based on observed land use in the field and examination through aerial imagery.

[1] The Vermont Agency of Natural Resources Reach Habitat Assessment (RHA). Online document link: https://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_RHAProtocolReport.pdf

[2] NH Stream Crossing Assessment Initiative Field Manual. Online document link: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/lrm-culvert-assessment-protocol.pdf

[3] The Wolman Pebble Count methodology was modified by grouping sediment size into fewer bins: silt and sand (< 0.007'), gravel (0.007'-0.21'), cobble (0.22'-0.83'), boulder (0.83'-13.3'), and bedrock (>13.3'). https://andrewsforest.oregonstate.edu/sites/default/files/lter/data/studies/gs002/Wolman_Pebble_Count.pdf

**Not included in FBE's assessment is biological monitoring such as electro-fish assessments, characterization of native fish assemblages, and a final determination of the overall biological integrity. This work and associated methods were conducted by NHF&G and results are available in the section "Native Fish Survey Results". **

Streamworks' rapid geomorphic assessment methods for evaluating the study area aimed to characterize the existing geomorphic conditions of the Melvin River, assess the dominant channel processes within each sub reach, and identify potential causes of impairment to evaluate and recommend actions and projects to improve geomorphic function, habitat, and water quality. The geomorphic survey consisted of measuring, characterizing, evaluating, and qualitatively documenting the following:

- bankfull width, depths, and the height of the floodplain terrace,
- dominant substrate,
- the general condition of the reach, notable impairments, and potential causes of impairment,
- adjacent properties' vulnerability to stream instability,
- opportunities to improve habitat and/or geomorphic function that address and reduce sediment and nutrient loading,
- dominant channel adjustment processes, geomorphic condition, and sensitivity to disturbance

The geomorphic assessment was derived from and utilized the Rapid Geomorphic Assessment Form per Phase II of the *Vermont Stream Geomorphic Assessment* which focuses on the relationships between landscape controls, stream morphology, and habitat.[4] Based on the sub reaches' stream type (riffle-pool, step-pool, plan bed, or braided), the appropriate Rapid Geomorphic Assessment data form was utilized to document and score the sub reach. Each data form includes scoring matrices assessing the overall condition of the stream reach with regard to geomorphic adjustment processes such as incision, aggradation, channel widening, and planform change. Visual observations, watershed conditions, and limited quantitative measurements contribute to assigning scores for categories under each adjustment process. Reviewers determine the stream's general condition based on these scores, with flexibility to assign numeric scores within each category. The forms also feature a section where the reviewer can note when current field conditions are likely the result of historical adjustment processes that are no longer ongoing. The numeric scores for each category are then summed and divided by a "perfect score" of 80 which results in a final numerical condition score that correlates to a descriptive condition rating of reference, good, fair, or poor for the reach. Additional details about Streamworks' methods, field findings, and completed data forms are provided in their Rapid Geomorphic Assessment Report enclosed in Appendix B.

FBE and Streamworks completed the rapid habitat and geomorphic assessments over the course of two field days. One consisted of wading through reaches where water levels were low enough to walk in the river (Reaches 1 and 5) and the other day by kayaking the reaches with deep and impounded water (Reaches 2a, 2b, 3, and 4). The survey area and sub reaches were also photo documented.

RAPID HABITAT ASSESSMENT RESULTS

The Melvin River and its associated riparian habitat is a diverse riverine system. The study reach, overall, is in good ecological condition. The study reach contains suitable aquatic organism habitat, mostly stable stream banks, minimal areas of erosion concern directly adjacent to the river, large areas of intact and connected vegetated riparian buffers, and limited areas of noticeable nutrient inputs. There is a higher degree of development and influence on the Melvin River lower in the study reach (near Melvin Village up through County Road) compared to the unfragmented, natural, and vast emergent and scrub-shrub wetland complex bordering the river up and downstream of the New Road crossing and forested landscape along Reach 4 and 5. The primary influences that directly impact the river are the culverts, bridges, dam, and dam ruins constructed along the reach that constrict channel width, flow, aquatic organism passage, and are sources/sites of sediment and nutrient inputs. In a select few locations, some residential properties have thin to no buffer where lawns or fields abutted the river and piles of lawn clippings and brush were observed falling into the river. Lawn clippings, a source of nutrients, can be detrimental to the river and are recognized contributors to excess nutrient levels.A few properties have harvested trees adjacent to and immediately along the edge of the river.

Although the Melvin River might be the largest "input" to Moultonborough Bay (i.e., largest river entering the Bay with a large drainage area) based on FBE and Streamworks' assessments, the Melvin River watershed is well buffered and forested with limited sources of nutrients observed during the field surveys. Shoreline development in the direct drainage along Melvin Bay is likely to be more influential to water quality and nutrient delivery to the big lake than input than the Melvin River. This is in line with the 2020 Lake Loading Response Model that identified the direct drainage to Melvin Bay as having high total phosphorus load, but the larger Melvin River watershed having a low total phosphorus load per area.

[4] Vermont Agency of Natural Resources. 2007. Vermont Stream Geomorphic Assessment. Online documentation available here: https://dec.vermont.gov/watershed/rivers/river-corridor-and-floodplain-protection/geomorphic-assessment

The following characterization section describes key observations from the rapid habitat assessment for each reach. A summary map showing reach locations and key observations is available on page 8 (Figure 2), following the text descriptions. Full assessment information for each reach is available in Appendix A, Table A1.

Reach 1

Reach 1 extends from the NH Route 109 crossing near Melvin Bay upstream just past the County Road crossing. Overall, Reach 1 is the most impacted and modified section of the watercourse. Aquatic organism and terrestrial habitat are the lowest quality in this reach due to a higher degree of development and disturbance. In-stream aquatic organism passage is reduced and in poor quality beginning at the Dam #1 Ruins encountered upstream of the High Street crossing and continues downstream due to several barriers including the dam ruins, the undersized and perched High Street culvert, the Pope Dam, and the stream channel straightening downstream of the dam leading to the Bay. In-stream passage improves in quality upstream of the Dam #1 Ruins. A riverine buffer providing shade to the river exists but is fragmented and thin in areas due to a higher concentration of residential homes and buildings in Melvin Village.

This reach also has the highest degree of bank erosion and the greatest number of banks stabilized and armored by riprap, stone walls, and concrete retaining walls. One area of concern is the river right bank (river banks are determined using the direction of flow, so the river right bank is the right bank looking downstream) immediately downstream of the County Road bridge crossing. There is significant bank scour and erosion along this very steep riverbank. The forest is predominantly eastern hemlock trees that have shallow root systems and are threatened by the invasive insect, hemlock woolly adelgid *(Adelges tsugae)*. Many of the trees have already fallen, destabilizing the bank, which is anticipated to be made worse by the adelgids killing more trees. The Melvin River takes a sharp turn at this location and the primary flow of the river is directed at the toe of the slope, likely leading to, and perpetuating the issue.

Reach 2a and 2b

Reach 2a continues upstream from Reach 1 to a point just past a property with an open field abutting the stream. Reach 2b meanders upstream to a point where the buffer transitions from forest to open emergent and scrub-shrub marsh. Reach 2a and 2b contain many areas of in-stream aquatic organism habitat such as natural bank undercutting, large coarse woody material interspersed throughout the channel, log jams, pools, and sandy substrate suitable for fish spawning. There are minimal to no in-stream barriers affecting passage. The vegetated buffer immediately along the river is mostly intact, providing shade to the stream, except for one location, where there is limited or no buffer at the edge of a large field abutting the reach. There is a low to moderate level of development throughout these reach segments; only a few homes are located along the reaches, however land use associated with the few properties (lawns, large field, and logging to the east) have partially fragmented the riparian corridor. FBE noted a high potential for erosion and sediment inputs to the stream as well as nutrients throughout this reach associated with the surrounding land use and development. One location of notable bank scour and destabilization was documented within this reach (see Figure 2).

Reach 3

Reach three is located in the middle of the Study Area and is very unique and diverse. This segment of the Melvin River flows through a very large emergent and scrub-shrub wetland complex bordered by blocks of unfragmented forest, that protects and provides excellent stabilization to the stream's channel and banks, flood flow storage, sediment and nutrient attenuation/absorption, as well as habitat for a diverse array of aquatic and terrestrial plants and animals. The wetland and forest provide a robust riparian corridor and intact vegetated buffer. Another distinctive characteristic of this reach is the stream channel's exposure to sunlight due to a lack of forest canopy along the watercourse, which often is an indication of warm water habitat. (However, this might not be the case for this reach as noted by NHF&G and summarized in the section "Native Fish Survey Results"). Although natural, this is a shift from the reaches up and downstream of it. This reach contains many areas of in-stream aquatic organism habitat which includes large coarse woody material, log jams, pools, small tributaries and channels interspersed throughout the wetland, and many beaver dams (Figure 2). Overall, there is minimal bank erosion and low development pressure within this reach.

The most notable influences within this reach include the electrical utility corridor which undergoes regular maintenance including vegetation removal and is used for recreation in the winter and three stream crossings, two of which are snowmobile trail crossings. In addition, FBE noted trees cleared adjacent to the wetland buffer's edge and a sizeable area of soil left exposed/un-stabilized near the residential developments along Lyndsay Lane and Partridge Berry Circle.

Reach 4

Reach 4 extends east from the prior reach up to a Private Trail crossing. The reach contains a variety of suitable aquatic organism and wildlife habitat. There are pools and undercut banks for refuge and a broad intact forested riparian buffer providing shade over the stream. Large boulders, likely dislodged from the forested landscape, along with sizeable trees and accumulations of woody material, create diverse and abundant habitat for aquatic organisms. The reach is predominately undeveloped with only a few notable anthropogenic features encountered including a wooden tent platform and a private trail bridge crossing spanning the stream banks assumed to be built by a landowner along Sodom Road, and their mowed lawn immediately abutting the river's edge. Limited to no signs of erosion were observed.

Reach 5

Reach 5 extends from the Private Trail crossing up through the Sodom Road crossing. Similar to the upper segments of Reach 1 and 2a, there are a few residential properties in the immediate vicinity of Reach 5, and large stone ruins that appeared to be associated with an old dam armored the streambanks. Overall, development surrounding this reach was low to moderate in comparison to the lower section of Reach 1 in Melvin Village. The vegetated buffer was mostly intact, except for a few locations where it has been thinned by a nearby property owner next to the Sodom Road crossing and the open field upstream of Sodom Road. The surrounding landscape is mostly unfragmented, providing great terrestrial habitat and buffer to the stream. This reach contains several areas of in-stream aquatic organism habitat including large coarse woody material, log jams, pools, and undercut banks for refuge.

The streambed is particularly unique within this reach; the mixed substrate abruptly changes to bedrock and the stream channel bifurcates approximately 200 feet downstream of the Sodom Road bridge crossing. The river cascades/waterfalls over the bedrock before returning to a mellow gradient. The bedrock feature acts as a barrier to aquatic organism passage; however, strong swimmers or organisms capable of walking on land may still be able to pass. Remnant stonewalls and stone features associated with a dam (Dam Ruins #2), as well as the heavily armored upstream river right bank, suggests that the Melvin River's stream channel was redirected, and its flow pattern altered to where it is presently located. FBE also noted sediment and nutrient input concerns within this reach particularly at the Sodom Road bridge crossing. Due to the steep gradient of Sodom Road leading to the crossing, stormwater rushes down the roadway carrying sediment from the road shoulder and directly discharges into the river.

RAPID GEOMORPHIC ASSESSMENT RESULTS

The rapid geomorphic assessment results indicate that all assessed reaches meet the category of "good" or "reference" geomorphic condition, as defined by the *Vermont Stream Geomorphic Assessment* methodology. The overall good and reference scores are related to the relatively low degree of development in the watershed, except in the vicinity of Reach 1, somewhat limited anthropogenic impacts to Melvin River and its floodplain, and the relationship between these factors and the stream types present. Half of the stream reaches are plane bed systems, and the other half are riffle-pool stream types. A plane bed stream type refers to a river or stream channel where the riverbed exhibits a relatively flat and uniform configuration, lacking distinct features such as riffles, pools, or other complexity. Riffle-pool stream type refers to a river or stream characterized by alternating sections of riffles (shallow, fast-flowing areas with turbulent water) and pools (deeper, slower-moving areas with calmer water). This alternating pattern is a distinctive feature of stream morphology, influencing the ecological and hydrodynamic characteristics of the watercourse. Reaches that are characteristic of plane bed stream types have a lower sensitivity to geomorphic change, whereas riffle-pool stream types experience geomorphic shifts more regularly through natural stream processes heightening the importance of connectivity to the river's floodplain adjacent to these stream types. This means the plane bed systems (Reach 1, 2b, and 5) exhibit greater resilient and resistance to disturbance while the geomorphically dynamic riffle-pool segments (Reaches 2a, 3, and 4) support in-stream aquatic habitat and sediment and nutrient storage, but are more susceptible to impacts when disturbed, which tends to lead to the release of sediment and nutrients downstream. The riffle-pool reaches fortunately were buffered by wide intact riparian buffers and wetland complexes, which stabilize and protect the stream reaches from disturbance as well as provide many wildlife and water quality benefits. Additional findings from the geomorphic rapid assessment are summarized in Figure 3.

With that said, there were indications of on-going instabilities and degradation along the study reach. There were signs and traits that indicate the river has historically been manipulated through re-alignment and impoundment as a result of past dams, bridges, and/or culvert installations which impact the river's overall geomorphic condition. Even within reaches where development was higher (Reach 1) and degradation was noted, these reaches still met the Vermont Agency of Natural Resources' definition for "good" geomorphic condition likely due to the lower sensitivity to geomorphic change.

For additional information on the rapid geomorphic assessment results, please review and reference Streamworks' report in Appendix B.

Table 1. A summary of the stream type and geomorphic condition score by reach.

Reach Segment	Description of Reach	Stream Type	Geomorphic Condition
Reach 1	Melvin Village up to County Road crossing	Plane-bed	Good
Reach 2a	Upstream of County Road crossing	Riffle-pool	Good
Reach 2b	Upstream of County Road crossing	Plane-bed	Reference
Reach 3	Upstream and downstream of New Road	Riffle-pool	Good
Reach 4	Downstream of the Private Trail crossing	Riffle-pool	Reference
Reach 5	Up and downstream of the Sodom Road crossing	Plane-bed or Step-pool	Good

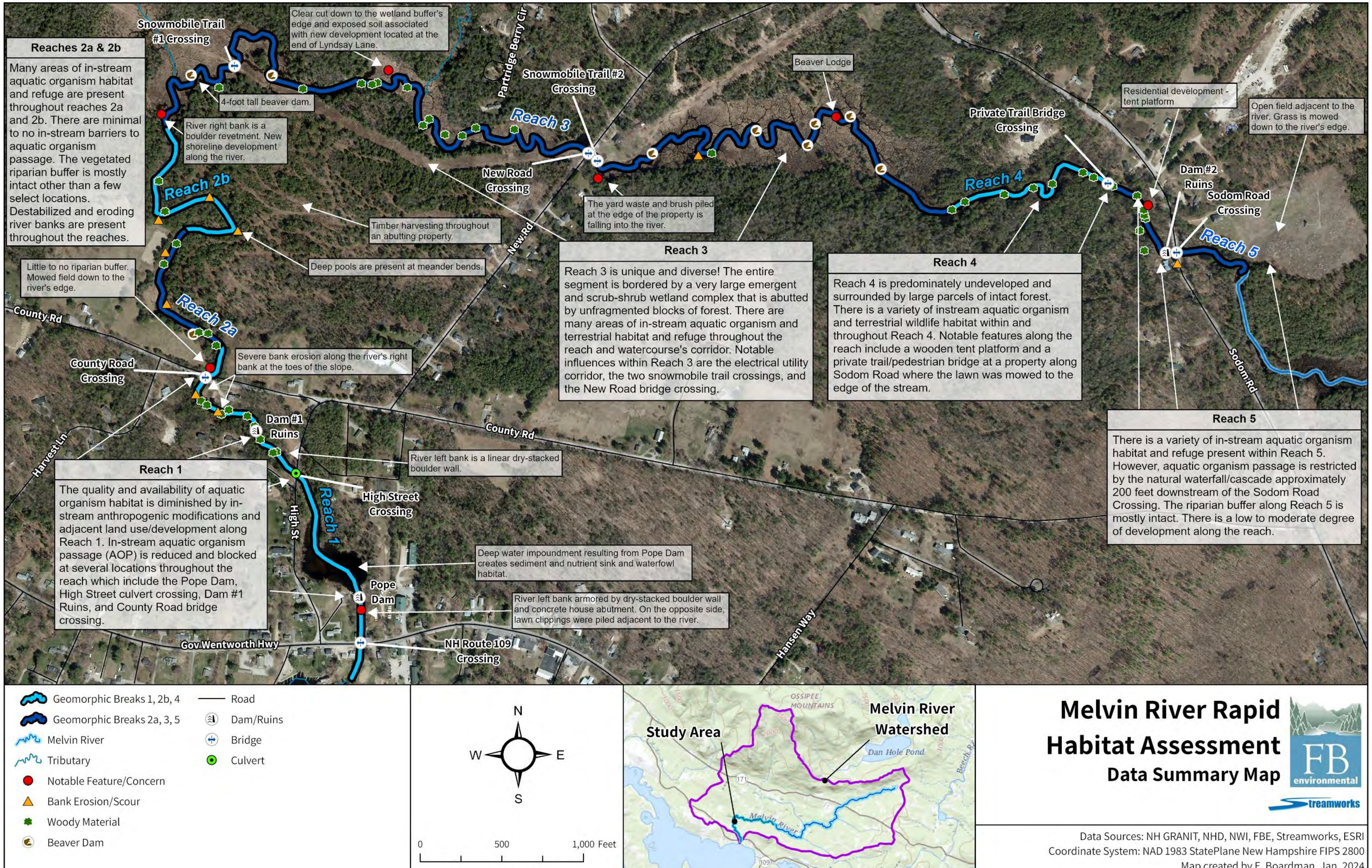

Figure 2. FBE's habitat assessment field findings and data summary map.

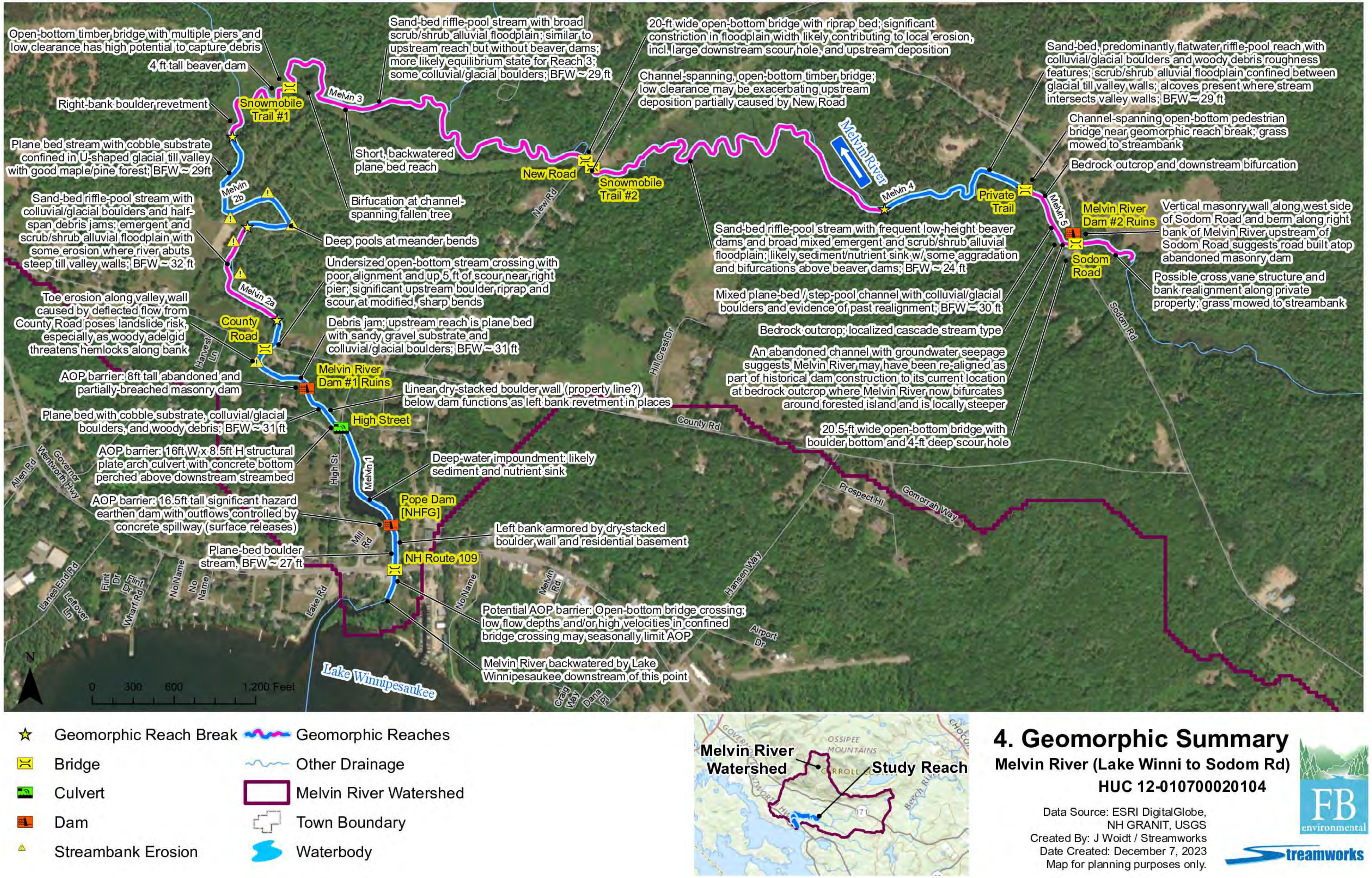

Figure 3. Streamworks' geomorphic assessment field findings and data summary map.

III. KEY FINDINGS & RECOMMENDATIONS

RAPID HABITAT & GEOMORPHIC ASSESSMENTS

FBE and Streamworks have identified the following recommendations, project opportunities, and actions for in-stream and riparian improvements watershed-wide and by reach to address the project's goal to restore and protect the Melvin River, its ecological characteristics and values and geomorphic condition, as well as improve water quality of Moultonborough Bay.

Watershed-Wide Opportunities – Development along the river, wetlands, and its tributaries is likely the biggest threat to the river's ecological health. Therefore, education and preventative actions to limit and guide development within the Melvin River watershed are highly recommended. Currently, development along this stretch of the river is relatively low, other than the sections closest to Melvin Village and the Bay, which has positive implications for the Melvin River, however high development pressure within the watershed is to be expected. Based on FBE's Moultonborough Bay – Winter Harbor build-out analysis, which included the Melvin River subwatershed, build-out results, based on zoning in the Town of Tuftonboro (as of 2020), indicated that approximately 1,522 new buildings could be built within the Melvin River watershed. As of 2020, the build-out analysis identified approximately 260 existing buildings within the Melvin River watershed. The full build-out would represent a 485% increase in development within the Melvin River's watershed!

Outreach and engagement to the community, in particular homeowners living in and developers working within the watershed, on the benefits of vegetated riparian buffer and unfragmented land, best management practices to reduce the impacts of yard waste (lawn clippings, tree trimmings, brush, etc.) placed near the river has on water quality, septic system maintenance, repair, and replacement, and development practices such as tree clearing and residential build outs will aid in improving the overall health and stability of the river and watershed. Other considerations include adopting additional municipal rules, ordinances, and/or zoning to further protect the river and watershed. This could include extending the protections of the state-level Shoreland Water Quality Protection Act to the Melvin River through local rule making or by assessing and classifying the river as a state designated river, and/or designating the wetlands associated with the Melvin River as prime wetlands and implementing a buffer through the NH Department of Environmental Services. Other zoning and ordinance development requirements and restrictions for consideration include the following: (1) Requiring key natural resource areas and areas vulnerable to flood hazards and climate impacts to be removed from the total land area available for development. (2) For proposed subdivisions, the town could require open space to be the first consideration in the design, with priority given to conservation of important natural resources; habitat; connectivity of conserved lands; and future flooding. (3) Encourage or require green building performance elements, including incorporation of on-site retention, detention, and low impact development (LID) measures for the treatment of stormwater runoff. (4) Encourage or require on-site and off-site stormwater drainage sizes to accommodate the effects of climate change impacts, including flooding, and increased frequency and intensity of storm events.

To further investigate potential nutrient sources, particularly from the direct drainage to Melvin Bay, FBE recommends a septic system vulnerability assessment or additional water quality sampling along the Melvin River and within its watershed. Additionally, exploration and modeling of inputs from other sources such as farms within the watershed could provide more insight. Aging infrastructure is vulnerable to the effects of climate change such as high intensity rainstorms and flooding, which leads to more inputs and threats to the Melvin River watershed's ecological health. Further exploration of a sewer utility for the downtown Melvin Village area could be another factor to research regarding its feasibility and usefulness.

The watershed survey completed as a component of the 2020 Moultonborough Bay and Winter Harbor Watershed Management Plan identified two high priority sites in the Melvin River subwatershed: the Melvin Village Boat Launch and the New Road Culvert. Upgrades at both sites would provide significant nutrient and sediment load reductions to Melvin Bay.

The following sections are targeted recommendations for each of the reaches. A summary of recommendations and project opportunities are ranked in Table 3.

Reach 1 –Key findings and recommendations within Reach 1 include a project to protect the river from further sedimentation, improving aquatic organism passage at current barriers. Located just downstream of the County Road bridge crossing, a potential project that would address erosion, sedimentation, and overall safety of the surrounding residences is to stabilize the very steep riverbank that has begun to slough and erode and realign the stream's flow towards the center of the channel. The proposed design could include bioengineered banks and in-stream flow modifications that mimic natural conditions to direct the flow away from the eroding bank and slope. This work could be completed in conjunction with the replacement and upgrade of the New County Road bridge, which is partially directing flow into the bank of concern. Installing a fish ladder or passage feature at the Pope Dam, replacing the undersized and perched High Street culvert, and restoring/enhancing stream connectivity at the Dam #1 ruins site would restore connectivity with Moultonborough Bay and improve aquatic organism passage through this reach of the stream. An evaluation of the Pope Dam and its associated river section could provide valuable insights into the interplay between the dam, the river, and community, helping to understand the balance between the benefits and impacts. The dam currently attenuates and stores sediment and nutrients in the deep open water habitat impounded behind the dam as well as regulates the water levels and discharge down through Melvin Village during severe storms.

Reach 2a and 2b - The primary findings within Reach 2a and 2b are locations of low severity bank erosion (see Figure 2 for the locations) that if left unaddressed could lead to potentially large bank slough/landslides and a massive amount of sediment entering the river. Factors leading to the erosion are narrow riparian buffers in certain locations and disturbance to surrounding and greater landscape along the reach. Improvements include restoring the vegetative buffer adjacent to the river, cutting leaning trees nearly ready to fall but leaving their root balls, implementing natural bank stabilization techniques and designs if the erosion becomes more severe, and adding in-stream woody debris additions. Municipal land use regulations that reduce land disturbance and clearing in close proximity to rivers could be considered.

Reach 3 – FBE and Streamworks highly recommend that the wetlands and land adjacent to Reach 3 be protected and conserved. The vast and lush wetlands and mostly unfragmented forest along this reach are high value habitat protecting the Melvin River's overall ecological health. This segment of the river showed minimal signs of habitat degradation and ranked as being in "good" or "reference" geomorphic condition. Given the high geomorphic sensitivity of the stream type at this reach, protection and conservation of this reach is a high priority. NH Granit's conservation lands database doesn't show any existing conservation properties along this reach.

The primary findings and influences on this reach include the three stream crossings spaced along the reach, new development at the end of Lyndsay Lane, residential development and yard waste practices along the river near the New Road crossing. Consideration of replacement and upgrading the stream crossings (New Road crossing, Snowmobile Trail #1 crossing, and Snowmobile Trail #2 crossing) to wider and larger structures that accommodate the stream's width and floodplain and provide enough freeboard for woody debris to pass, in addition to re-alignment with stream is recommended. A large volume of debris was blocking flow at Snowmobile Trail #1 crossing, likely both due to beaver activity and the low profile of the bridge. An alternative at the New Road crossing is to rehabilitate and repair the current bridge to prevent further erosion and sedimentation and adding floodplain relief culverts for added capacity during storm events. Another restoration alternative includes adding additional coarse woody material and creating beaver dams throughout the lower portion of Reach 3 to replicate the habitat conditions upstream of the New Road crossing. This would enhance the existing and great aquatic habitat by creating more complexity.

A finding that should be monitored is a very large steep beaver dam located downstream of the Snowmobile Trail #1 crossing, which is impounding a lot of water. The beaver dam was approximately 4-feet in height and backwatered the river to the bridge. This dam should be monitored for integrity. If the beaver dam blows out, it could cause a natural, but large shift in the geomorphic condition downstream, potential bank scour and erosion in Reach 2a and 2b and/or temporary flooding.

Reach 4 – Overall, Reach 4 was in "good" or "reference" habitat and geomorphic condition and ecological health. Based on our findings, the primary recommendation for this reach includes additional conservation and protection of the riparian corridor. Given the high geomorphic sensitivity of the stream type at this reach, protection and conservation of this reach is a high priority. An existing conservation parcel, the Gale Property, extends south from this reach of Melvin River. Additional forest and land to the east could be protected providing contiguous habitat. Other actions include improvements to the vegetated buffer in at a few residential properties along Sodom Road that have river shoreline.

Reach 5 - The primary findings within Reach 5 include the Sodom Road bridge crossing, dam ruins (dam ruins #2), riprap armored upstream banks, areas of thin riparian buffer at residential properties, and the bedrock outcrop that the river waterfalls/cascades over. Several conservation parcels protect and conserve the river, wetlands, and land within the Melvin River watershed upstream of Reach 5. Additional conservation and/or limitations on development in the vicinity of Reach 5 would protect the intact and unfragmented forested landscape and corridor connecting to these existing conservation areas. FBE and Streamworks recommend restoring and improving the vegetated buffer where an open field meets the river upstream of the Sodom Road crossing and allowing the thin shrub and herbaceous buffer immediately downstream of the crossing to grow and develop a tree canopy that overhangs and shades the river. Other potential actions include naturalizing the upstream banks utilizing, where possible, green bank stabilization methods, fully removing the abandoned dam structures, and replacing the Sodom Road crossing and restoring the river's natural alignment and connectivity to its floodplain. Other less costly and lower time intensity alternatives include rehabilitating and repairing the existing bridge crossing or replacing it with a structure that spans the river's banks and accommodates the floodplain. These alternatives, however, will not fix the natural barrier to aquatic organism passage, particularly fish, that the waterfall/cascade imposes on the stream's connectivity. Restoring the natural alignment potentially would.

STREAM CROSSING ASSESSMENTS & RESULTS

Upgrades and improvements at each of the stream crossings located along the study reach will improve the ecological condition and connectivity of the Melvin River. Concurrent to the Rapid Habitat and Geomorphic Assessments, the NH Fish and Game Department (NHF&G) conducted stream crossing assessments within the study reach, following the Statewide Asset Data Exchange System (SADES)/ NH Stream Crossing Initiative's Stream Crossing Assessment Field Manual which evaluates geomorphic compatibility, aquatic organism passage, and structural condition. NHF&G completed assessments for six of the eight crossings FBE and Streamworks encountered within the study reach (Table 2). However, NHF&G was unable to access the Snowmobile Trail #1 crossing and the Private Trial bridge to complete an assessment. The structure sizes and geomorphic compatibility score for each of the evaluated crossings met the mostly compatible or fully compatible classifications, however several crossings were scored as having no or reduced aquatic organism passage. All of the evaluated crossings were deemed to be in good structural condition, besides the New Road concrete bridge which was in poor condition. The results of the NHF&G assessment generally aligned with Streamworks' observations, with only a few exceptions. Streamworks evaluated the New Road crossing to have full aquatic organism passage due to the backwater through the bridge and impaired/reduced geomorphic compatibility since the crossing does not accommodate the river's floodplain. In addition, Streamworks identified both of the snowmobile trail crossings to have reduced geomorphic compatibility due to the accumulated woody material caught on the piers of the Snowmobile Trail #1 crossing and the scour and poor alignment at the Snowmobile Trail #2 crossing. Aquatic organism passage was also reduced due to the woody material blocking flow at Snowmobile Trail #1.

Maintenance and rehabilitation of the crossings will extend their service life whereas modifications and/or upgrades at the crossings restricting connectivity will improve aquatic organism passage and restore natural stream geomorphic condition and processes. Modifications, upgrades, and improvements include adding natural streambed material through the crossings, wider span structures to accommodate the streambanks and river's floodplain, re-aligning the structure with the natural direction and flow to reduce water deflection and scour, as well as replacing crossings with open bottom spanned structures. Addressing the erosion and non-point source pollution that concentrates and enters the watercourse at this type of infrastructure is also needed.

Table 2. Summary of Stream Crossing Assessment results for the crossings within the Study Area.

Stream Crossing	Size and Type	Structural Condition	Geomorphic Compatibility	Aquatic Organism Passage Score
NH Route 109	24.6-ft W x 8.3-ft H concrete bridge	Good	Mostly Compatible	Reduced Passage
High Street	15.3-ft W x 9-ft H corrugated steel pipe-arch culvert with concrete bottom	Good	Mostly Compatible	No passage
County Road	Two-pier timber bridge	Good	*Not assessed*	*Not assessed*
Snowmobile Trail #1	Multi-pier timber bridge with natural bottom	*Not assessed*	*Not assessed**	*Not assessed**
New Road	20.7-ft W x 10.1-ft H concrete bridge with riprap bottom	Poor	Fully Compatible*	Reduced Passage*
Snowmobile Trail #2	34.8-ft W x 6.8-ft H timber bridge with natural bottom	Good	Fully Compatible*	Full Passage
Private Trail	Clear-span timber bridge with natural bottom	*Not assessed*	*Not assessed*	*Not assessed*
Sodom Road	22.0-ft W x 8.3-ft H concrete bridge with natural bottom	Good	Fully compatible	Full passage

* Streamworks' evaluation differed slightly from NHF&G's assessments for parameters demarcated with an asterix.

Table 3. A summary of the recommendations, project opportunities, and action items to improve, restore, and protect the Melvin River and its watershed. [5]

Item Number	Priority Ranking	Reach Number	Category	Recommendation	Responsible Party	Mark When Complete
1	Tier 1	Watershed-wide	Education & Outreach	Promote best management practices for yard waste disposal.	LWA	☐
2	Tier 1	Watershed-wide	Education & Outreach	Promote benefits of a diverse vegetated buffer and recommend best management practices.	LWA	☐
3	Tier 1	Watershed-wide	Education & Outreach	Promote awareness of septic system inspection, maintenance, repair, and replacement.	LWA	☐
4	Tier 1	Watershed-wide	Regulatory Protections	Assess classifying the Melvin River as a designated waterbody protected by the state under the Shoreland Water Quality Protection Act (SWQPA) and/or adopt state level SWQPA regulations into town regulation, zoning, or ordinances.	Town of Tuftonboro & NHDES	☐
5	Tier 1	Watershed-wide	Regulatory Protections	Designate wetlands as prime wetlands and establish buffer protections.	Town of Tuftonboro & NHDES	☐
6	Tier 1	Watershed-wide	Regulatory Protections	Remove natural resource areas and areas vulnerable to flood hazards and climate impacts from the total land area available for development.	Town of Tuftonboro	☐
7	Tier 1	Watershed-wide	Regulatory Protections	Require open space allotments for subdivisions with priority given to conservation of high value natural resources.	Town of Tuftonboro	☐
8	Tier 1	Watershed-wide	Regulatory Protections	Require green building performance elements and low impact development measures.	Town of Tuftonboro	☐

[5] *Streamworks established a prioritization tiered structure which is described as follows:*

Tier 1 or "high priority" recommendations are defined as opportunities that conserve existing high-importance resources that maintain water quality and/or prevent significant stream impairments before more costly and complex actions are taken.

Tier 2 or "moderate priority" recommendations are opportunities that benefit habitat and geomorphic function within the Melvin River and/or modestly reduce sediment and nutrient runoff to Moultonborough Bay and where the benefits are the primary project focus and driver.

Tier 3 or "opportunistic" opportunities are recommendation that benefit habitat and geomorphic function and/or reduce sediment and nutrient runoff to the bay but are anticipated to be costly or increasingly complex and provide these benefits as a secondary benefit to the primary action (such as a stream crossing replacement due to poor condition) or funding (specifics of a grant).

Item Number	Priority Ranking	Reach Number	Category	Recommendation	Responsible Party	Mark When Complete
9	Tier 1	Watershed-wide	Regulatory Protections	Encourage or require on-site and off-site stormwater drainage systems be sized to accommodate the effects of climate change impacts.	Town of Tuftonboro	☐
10	Tier 1	Reach 1	Erosion Control and Bank Stabilization	Stabilize the bank and eroding toe of slope located downstream of the County Road bridge crossing.	Town of Tuftonboro with LWA Grant Support	☐
11	Tier 2	Reach 1	Aquatic Organism Passage	Provide upstream aquatic organism passage at the Pope Dam.	Fish and Game with LWA Support	☐
12	Tier 2	Reach 1	Aquatic Organism Passage & Geomorphic Realignment	Replace the High Street culvert with a geomorphically compatible crossing.	Town of Tuftonboro with LWA Grant Support	☐
13	Tier 2	Reach 1	Aquatic Organism Passage & Geomorphic Realignment	Remove the abandoned dam (Dam #1 Ruins) to provide upstream aquatic organism passage and restore geomorphic processes.	Town of Tuftonboro with LWA Grant Support	☐
14	Tier 2	Reach 1	Geomorphic Realignment & Erosion Control and Bank Stabilization	Replace County Road bridge with a stream-sized crossing and/or restore the river alignment to reduce downstream erosion.	Town of Tuftonboro with LWA Grant Support	☐
15	Tier 3	Reach 1	Aquatic Organism Passage	Provide a natural streambed bottom through the NH Route 109 crossing.	NHDOT with NHF&G and LWA Support	☐
16	Tier 3	Reach 1	Erosion Control and Bank Stabilization	Restore the streambank between Dam #1 Ruins and the High Street crossing by replacing the remnant dam/historic aqueduct feature with a natural bank or green bank stabilization.	Town of Tuftonboro with LWA Grant Support	☐
17	Tier 3	Reach 1	Floodplain Restoration	Acquire residential properties and restore natural streambank between Pope Dam and NH Route 109 if flood risk is a concern.	Town of Tuftonboro with LWA Grant Support	☐
18	Tier 2	Reach 2a & 2b	Habitat Restoration & Water Quality Best Management Practice	Restore, improve, and expand the riparian buffer in locations where it is thin or has been degraded.	Town of Tuftonboro with LWA Grant Support	☐
19	Tier 2	Reach 2a & 2b	Habitat Restoration	In-stream large woody debris additions to improve aquatic organism habitat, stream roughness, raise water levels, and decrease bank erosion potential.	NH Fish & Game with LWA Support	☐

Item Number	Priority Ranking	Reach Number	Category	Recommendation	Responsible Party	Mark When Complete
20	Tier 2	Reach 2a & 2b	Erosion Control and Bank Stabilization	Manage streambank erosion at meander bends.	Town of Tuftonboro with LWA Grant Support	☐
21	Tier 1	Reach 3	Land Conservation and Protection	Conserve land and protect wild and scenic resources.	Town of Tuftonboro with LWA Grant Support	☐
22	Tier 1	Reach 3	Preservation of Habitat & Geomorphic Condition	Monitor and manage the 4-ft tall beaver dam downstream of the snowmobile trail crossing #1 to prevent catastrophic changes to the stream's downstream geomorphology.	Town of Tuftonboro with LWA Support	☐
23	Tier 2	Reach 3	Aquatic Organism Passage & Geomorphic Realignment	Snowmobile trail stream crossing improvements and upgrades. Replace, realign, and up-size both snowmobile trail crossings to stream-sized crossings and with enough freeboard to pass woody debris transported downstream. Or potentially consider a new location and alignment for Snowmobile Trail #1.	Snowmobile Club with LWA Grant Support	☐
24	Tier 2	Reach 3	Habitat Restoration & Water Quality Best Management Practice	Restore, improve, and expand the riparian buffer in locations along the powerline corridor.	Town of Tuftonboro with LWA Support	☐
25	Tier 3	Reach 3	Aquatic Organism Passage & Geomorphic Realignment & Floodplain Restoration	New Road stream crossing improvements and upgrades. Replace and up-size the bridge with a wider spanned crossing to accommodate the stream width and floodplain. Or Repair the existing crossing and add relief culverts to accommodate storm volumes.	Town of Tuftonboro with LWA Grant Support	☐
26	Tier 3	Reach 3	Habitat Restoration & Erosion Control and Bank Stabilization	Restore natural streambanks where residential development is occurring immediately along the shoreline.	Town of Tuftonboro with LWA Grant Support	☐
27	Tier 1	Reach 4	Land Conservation and Protection	Conserve land and protect wild and scenic resources.	Town of Tuftonboro with LWA Grant Support	☐
28	Tier 2	Reach 4	Habitat Restoration & Water Quality Best Management Practice	Restore, improve, and extend the riparian buffer at the residential properties noted along Sodom Road.	Town of Tuftonboro with LWA Support	☐

Item Number	Priority Ranking	Reach Number	Category	Recommendation	Responsible Party	Mark When Complete
29	Tier 1	Reach 5	Land Conservation and Protection	Conserve land and protect wild and scenic resources.	Town of Tuftonboro with LWA Grant Support	☐
30	Tier 2	Reach 5	Habitat Restoration & Water Quality Best Management Practice	Restore, improve, and extend the riparian buffer along the river associated with residential properties along Sodom Road.	Town of Tuftonboro with LWA Support	☐
32	Tier 3	Reach 5	Geomorphic Realignment	Replace the Sodom Road bridge crossing with a wider spanned crossing and re-align the stream channel to its historic alignment.	Town of Tuftonboro with LWA Grant Support	☐
33	Tier 3	Reach 5	Stream Restoration & Geomorphic Realignment	Remove abandoned dam #2 ruins, relocate the stream channel to realign it with its original path, and reconnect the river to its floodplain and associated wetlands.	Town of Tuftonboro with LWA Grant Support	☐

NATIVE FISH SURVEY RESULTS

In conjunction with the Rapid Habitat and Geomorphic Assessments, the NH Fish and Game Department (NHF&G) conducted fish community surveys throughout the Melvin River watershed to update their records and deployed four loggers to monitor the water temperature. NHF&G recorded eleven different fish species in the Melvin River watershed across nine electrofishing surveys that took place in 2010, 2022, and 2023 (Figure 4). Most electrofishing sites focused on the mainstem of the Melvin River, spanning from below the Pope Dam to a site north of Route 171. One tributary site was selected in Fields Brook, located in the northwestern portion of the watershed near the intersection of Route 171 and Sodom Rd (F&G Site 3). Wild brook trout *(Salvelinus fontinalis)* were the most common species across all survey sites, except below the Pope Dam (F&G Site 8). The blacknose dace *(Rhinichthys atratulus)* and white sucker *(Catostomus commersonii)* were other common fish species found that are somewhat more tolerant to the warmer water temperatures associated with low-lying wetland-riverine ecosystems. Other fish species found in the Melvin River include the creek chub *(Semotilus atromaculatus)*, common shiner *(Luxilus cornutus)*, common sunfish *(Centrarchus macropterus)*, hatchery brook trout, fallfish *(Semotilus corporalis)*, golden shiner *(Notemigonus crysoleucas)*, largemouth bass *(Micropterus salmoides)*, longnose dace *(Rhinichthys cataractae)*, and rock bass *(Ambloplites rupestris)*. Despite stocking efforts, hatchery raised brook trout were rarely found in the higher reaches but were most common below the Pope Dam. Fish species utilizing the river below the dam are likely to have migrated upstream from Melvin Bay and Lake Winnipesaukee, as evidenced by the presence of common sunfish, fallfish, largemouth bass, and rock bass, which were rarely, if ever, observed at the upstream sites. Fish found in Lake Winnipesaukee, such as landlocked salmon *(Salmo salar)*, sometimes use the area below the dam as spawning grounds.

In 2023, the highest average water temperature in the Melvin River was observed at monitoring sites in the lower watershed (below County Road, below the Pope Dam, and below Sodom Road; F&G Sites 7,8,9) (Figure 4). These sites are located between the wetland complex at the Great Meadows Conservation Easement and Lake Winnipesaukee. During most days in July, the water temperature at these sites exceeded 21.1°C (70°F), above which salmonids such as wild brook trout may experience physiological stress. These sites, especially the two most downstream sites (F&G Site 7 below County Road and F&G Site 8 below Pope Dam), saw the fewest wild brook trout across all electrofishing surveys. No young-of-the-year brook trout were captured during the surveys at these two sites, which may be related to high mean July water temperature (>19.5°C or 67.1°F), according to unpublished data from NHF&G. The three electrofishing sites located lower in the watershed were the only sites where the longnose dace was captured.

Upstream of the wetland in the Great Meadows Conservation Easement (F&G Sites 4, 5, 6), brook trout were found to be incredibly abundant during the 2022 electrofishing surveys, consisting of 49-64% of all captured fish. Situated between two expansive wetland complexes, it was expected that the river would have warmer water temperatures, attributed to the absence of a forested riparian zone that typically provides shade. However, the abundance of brook trout in this river reach implies that cooler groundwater may have a notable impact on water temperature, since brook trout prefer cooler waters and will migrate to more tolerable river reaches if the water temperature is too high.

The Great Meadows Conservation Easement area is an ecologically important area of the Melvin River. Wild brook trout were more abundant throughout this section of the river than any other surveyed river reach. The blacknose dace and white sucker were also common at these sites. No temperature monitoring was conducted in this area in 2023.

The coolest water temperatures were observed in the upper watershed at a monitoring site Below Route 171. The site had a mean summer water temperature of 16.9°C (62.4°F), compared to the warmest site which was below the Pope Dam (20.1°C or 68.2°F). Below Route 171, the water temperature only rose above 21.1°C (70°F) for six hours on one day in July, meaning temperatures were low enough to be unlikely to stress fish. At the two electrofishing sites on the mainstem of the Melvin River (F&G Sites 1 and 2), wild brook trout and the blacknose dace were the most common species found. At the Fields Brook site (F&G Site 3), only wild brook trout were captured. No hatchery raised brook trout were captured at the upper watershed electrofishing sites.

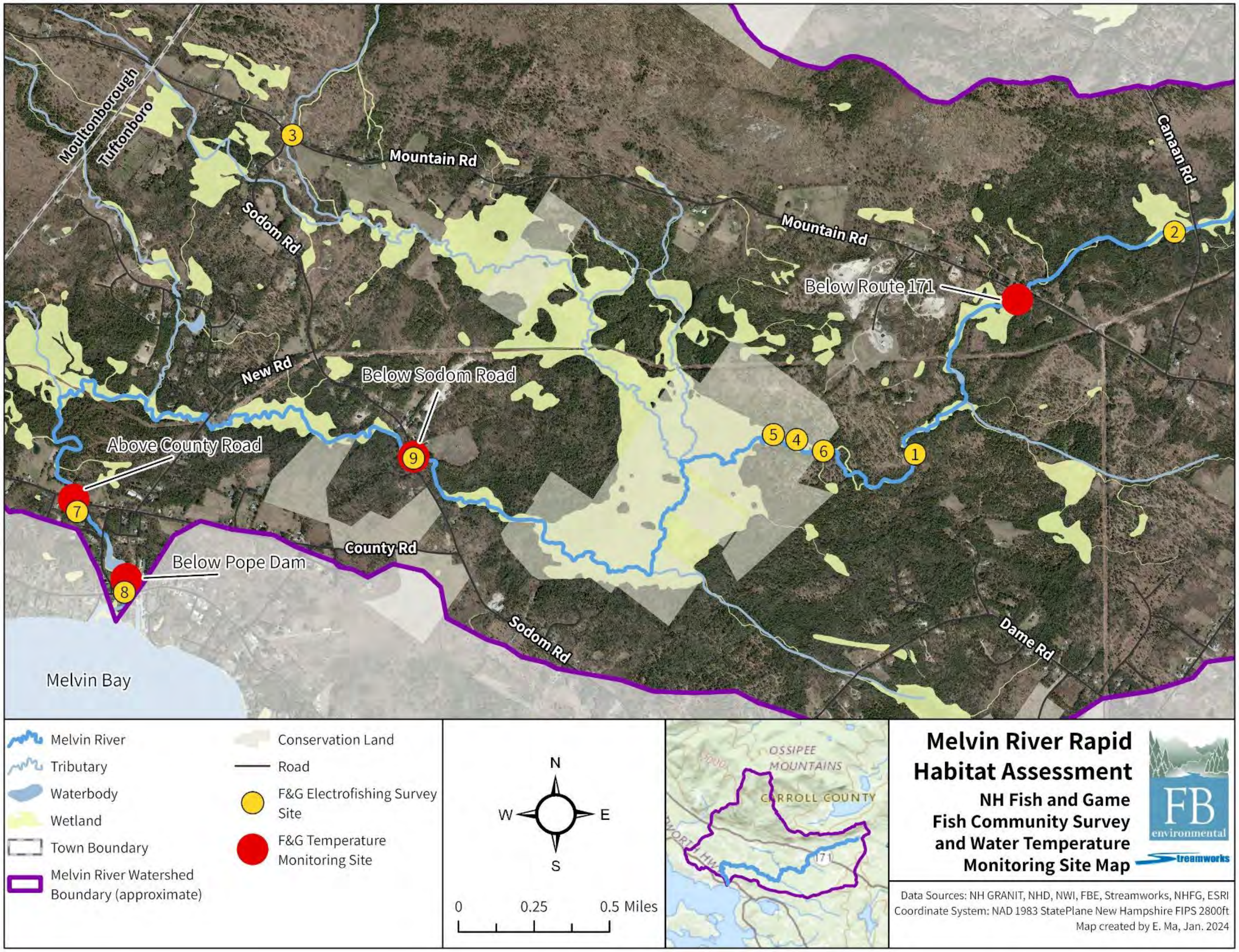

Figure 4. A site location map for the NHF&G's Fish Community Surveys and water temperature monitoring locations within the Melvin River Watershed.

IV. CONCLUSION

The Melvin River and its in-stream and riparian habitat exhibit a diverse and healthy riverine system. The study reach, encompassing the section from the river's confluence with Moultonborough Bay to Sodom Road, reflects generally good ecological and geomorphic condition. Noteworthy features include intact riparian buffers, suitable aquatic organism habitats including in-stream woody material, pools, sandy substrate, and more, a vast wetland floodplain surrounding a large section of the study reach, mostly stable banks, and only isolated areas of scour and erosion concern. While the lower reach near Melvin Village experiences higher development pressure and impacts, the upper sections are bordered by unfragmented landscapes and extensive wetland complexes. Despite the river and its watershed being in overall good condition, there are still factors imposing pressure on and potential influence on the river. Key influences on the river include road-stream crossings, snowmobile trail crossings, a dam, dam ruins, and residential development near the river. These factors all contribute to channel constriction, diminished in-stream and terrestrial habitat, sedimentation, and nutrient inputs.

While the Melvin River plays a significant role in Moultonborough Bay, the watershed is well-buffered and forested which supports a healthy riverine system. Conserving the unique and diverse wetland and forested land adjacent to the river should be a top priority for the health of Melvin Bay. Shoreline development around Melvin Bay emerges as a more likely influential factor in water quality and the ecological health of the bay. Despite the study reach's overall good condition, strategic conservation measures and actions can still improve the watershed's overall condition and preservation of the intact landscape should continue to be pursued. The study's reach-specific assessments shed light on distinct characteristics and challenges. Reach 1 faces obstacles like barriers affecting aquatic organism passage, while Reach 2a and 2b require attention to potential bank erosion and infringement on a robust riparian buffer. Reach 3 stands out for its large wetland complex, urging conservation efforts, while Reach 4 exhibits overall good ecological health, emphasizing the need for additional riparian corridor protection. Reach 5, with its unique bedrock features, requires careful consideration for restoration and improved connectivity.

A comprehensive list of recommendations for watershed-wide and reach-specific improvements is included with this report as a guide and tool to improve the watershed's overall condition. These include addressing development pressures, enhancing riparian buffers, upgrading and/or repairing stream crossing, and considering conservation initiatives. In addition to addressing anthropogenic influences, such as under sized culverts, eroding banks, nutrient inputs, and habitat fragmentation, proactive and preemptive measures like local education and outreach and additional regulatory protections could be beneficial. The overarching goal is to ensure the sustained ecological health of the Melvin River and its contribution to the well-being of Moultonborough Bay. Through collaborative efforts and strategic interventions, the report aims to guide future actions and initiatives to safeguard this vital watercourse.

V. REPRESENTATIVE PHOTOGRAPHS

Photo 1. A representative image of a section of Reach 1 downstream of the County Road bridge crossing.

Photo 2. Large woody material and naturally undercut banks were present throughout Reach 1.

Photo 3. The Melvin River and NH Route 109 bridge are immediately abutted by residential and commercial development.

Photo 4. Dry-stacked boulder and concrete retaining walls line the banks of the lower segment of Reach 1.

Photo 5. Downstream of the Pope/Melvin River Dam.

Photo 6. The Pope Dam impounds and widens the Melvin River's channel.

Photo 7. The inlet and out of the High Street culvert crossing are armored with riprap.

Photo 8. Dry-stacked boulder wall running parallel to the river upstream of the High Street Crossing.

Photo 9. Remnants of a dam (Dam #1 Ruins) extend across Reach 1's channel.

Photo 10. The Dam #1 Ruins were comprised of large and medium boulders stacked perpendicular across the river.

Photo 11. Severe erosion along the river's right bank immediately downstream of the County Road Crossing.

Photo 12. Bank scour that if left unaddressed possess a landslide risk resulting in a large addition of sediment.

Photo 13. The County Road Crossing is an undersized open-bottom bridge with poor stream alignment.

Photo 14. There's a narrow, forested buffer between a large, mowed field and the river in a few locations along Reach 1, 2a, and 2b.

Photo 15. A representative photo of Reach 2a.

Photo 16. Suitable in-stream aquatic organism habitat, woody material and log jams, are present throughout Reaches 2a and 2b.

Photo 17. Logging activity, a thinned forest adjacent to Reach 2a and 2b, was noticeable from the channel.

Photo 18. A bank vegetated with eastern hemlock *(Tsuga canadensis)* slumping into the river, a result of erosion at the toe of slope along a meander bend within Reach 2b.

Photo 19. Reach 2b's riparian corridor transitions from predominantly forested to a thin forest buffer along the edge of a field.

Photo 20. Newly cleared riverbank and boulder revetment along Reach 2b.

Photo 21. Reach 3 meanders through a very large emergent and scrub-shrub wetland complex.

Photo 22. A utility corridor runs along the lower half of Reach 3.

Photo 23. Connected to the utility corridor is Snowmobile Trail #1 crossing.

Photo 24. The Snowmobile Trail #1 crossing was nearly submerged due to woody material caught on and blocking flow through the structure in addition to backwatering effects from a large beaver dam downstream.

Photo 25. The utility corridor, accessible from New Road, is comprised of a mix of scrub-shrub vegetation.

Photo 26. Reach 3 flows through a box culvert under New Road at approximately its midpoint, revealing deteriorating headwalls and wingwalls, and erosion around the structure.

Photo 27. Immediately upstream of the New Road crossing is another Snowmobile Traill crossing (#2) spanning across Reach 3.

Photo 28. Bank scour causing several large trees to lean over the river, poses a potential risk.

Photo 29. The wetland complex surrounding Reach 3 is a diverse and robust ecosystem supporting aquatic and terrestrial wildlife.

Photo 30. Many small tributaries connect to the main channel throughout Reach 3.

Photo 31. Numerous beaver dams, like this 4-foot tall dam, are scattered throughout Reach 3, creating impoundments and pools.

Photo 32. A beaver lodge was encountered within the upper section of Reach 3.

Photo 33. The study reach transitions back to a forested and scrub-shrub riparian buffer in Reach 4.

Photo 34. Reach 4 contained an abundant amount of large woody material providing in-stream aquatic organism habitat.

Photo 35. The riparian buffer along Reach 4 is predominately undeveloped, except for a few discrete features associated with residences along Sodom Road, such as the wooden platform depicted above.

Photo 36. A resident along Sodom Road constructed a private trail bridge spanning the banks of Reach 4 linking their backyard to a forested trail on the other side.

Photo 37. Reach 5 exhibited a geomorphic shift in substrate and slope, featuring bedrock outcrops and a steeper gradient.

Photo 38. Another notable characteristic of Reach 5 is the stream channel's shift in morphology, showcasing an area of bifurcation.

Photo 39. At the bifurcation, one branch of Reach 5's channel flows down a bedrock sluice.

Photo 40. Along the other branch of Reach 5, the channel cascades/waterfalls over boulders.

Photo 41. An open-bottom bridge conveys flow of Reach 5 under Sodom Road.

Photo 42. Remnants of dam structures, identified as Dam #2 Ruins, were found adjacent to (upstream and downstream) Reach 5.

Photo 43. An open field/lawn is mowed to the river's edge within Reach 5.

Photo 44. In the lower half of Reach 5, a resident along Sodom Road built a riverside wooden platform.

VI. APPENDIX A. RAPID HABITAT ASSESSMENT FULL RESULTS

Table A1. FBE's field findings collected during the rapid habitat assessment by stream reach.

Reach Segment	Stream Type	Streambed Substrate & Composition	Bank Scour & Erosion	In-Stream AOP Habitat	Canopy Cover	Vegetative Riparian Buffer	Connectivity	Development
Reach 1	Plane-bed	• Dominant substrate = cobbles. • Pebble Count = 15% sand, 45% gravel, 25% cobble, and 15% boulder • Sandy mid-bars and sidebars present. • Streambed is uniform. Modified/straightened streambed downstream of the Pope Dam. • Streambed modified by Dam #1 Ruins upstream of the High Street crossing.	• Locations of high/severe bank scour and erosion. • Distinct areas of scour throughout the reach. Mainly located in the vicinity of the High Street crossing, dam ruins, and the County Road bridge crossing. • Moderately to highly armored with riprap/stone, rock walls, or concrete retaining walls in key areas (dam, dam ruins, High Street and Country Road crossings). • Significant/severe erosion immediately downstream of the County Road crossing.	• Woody debris recruitment = Good • A moderate amount of woody material within the floodplain. • Natural bank undercutting in the upper section of the reach. • Pools present! Large pool located downstream of Dam #1 Ruins. • Sandy mid-bars and sidebars suitable for fish spawning.	• Average range: 40-50% canopy cover.	• Fair condition – partially degraded/fragmented. • Narrow, fragmented buffer in the upper segment of the reach to no buffer in the lower portion. • A thin tree line was present along most of the reach. • Residential properties including one with a large field, commercial development, and the dam fragment the buffer. • Vegetation is primarily forest with some shrubs. • Low to moderate presence of invasives plant species such as barberry *(Berberis sp.)* and glossy false buckthorn *(Frangula alnus)*	• Several in-stream barriers throughout the reach: the Pope Dam, undersized High Street culvert crossing, and Dam #1 ruins. • The watercourse is constricted by the High Street crossing, impounded by the Pope Dam and Dam #1 ruins. • Built up embankments along the roads and buildings downstream of the Pope Dam cut the watercourse off from its floodplain.	• Highly influenced and moderately modified by anthropogenic forces (residences, commercial buildings, roads, Pope Dam, Dam #1 ruins, etc.) • The most instances of bank stabilization and armoring.
Reach 2a	Riffle-pool	• Co-dominant substrate = sand and gravel. • Pebble Count = 40% sand, 40% gravel, 10% cobbles, and 10% boulders.	• Moderate bank scour and erosion. • Banks appeared stable throughout the majority of the two reaches. • Some natural bank undercutting was observed along the bankfull water level line. • Concerns for erosion and sedimentation	• Natural undercut banks available for refuge. • Pools are present. • 2b- Sandy substrate suitable for spawning. • Some woody material within the stream throughout the reach. Fallen trees spanning across the stream channel.	• Average: 40% canopy cover. • Trees comprised of red maple *(Acer rubrum)* and eastern hemlock *(Tsuga*	• Fair to good – partially degraded/fragmented to mostly intact buffer. • 2a - Low to moderately intact riparian buffer. 2b – moderately intact riparian buffer. • • Fair to good – partially degraded/fragmented to mostly intact buffer. • Areas of fragmented buffer associated with nearby logging to the east.	• Limited to no in-stream barriers to passage and flow. • Due to the entrenchment of the river, the stream naturally has a narrow floodplain throughout this reach	• Moderate levels of development within the reach. • Residential properties including one with a large field (partially agricultural) that directly abuts the river. • Timber harvesting operations adjacent to the
Reach 2b	Plane-bed	• Dominant substrate = sand. • Pebble Count = 100%.					• Limited to no in-stream barriers to passage and flow. • A few small beaver dams were encountered.	

Reach Segment	Stream Type	Streambed Substrate & Composition	Bank Scour & Erosion	In-Stream AOP Habitat	Canopy Cover	Vegetative Riparian Buffer	Connectivity	Development
			associated with logging to the east. • Reach 2b - An area of destabilized bank was noted within this reach and is associated with hemlock trees leaning and beginning to fall into the watercourse along a field's edge.	• Moderate to high woody debris recruitment potential from surrounding riparian buffer.	*canadensis).*	• Open field habitat, to the west, directly up to the river's edge in some locations and a thin forested buffer in other locations. • Infrequently encountered invasive species along the river's edge.	• The river's floodplain begins to widen. It is connected to adjacent forested and scrub-shrub wetlands.	river and areas that have been clear cut directly to the river's edge. • Encountered an abutting landowner to the west utilizing small machinery to carry stone and gravel to a cleared portion of land adjacent to the river. Appeared to be creating a stonewall along the river's edge and other development.
Reach 3	Riffle-pool	• Dominant substrate = sand and silt/muck • Pebble count – 100% sand	• Low bank scour & erosion. Banks are very stable and nearly no bank erosion was observed within the reach. • Thick emergent and scrub-shrub vegetation is growing along the watercourse which is very stable. • One notable location of erosion was encountered within the reach where the stream flows close to the adjacent forest; a few very large pine trees growing immediately along the bank have fallen/are falling into the river. This likely happened due to natural erosion along the inside corner of the river.	• Many small channels throughout the marsh branching off from the main river channel, that are shaded and shallower which provide great AOP habitat. • Alcoves and "bank" undercutting along the herbaceous vegetated edges of the watercourse provide refuge. • Low/ minimal woody debris encountered. Woody debris included some beaver gnawed sticks embedded into the substrate. • Low to moderate woody debris recruitment potential within the reach. The	• Average range: 0-10% canopy cover. • The majority of the watercourse throughout this reach receives nearly full sunlight.	• Good to reference condition- mostly intact to entirely natural buffer. • Highly intact vegetated buffer. • A very large and broad emergent and scrub-shrub wetland complex surrounds the meandering water. • Vegetation includes grasses, sedges, shrubs, and stunted/deceased saplings/trees. The vegetation growing within the buffer was very dense and diverse. • Plant species noted within the complex included common buttonbush *(Cephalanthus occidentalis)*, alders *(Alnus* spp.), meadowsweet *(Spirea latifolia var. alba)*, smooth arrowwood *(Viburnum dentatum)*, maleberry *(Lyonia ligustrina)*, bur-reed *(Sparganium* sp.), willows *(Salix* sp.), and blue joint *(Calamagrostis*	• Many beaver dams are located throughout the reach that impound water. • The river is well connected to its floodplain. The floodplain is wider upstream of the New Road crossing and narrowed by the electrical utility corridor downstream. • Floodplain capacity is very high.	• Low to moderate levels of development within the reach. • The prominent anthropogenic influences on this reach includes the New Road bridge crossing and two snowmobile trail bridge crossings. • Other development present within this segment includes the electrical utility corridor that runs directly along the river in some locations, a few residences on New Road, some newer residential development along Partridge Berry Circle and Lyndsay Lane, and the logging to

Reach Segment	Stream Type	Streambed Substrate & Composition	Bank Scour & Erosion	In-Stream AOP Habitat	Canopy Cover	Vegetative Riparian Buffer	Connectivity	Development
				emergent/scrub-shrub marsh surrounding the water is mostly small woody material. Woody debris recruit potential is higher upstream of this reach.		*canadensis).* Submerged and aquatic vegetation was also noted in section of the watercourse, especially in shallower or slower moving areas. Aquatic vegetation included yellow marsh marigold *(Caltha palustris)*, floating brown leaf, and tape grass *(Vallisneria americana).* • Some invasive plant species were noted along the banks, mostly glossy false buckthorn *(Frangula alnus)*. There was not much shading over the stream, since the surrounding buffer was low growing grasses, sedges, and small woody shrubs.		the south and east of the river.
Reach 4	Riffle-pool	• Dominant substrate = sand and silt/muck • Pebble count = 100% sand/silt/muck • Boulders occasionally present.	• Low to moderate bank scour & erosion. Natural stable banks. No visible erosion or scour. • Natural bank undercutting along the bankfull water level line.	• Natural undercut banks suitable refuge. • Pools are present. • Sandy soils suitable for fish breeding habitat. • A large amount of woody debris and trees were encountered. • Moderate to high woody debris recruitment potential.	• Average range: 20-30% canopy cover, but in areas in close proximity to homes as low as 10-15%.	• Good to reference condition-mostly intact/moderate to highly intact riparian buffer. • Riparian buffer is a mix of upland and wetland forest systems and some scrub-shrub floodplain wetlands. • Low to moderate presence of invasive plant species were noted growing within the forest and vegetated buffer adjacent to the river and specifically noted closer to developed areas such as the trail near the private bridge.	• The river is well connected to its floodplain.	• Low to moderate levels of development within the reach. • The primary anthropogenic influences noticed was a private bridge crossing the river and a wooden platform located near the river's edge. • Primarily undeveloped along the river's edge.
Reach 5	Plane-bed and Step-pool	• Dominant substrate = cobble • Pebble count = 15% sand, 10% gravel, 45% cobble, 30% boulder • Approximately 200 feet downstream of the Sodom Road crossing the	• Mostly natural stable banks except for immediately adjacent to the Sodom Road bridge crossing. • The banks immediately adjacent to and abutting the Sodom Road bridge	• Natural undercut banks suitable refuge. • Pools present. • Sandy point bars along the edges of the watercourse are suitable for fish breeding habitat.	• Average range: 40-50% canopy cover.	• Good to reference condition- moderate to highly intact riparian buffer. • The riparian buffer is mostly upland forest and floodplain. • The buffer was thinner and comprised of shrubs and herbaceous plants near the Sodom bridge due to	• There is a steep bedrock cascade/waterfall approximately 200 feet downstream of the Sodom Road crossing that is a barrier to aquatic organism passage.	• Low to moderate levels of development within the reach. • The primary anthropogenic influences are the Sodom Bridge crossing, a wooden platform located

Reach Segment	Stream Type	Streambed Substrate & Composition	Bank Scour & Erosion	In-Stream AOP Habitat	Canopy Cover	Vegetative Riparian Buffer	Connectivity	Development
		streambed changes to bedrock.	abutments are armored with riprap. • Natural bank undercutting along the bankfull water level line.	• A large amount of woody debris in varying sizes. A large log jam where the streambed transitions to bedrock and branches contained 100-200 pieces of wood of various sizes. • Woody debris recruitment is high due to well vegetated banks and riparian corridor.		residential development and the bridge infrastructure. • Some tree and shrub species noted include eastern hemlock *(Tsuga canadensis)*, red maple *(Acer rubrum)*, highbush blueberry *(Vaccinium corymbosum)*, and witch hazel *(Hamamelis virginiana).* • Low to moderate presence of invasive plant species were noted growing within the forest and vegetated buffer adjacent to the river and specifically noted closer to developed areas.		near the river's edge downstream, and the residential development on Sodom Road adjacent to the river. • Bank and sediment stabilization in and around the road shoulders and bridge are of concern.

VII. APPENDIX B. STREAMWORKS' RAPID GEOMOPRHIC ASSESSEMENT REPORT

Rapid Geomorphic Assessment

Project: Melvin River Geomorphic and Habitat Assessment
Prepared For: Sarah Large / FB Environmental Associates, LLC
Lake Winnipesaukee Association
Prepared By: James Woidt / Streamworks, PLLC
Reviewed By: Joel Ballestero / Streamworks, PLLC
Date: January 8, 2024

Background

Moultonborough Bay (Bay) is an important part of Lake Winnipesaukee, a cornerstone of the economy and culture of New Hampshire's Lake Region that provides ample fishing, boating, swimming, and other recreational activities. The water quality of the Bay is of special concern due to the risk of degradation from phosphorous loading that may drive an increased frequency of cyanobacteria blooms in the absence of management efforts. The Lake Winnipesaukee Association (LWA), along with others, have overseen the preparation of the *Moultonborough Bay & Winter Harbor Watershed Management Plan* (FB Environmental Associates, 2020) which identified phosphorous as the principal nutrient contributing to cyanobacteria blooms. As such, identifying and managing sources of phosphorous are a primary goal for LWA and others that are implementing actions recommended in the watershed plan to manage sediment and phosphorous runoff to protect the water quality of the Bay.

As part of these efforts to preserve the health and integrity of the Bay, LWA contracted FB Environmental Associates, LLC (FBE) to prepare a geomorphic and habitat assessment of the Melvin River, a major tributary to Moultonborough Bay in Tuftonboro, NH, between the river's terminus at Lake Winnipesaukee and Sodom Road (study reach). The LWA's goal for the project is to characterize the existing geomorphic and habitat conditions along the study reach and develop recommendations to improve geomorphic and habitat function in the study reach and, where possible, identify in-stream or riparian opportunities in the study reach to reduce the sediment and nutrient loading to the Bay.

Memorandum Purpose

FBE procured Streamworks, PLLC (Streamworks) to lead the rapid geomorphic assessment of the study reach. This memorandum documents the field work and technical assessments by Streamworks that were used to characterize the existing geomorphic conditions of the Melvin River within the study reach, to identify potential causes of impairment, and propose actions to improve habitat, geomorphic function, and/or water quality. The geomorphic assessments summarized in this memorandum have been performed to characterize geomorphic processes of the study watercourses as a function of their location within the watershed; further discretization and detailed analyses (i.e., smaller sections of each geomorphic reach) may be appropriate as part of advanced planning and/or implementation of proposed actions to better understand anthropogenic impacts on geomorphic processes at specific locations.

Geologic Context

The Melvin River Watershed is located within the New England Uplands section of the New England physiographic province. The New England Uplands section is generally characterized as an upraised plain that has been dissected through fluvial and glacial processes into a series of hills and valleys, with frequent lakes. The section is generally underlain by thin glacial till and bedrock outcrops and glacial deposits (e.g., kames, eskers) are common. Bedrock in the study area includes tonalites in the flatter-gradient sections of the watershed near Lake Winnipesaukee and rhyolites, basalts, and granites in the steeper slopes along the Ossipee Mountains (Lyons et al., 1997), the remains of an ancient volcanic ring dike. All such rocks are massive (usually lacking significant fracture networks), igneous rocks formed by cooling of magma (below surface) or lava (above surface.) The various rocks can decompose into fine- or coarse-grained sediments.

According to the “Surficial Geologic Map of the Melvin Village Quadrangle” by Brooks and Tinkham (2015) provided as Exhibit 1, the present surficial material across the watershed is dominated by poorly sorted glacial tills with grain sizes ranging from silts to large particles. Along the upslope margins of the wetland adjacent to either side of New Road are glaciofluvial deposits that are generally coarser than glacial tills and include particles ranging from silty sands to cobbles. These deposits were formed along the ice margin of former glaciers as well by glacial meltwater and precipitation re-working glacial sediments that re-deposited the sediments in an alluvial fan or outwash plain shortly after the glaciers receded. Present-day streams have incised through these glaciofluvial deposits such that these glaciofluvial deposits are fixed features and unlikely to be fluvially re-worked under current climate conditions.

Upstream of County Road, the surficial geology of the Melvin River valley bottom is predominantly alluvial materials deposited under current climactic conditions since the recession of glaciers from the area. Fine-grained wetland deposits are common across the study reach especially in low-gradient, broad valleys where such materials are expected to deposit as stream power decreases in relation to upstream reaches (both sides of New Road; upstream of County Road.) Coarser-grained alluvial deposits including sands, pebbles, cobbles, and boulders or the aforementioned glaciofluvial deposits exist at the downstream end of these wetland deposits, generally in narrower valleys of steeper gradient, and likely are relatively immobile under the current climate conditions and thus form a geologic control that prevents downcutting in the upstream wetland and maintains their low gradient. County Road is also the approximate limit of the paleo-Lake Winnipesaukee. Downstream of County Road, Brooks and Tinkham’s (2015) surficial geologic map shows the Melvin River underlain by glacial tills. The Melvin River likely downcut through these tills as Lake Winnipesaukee receded to its current level and continued downcutting until sufficient coarse materials were exposed and/or rolled off of exposed hillsides to armor the channel and resist erosion by fluvial forces.

Delineation of Geomorphic Reaches

The geomorphic function, quantity and quality of in-stream physical habitat, and generation and/or transport of nutrients are dependent not only on the presence or absence of anthropogenic impacts but also by landscape controls such as geology or topography: a steep, boulder-lined stream will respond differently to anthropogenic impacts and provide different habitat than a meandering, sand-bed river. Therefore, the “best habitat”, or restoration potential, of a stream reach is dependent on natural landscape controls and processes that influence the stream’s morphology, including channel dimensions, substrate, and bedforms.

Numerous systems, including the *Vermont Stream Geomorphic Assessment* (Vermont Agency of Natural Resources [VANR], 2007) have been developed that recognize the relationships between landscape controls, stream morphology, and habitat. With the goal to identify the geomorphic and habitat *potential* (not existing condition) of the study reach, Streamworks used valley width, longitudinal gradient, and, to a lesser extent, surficial geologic materials per modified VANR (2007) procedures to delineate reaches and identify reference stream types, which are defined by VANR (2007) as "channel forms expected to exist in the absence of anthropogenic impacts." Longitudinal profiles, provided as Exhibit 2, and natural valley width were developed using lidar downloaded from NH Granit which was also used to delineate the stream centerlines. As shown on Exhibit 2, geomorphic reaches often coincide with breaks in longitudinal gradients that are often associated with a change in dominant geomorphic processes (e.g., degradation to aggradation.)

Similar to the VANR (2007) process to assign reference stream types, Streamworks also inverted the typical application of the Montgomery and Buffington (1993) stream classification system and used representative confinement and typical slope parameters for each geomorphic reach to identify potential equilibrium stream types that may exist for each of the geomorphic reaches if they were unimpacted and in a state of dynamic equilibrium (neither degrading nor aggrading over the long-term.) Exhibit 3, an excerpt from the Natural Resource Conservation Service's (2007) *National Engineering Handbook* summarizes the stream types and typical parameters of the Montgomery and Buffington (1993) stream classification system.

Comparison of these two reference stream types to the existing condition of the study reach can inform habitat and geomorphic impairments in the study reach, their causes (in some cases), and potential restoration treatments. Exhibit 4 provides a map of the study reach which includes identification of the six delineated geomorphic reaches. Table 1 summarizes metrics and miscellaneous comments used to delineate the geomorphic reaches.

Habitat Restoration Potential

Another useful application of the Montgomery and Buffington (1993) stream classification system is that the "Dominant Roughness Category" presented in Exhibit 3, while intended to convey the principal stream features that dissipate energy with the stream, can also serve as a reference for expected habitat features within each stream classification. For example, whereas geomorphic reaches Melvin 2a and Melvin 2b may exhibit many similar characteristics, habitat complexity within a plane-bed stream like Melvin 2b is expected to result from large colluvial materials and, to some degree, large woody material whereas in Melvin 2a habitat complexity is expected to include woody material and pool-riffle sequences of varying flow depths. Thus, the two reaches would be expected to have different habitat restoration potential because of differing geomorphic processes that control the formation of channel morphology in each reach.

Table 1: Valley Characteristics and Reference Stream Types for Delineated Reaches

Reach Segment	Valley Type [a]	Channel Slope / Valley Slope	Surficial Geology [b]	Reference Stream Type[c]	Other
Melvin 1 (Melvin Village)	Semi-confined[d] (2 ≤ VCR < 4)	1.3% / 1.4%	Glacial tills, with lower end of reach within estimated shoreline of Paleo-Lake Winnipesaukee	Bc (Plane bed)	Key criteria in reference stream type is U-shaped (glacial) valley
Melvin 2a (County Rd)	Narrow (4 ≤ VCR < 6)	0.10% / 0.39%	Alluvium confined by glacial till hillsides	C (Riffle-pool)	
Melvin 2b	Semi-confined (2 ≤ VCR < 4)	0.30% / 0.42%	Alluvium confined by glacial till hillsides	Bc (Plane bed)	Key criteria in reference stream type is U-shaped (glacial) valley
Melvin 3 (New Road wetland)	Broad (6 ≤ VCR < 10)	0.11% / 0.15%	Wetland deposits (sands and finer) confined by glacial till (left bank) and glaciofluvial fan deposits of silty sand to cobbles	E (Riffle-pool)	Some sections of Very Broad valley type at downstream end and upstream of New Road
Melvin 4	Narrow (4 ≤ VCR < 6)	< 0.01% / < 0.01%	Alluvium (sands and larger) confined by glacial till (left bank) and [glacial] ice contact deposit composed of sands and cobbles (right bank)	Cc- (Riffle-pool)	
Melvin 5 (Sodom Road)	Semi-confined (2 ≤ VCR < 4)	2.3%[e] / 2.7%	Glacial till with right bank [glacial] ice contact deposit composed of sands and cobbles transition to alluvium (sands and larger)	B (Plane Bed or Step-pool)	Key criteria in reference stream type is U-shaped glacial valley and suspected dam construction and channel realignment that over-steepened current stream

[a] "[Valley] Confinement Ratios" (VCR) in VANR's *Vermont Stream Geomorphic Assessment* used to define Valley Type
[b] Per Surficial Geologic Maps of the Melvin Village Quadrangle by Brooks and Tinkham (2015)
[c] Per Rosgen (1994); Montgomery and Buffington (1993) stream type presented in parentheses
[d] Including abandoned floodplain terrace (possibly from Paleo-Lake Winnipesaukee) yields Narrow valley width
[e] Sub-reach slopes vary from 1.0% to 7.0%, with steeper ranges at bedrock outcrops. Steeper slopes may be the result of past channel realignment.

Table 2: Interpreted Equilibrium Channel Form from Valley Characteristics

Reach Segment	Reference Stream Type[a]	Reach Type	Dominant Roughness Element	Comments
Melvin 1 (Melvin Village)	Bc (Plane bed)	Response[b]	Substrate, colluvial/glacial elements, woody material, and streambanks	Generally responsive to colluvial inputs (boulders; large woody debris) or significant upstream sediment supply (e.g., fining of bed)
Melvin 2a (County Rd)	C (Riffle-pool)	Response	Bed complexity, substrate, woody material, and/or sinuosity	Frequent colluvial and woody material along reach
Melvin 2b	Bc (Plane bed)	Response[b]	Substrate, colluvial/glacial elements, woody material, and streambanks	Generally responsive to colluvial inputs (boulders; large woody debris) or significant upstream sediment supply (e.g., fining of bed)
Melvin 3 (New Road wetland)	E (Riffle-pool)	Response	Bed complexity, substrate, woody material, and/or sinuosity	
Melvin 4	Cc- (Riffle-pool)	Response	Bed complexity, substrate, woody material, and/or sinuosity	Frequent colluvial and woody material along reach; likely insufficient capacity to convey particles delivered by upstream reach
Melvin 5 (Sodom Road)	B (Plane Bed or Step-pool)	Response[b]	Substrate, colluvial/glacial elements, woody material, and streambanks	Generally responsive to colluvial inputs (boulders; large woody debris) or significant upstream sediment supply (e.g., fining of bed)

[a] Per Rosgen (1994); Montgomery and Buffington (1993) stream type presented in parentheses

[b] In the context of managing the supply of sediments and nutrients to Moultonborough Bay, fine-grained sediments (which have relatively more surface area to bind nutrients and contaminants per unit weight than coarser sediments) tend to be of most importance. Fine-grained sediments are expected to readily transport through Plane Bed reaches except in cases of extreme sediment supply.

The Montgomery and Buffington (1993) stream classification system also identifies whether a given reach is expected to be a source of sediment (source reach), bypass for sediment (transport reach), or sink of sediment (response reach). As the name implies, response reaches are those reaches that respond to upstream factors and are generally more sensitive to anthropogenic disturbances. Thus, understanding whether a reach is a source, transport, or response reach is useful in a watershed context as it can be used to identify the sensitivity of a stream to anthropogenic disturbances. As an example, envision clearing a forest which may cause additional sediment erosion from the cleared surface. The additional sediment may have a negligible effect on source and transport reaches that generally have sufficient capacity to convey sediments delivered to them. Instead, the source and transport reaches may deliver the increased sediment supply to a downstream response reach which may have insufficient capacity to convey the increased sediment supply, resulting in the sediment depositing within the downstream reach. Reviewing Table 2, all delineated geomorphic reaches are response reaches that are more sensitive to change. However, Montgomery and Buffington (1993) note that Plane Bed channels such as Melvin 1, Melvin 2b, and Melvin 5 are generally responsive to excess sediment supply and/or colluvial inputs. In the context of sediment and nutrient management for Moultonborough Bay, fine-grained sediments are generally of the most concern and such sediments would be expected to be readily transported through these plane bed reaches except in the cases of extreme sediment supply.

Rapid Geomorphic Assessments

Following a preliminary delineation of stream reaches, Streamworks performed field visits to verify the breaks between geomorphic reaches and assess the current geomorphic condition and dominant channel processes of each geomorphic reach. On July 12, 2023, Streamworks walked the entirety of reaches 1 and 5 and performed a windshield survey of the other reaches, with site visits to publicly accessible portions of each stream reach, usually near stream crossings. In addition, the entirety of reaches 2 through 4 were reviewed by launching a kayak on August 9, 2023 near New Road and pulling out at County Road.

For each reach, Streamworks identified the appropriate Rapid Geomorphic Assessment data form from VANR's (2007) *Vermont Stream Geomorphic Assessment* based on the stream classification documented in Table 2 and visually confirmed the selected data form was appropriate to geomorphic observations. For each reach, Streamworks completed a single Rapid Geomorphic Assessment form based on representative conditions across that reach. Each data form contains a series of scoring matrices to assess the general condition of the reach in terms of the geomorphic adjustment processes: incision, aggradation, channel widening, and planform change. A score is assigned to each of several categories for each adjustment process based on visual observations, watershed conditions, and limited quantitative measurements. Based on these scores, the reviewer selects a general condition of the stream but is provided some leeway to assign a numeric score within the category for each adjustment process. Each form also contains a box to identify for when the reviewer opines the current field conditions are the result of historic adjustment processes that are no longer on-going.

Following the rapid geomorphic assessment, the numeric scores for each adjustment process are summed and divided by a "perfect score" of 80 to assign a numerical condition score that VANR's *Vermont Stream Geomorphic Assessment* correlates to a condition rating for the stream. VANR's *Vermont Stream Geomorphic Assessment* also provides a lookup table correlating Rosgen stream types to stream sensitivity which is reported on each form; Streamworks classification of each Rosgen stream type was based upon the reach-averaged slopes presented in Exhibit 2, review of channel field planform, field measurements of representative bankfull dimensions, and visual classification of channel substrate materials.

Completed data forms for each reach are provided in Appendix B. The field-identified channel type, representative bankfull width, geomorphic condition rating, interpreted channel adjustment process, and geomorphic sensitivity reported on each data form are summarized for ease of use in Table 3 as are potential impairments observed in the field. Key observations pertinent to understanding the geomorphic condition and function of the geomorphic reaches and identifying potential impairments are provided in Exhibit 4.

Stream Crossing Assessments

Concurrent to the Rapid Geomorphic Assessment, the New Hampshire Fish and Game Department (NHFG) performed assessments of stream crossings within the Melvin River watershed in June and July of 2023. NHFG performed stream crossing assessments in accordance with the 2022 procedures of the Statewide Asset Data Exchange System (SADES). The assessments were reviewed and approved by the New Hampshire Geological Survey in late 2023 and subsequently posted to the New Hampshire Department of Environmental Services' New Hampshire Aquatic Restoration Mapper (NHDES, 2024.) The results of the assessments as presented in the New Hampshire Aquatic Restoration Mapper are summarized in Table 3.

Table 3: Summary of NHFG Stream Crossing Assessments

Stream Crossing	Size and Type	Structural Condition	Geomorphic Compatibility	Aquatic Organism Passage Score
NH Route 109	24.6-ft W x 8.3-ft H concrete bridge	Good	Mostly Compatible	Reduced Passage
High Street	15.3-ft W x 9-ft H corrugated steel pipe-arch culvert with concrete bottom	Good	Mostly Compatible	No passage
County Road	Two-pier timber bridge	Good	N/A	N/A
Snowmobile trail below New Road	Multi-pier timber bridge with natural bottom	N/A	N/A	N/A
New Road	20.7-ft W x 10.1-ft H concrete bridge with riprap bottom	Poor	Fully Compatible	Reduced Passage
Snowmobile trail above New Road	34.8-ft W x 6.8-ft H timber bridge with natural bottom	Good	Fully Compatible	Full passage
Private trail below Sodom Road	Clear-span timber bridge with natural bottom	N/A	N/A	N/A
Sodom Road	22.0-ft W x 8.3-ft H concrete bridge with natural bottom	Good	Fully Compatible	Full passage

N/A = Not assessed by NHFG

NHFG's assessment of the stream crossings generally concurred with Streamworks' observations collected during the rapid geomorphic assessment summarized in Exhibit 4. One exception is New Road which Streamworks assessed to have full passage for aquatic organisms (due to backwatering) and impaired geomorphic compatibility due to restriction of the overall floodprone width through the crossing in comparison the upstream reach. In stream with wide floodplain, the constriction of floodplain flows through an otherwise channel-spanning bridge cause flow velocities and erosive forces to increase through the bridge, evidence of which is provided by the downstream scour pool. Beyond the New Road crossing, Streamworks identified both the snowmobile trail downstream of New Road and County Road, which were unassessed by NHFG, to have reduced geomorphic compatibility. Streamworks assessed the downstream snowmobile crossing to be at-risk for debris accumulation due the large number of piers and the County Road to be prone to scour due to its poor alignment with the Melvin River and narrow span.

Table 4: Summary of Impairments and Geomorphic Condition

Reach Segment	Stream Type; *BFW**	Potential Impairments	Channel Adjustment Process	Geomorphic Sensitivity	Condition Assessment	Comments
Melvin 1 (Melvin Village)	B3c (Plane-bed) *BFW ~ 27 / 31 ft (below / above Pope Dam)*	• Stream crossings • Active dam** • Abandoned dam • Channel realignment • Streambank armoring** • Some loss of riparian buffer (including via wooly adelgid)	Historic degradation (recession of Lake Winnipesaukee) and planform adjustment (County Road)	Moderate	61 / 80 "Good"	Local aggradation behind Pope Dam; channel likely armored due to geomorphic setting and low supply of substrate-size sediments from upstream reaches
Melvin 2a (County Rd)	C5 (Riffle-pool) *BFW ~ 32 ft*	• Upland logging • Some loss of riparian buffer (including via wooly adelgid)	Stable	High	65 / 80 "Good"	Some localized erosion where river abuts steep glacial till slopes, which are largely stabilized by hemlocks
Melvin 2b	B3c (Plane-bed) *BFW ~ 29 ft*	• Upland logging • Some loss of riparian buffer (including via wooly adelgid)	Dynamically stable	Moderate	77 / 80 "Reference"	Limited erosion at outside of stream meanders; some embedment of cobble substrate from upstream sediment supply
Melvin 3 (New Road wetland)	E5 (Riffle-pool) *BFW ~ 29 / 24 ft (below / above New Road)*	• Stream crossings • Some floodplain encroachment • Streambank armoring** • Some loss of riparian buffer (power line corridor)	Dynamically stable, with aggradation occurring where greater prevalence of beaver dams	High	64 / 80 "Good"	Reach likely is a sink of sediment / nutrients that deposit behind beaver dams and atop floodplain; reach may change rapidly if beaver dams are disturbed
Melvin 4	C5/2c- (Riffle-pool) *BFW ~ 29 ft*	• Some loss of riparian buffer	Stable	High	73 / 80 "Reference"	
Melvin 5 (Sodom Road)	B2 (Plane-bed *and* Step-pool) *BFW ~ 30 ft*	• Stream crossing • Abandoned dam • Channel realignment, likely from two above impairments • Some loss of riparian buffer	Historic degradation and planform change	Low	55 / 80 "Good"	Channel likely armored due to geomorphic setting and low supply of substrate-size sediments from upstream reaches

* BFW = Bankfull width; ** Likely beneficial for reduction of sediment and nutrients to Lake Winnipesaukee

Synthesis

Reviewing Table 4, each of the reaches in the Melvin River was categorized in "good" or "reference" condition, a reasonable finding given the relatively low degree of development in the watershed and relatively few direct anthropogenic impacts along the Melvin River and its floodplain. Half of these reaches are plane bed systems which are naturally less sensitive to geomorphic change due to their coarse substrates and low, generally forested, streambanks. This naturally lower sensitivity is likely a key factor contributing to the good and reference ratings for these plane bed stream types. This is most evidenced in Melvin 1 near Melvin Village and Melvin 5 near Sodom Road, which received the lowest condition scores of any the reaches. Both reaches have a history of anthropogenic impacts: revetments that constrict the channel width, multiple stream crossings, and dams that interrupt sediment supply impact most of Melvin 1 although there are few signs of on-going instabilities along this reach. In Melvin 5, the river appears to have been historically re-aligned as the result of past dam and/or bridge construction although the river is stable, in large part due to its coarse substrate. The location of these reaches downstream of low-gradient reaches also protects them from aggradation: the plane bed reaches generally have significantly higher transport capacity than the upstream reaches which are primarily transporting sands.

Although these plane bed systems have relatively lower geomorphic sensitivity, they are naturally responsive to colluvial processes that can include landslides and other hillslope processes. Such processes can introduce a substantial amount of sediment into the system that although may have a marginal impact on the geomorphic function of these reaches and their habitat, could have a large impact on the water quality of the Melvin River and/or Moultonborough Bay. An interesting example of this process is Newfound Lake: the sediments eroding from a landslide along a 300-foot section of a small tributary to the lake discolors the entire lake following heavy rainfalls.

An addition item of note to Melvin 1 and Melvin 5, also identified in Table 4, is that some of the impairments limiting the geomorphic function of these reaches may be benefitting Moultonborough Bay. Specifically, the perched High Street culvert and dams along Melvin 1 may be acting as a local grade controls limiting incision along this reach. Additionally, while the Pope Dam interrupts sediment transport and geomorphic processes, it also likely acts as a sink that traps sediments and associated nutrients that benefit the water quality of the Moultonborough Bay.

The remaining riffle-pool reaches, which generally have high sensitivity to geomorphic change, were all found to be in good condition and Melvin 4 was found to be in a reference condition. The relatively broad wetlands associated with these reaches and ample nearby developable land have likely deterred direct impacts to these reaches and prevented the degradation of their condition. These riffle-pool reaches have generally well-formed pool-riffle sequences, some woody debris, a diversity of streamside vegetation that provide a diverse patchwork of in-channel habitat, off-channel refugia, and riparian habitat. These reaches are also likely nutrient sinks (Ury et al, 2023) that benefit the water quality of Moultonborough Bay due to sediment deposition on their well-connected alluvial floodplains and temporary sediment storage behind beaver dams. Given the high geomorphic sensitivity of these systems and the potential that geomorphic disturbances can rapidly convert these systems from nutrient sinks to nutrient sources via streambank erosion, protection and conservation of these reaches should be a top priority for LWA.

Conclusions and Recommendations

Streamworks, under subcontract and in concert with FB Environmental Associates who led a habitat assessment, performed a rapid geomorphic assessment of Melvin River between Lake Winnipesaukee and Sodom Road on behalf of the Lake Winnipesaukee Association. The goal of the geomorphic assessment was to characterize the geomorphic conditions of the Melvin River, assess its potential to provide aquatic habitat, identify potential impairments, and identify in-stream and riparian opportunities to improve the geomorphic function of the Melvin River and improve water quality of Moultonborough Bay (noting per FBE [2000] that land use change and septic systems are large contributors to water quality issues.) In general, the Melvin River contains numerous riffle-pool reaches with broad wetland complexes that are in good geomorphic condition, provide a myriad of habitat, and likely act as sinks for sediments and nutrients that benefit the water quality of Lake Winnipesaukee; preservation of these reaches should be a top priority for LWA. Even the more heavily-impacted reaches are in good condition per VANR (2007) conditions, likely due to such reaches being naturally less sensitive to geomorphic change.

Based on Streamworks' geomorphic assessments and with the goal to preserve and improve the geomorphic function and habitat of the Melvin River while also protecting the water quality of Moultonborough Bay and Lake Winnipesaukee, Streamworks has developed a list of potential actions identified in Exhibit 5. The potential actions provided in Exhibit 5 have been prioritized according to three tiers:

1. **Tier 1, "High Priority"** opportunities would conserve existing, high-importance resources important to maintaining the water quality of Moultonborough Bay and/or prevent significant stream impairments (and ensuing sediment and nutrient runoff) before more significant and costly actions are necessary;
2. **Tier 2, "Moderate Priority"** opportunities include those opportunities that would benefit the geomorphic function and available habitat within the Melvin River and/or modestly reduce sediment and nutrient runoff to Moultonborough Bay; such benefits may be the project driver.
3. **Tier 3, "Opportunistic"** opportunities include those opportunities that would benefit the geomorphic function and available habitat within the Melvin River and/or reduce sediment and nutrient runoff to Moultonborough Bay, but, due to their anticipated increased complexity and/or cost relative to their expected gain, are expected to be secondary project drivers that occur coincident with other actions (e.g., replacement of a stream crossing for structural reasons) or targeted grant opportunities.

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Brooks, J.A. and Tinkham, D.J. (2015). *Surficial Geologic Map of the Melvin Village Quadrangle, Carroll and Belknap Counties, New Hampshire, Open-File Series GEO-099-024000-SMOF*. New Hampshire Geological Survey and New Hampshire Department of Environmental Services.

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Vermont Agency of Natural Resources (VANR; 2007). *Vermont Stream Geomorphic Assessment, Phase 1 Handbook: Watershed Assessment*. Prepared by DEC River Management Program. May.

Exhibits

Streamworks, PLLC
45 Evans Road, Madbury, NH 03823 | (207) 303-0534 | e-mail: jwoidt@streamworkspllc.com

SURFICIAL GEOLOGIC MAP
OPEN-FILE SERIES GEO-099-024000-SMOF

Frederick Chormann
State Geologist

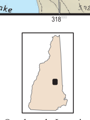
SURFICIAL GEOLOGIC MAP OF THE MELVIN VILLAGE QUADRANGLE
Belknap and Carroll Counties, New Hampshire

Base map (provisional) by the U.S. Geological Survey, 1987, Ashland, New Hampshire. 10,000-foot grid ticks based on New Hampshire coordinate system. 1000-meter Universal Transverse Mercator grid ticks, Zone 19. Horizontal Datum: 1927 North America Datum.

SCALE 1:24,000

Contour Interval 20 Feet

Declination 16 deg.



Quadrangle Location
GRANIT Tile No. 99

DESCRIPTION OF MAP UNITS

af — **Artificial Fill (Holocene)**

aft — **Landfill Material (Holocene)**

Wetland Deposits (Holocene) - Generally 5 to 10 feet thick. Muck, peat, silt, and sand.

Surface Water

Bedrock Exposure or Area of Abundant Exposure

NON-GLACIAL DEPOSITS (Pleistocene to Holocene)

Qal — **Alluvium (Holocene)** - Sand, pebbles, cobbles, and boulders in active floodplains along rivers and streams. Up to 20 feet thick.

Qst — **Stream Terrace (Pleistocene to Holocene)** - Sand terraces deposited at higher elevations than current streams. Formed in part during late glacial time. Up to approximately 30 feet thick.

Ql — **Lakeshore Deposit (Pleistocene to Holocene)** - Lacustrine deposits formed by the post-glacial re-working of sand to pebbles along the shorelines of lakes and ponds. Deposits grade to the present lake and pond elevations. Up to 15 feet thick.

UNCORRELATED GLACIOFLUVIAL DEPOSITS (Pleistocene)

Qgu — **Undifferentiated Sand and Gravel Deposit** - Glaciofluvial sand and gravel deposits uncorrelated with a specific spillway or lake deposit. Likely formed during short-term meltwater events near the ice margin. Up to 40 feet thick.

Qf1 - 5 — **Fan Deposits** - Silty sand to cobble glaciofluvial deposits derived from reworked glacial sediments (Photo 3). Formed in part during post-glacial time as sub-aerial fans of braided streams (Inset 3). Qf1, Qf5, and Qf7: Developed from glacial and meteoric water flowing out of Ossipee Mountains. Qf3: Source of sediment in large part from deeply incised meltwater channel at northern end of fan.

Qic1 - 5 — **Ice Contact Deposits** - Silty sand to cobble glaciofluvial deposits that developed along ice margin. Qic1: Developed between ice and hillside. Possibly graded to Glacial Lake New Durham. Qic2: Developed between ice and hillside. Qic3: Graded to approximately 720-foot elevation. Qic4: Irregular hills of sand to cobbles (Photos 1 and 2). Possibly ablation till. Qic5: Developed along southern flank of Ossipee Mountains. Possible eskers.

Lake Winnipesaukee Deposits

Lake Winnipesaukee formed after the glacier receded past the Winnipesaukee River outlet, allowing Glacial Lake New Durham to lower to a nick point at Weirs Beach. During the continued recession of the glacier through the region, Lake Winnipesaukee remained in contact with the ice margin and a series of glaciofluvial and glaciolacustrine deposits formed around the perimeter of the Lake. The elevations of the paleo-lake surface within the quadrangle range from approximately 515 feet (southeast corner of quadrangle) to 560 feet (northwest corner of quadrangle).

Qgsc — **Shannon Cemetery Deposit** - Silty sand to pebble glaciofluvial to glaciolacustrine deposit graded to the level of paleo-Lake Winnipesaukee. Lower portion of deposit was reworked by wave action as the lake level lowered in response to post-glacial crustal rebound. Local exposures of till occur within deposit. Up to 30 feet thick.

Qgmb — **Meadow Brook Deposit** - Sand to pebble glaciofluvial to glaciolacustrine deposit. Portions of the deposit graded to the level of paleo-Lake Winnipesaukee. Up to 40 feet thick.

Qglw — **Lake Winnipesaukee Deposit** - Silty sand to pebble glaciofluvial to glaciolacustrine deposits grading to paleo Lake Winnipesaukee. Up to 20 feet thick.

Qgtb — **Twenty Mile Brook Deposit** - Silty sand to pebble glaciofluvial to glaciolacustrine deposit graded to the level of paleo-Lake Winnipesaukee. Up to 30 feet thick.

Qgnb — **Nineteen Mile Brook Deposit** - Silty sand to pebble glaciofluvial to glaciolacustrine deposit graded to the level of paleo-Lake Winnipesaukee. Up to 30 feet thick.

Glacial Lake New Durham Deposits

Glacial Lake New Durham, named for the location of its spillway, was first described by Goldsmith (1995) during his mapping of the Alton Quadrangle. During the recession of the glacier through the area, this glacial lake remained in contact with the ice margin and a glaciolacustrine deposit (Qlnb) graded to the lake level. In addition, an ice contact deposit (Qic1) may have graded to this lake.

Qlnb — **Nineteen Mile Brook Deposit** - Silty sand to pebble glaciolacustrine deposit. Distal end of glaciofluvial deposit grades to approximately 620 feet. Up to 40 feet thick.

GLACIAL TILL

Qtt — **Thin Till** - Area of bedrock exposures or till deposits interpreted to be less than 10 feet thick.

Qt — **Till** - Non- to poorly-sorted mixture of silt, sand, pebbles, and Basal till is very compact, light to dark gray, and limited to only a few exposures.

EXPLANATION OF MAP SYMBOLS

- Estimated shoreline of Paleo-Lake Winnipesaukee
- Meltwater channel
- Ice Margin
- Gravel pit extent
- Stream-lined Hills *Symbol oriented in interpreted direction of ice flow.*
- NHGS Well Data: Number posted is depth to bedrock in feet.
- **Photo 1** Location of photograph on map.

LEGEND FOR SEDIMENT TEXTURES

- **Mixed sand and gravel**
- **Sand**

MAP PREPARATION

Surficial mapping completed by John A. Brooks and Daniel J. Tinkham (consulting geologists at Emery & Garrett Groundwater Investigations, LLC) during the 2015 field season.

Representative Photographs of the Map Area

Photos 1: Sand and irregular ground surface of ice contact deposit Qic4.

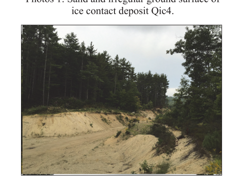


Photo 2: Large drop stone in ice contact deposit Qic4.

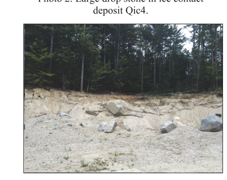


Photo 3: Sand and cobbles in proximal portion of Fan Qf3.

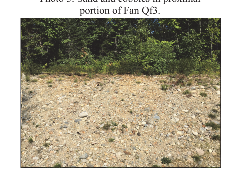
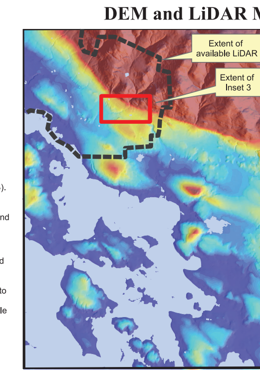
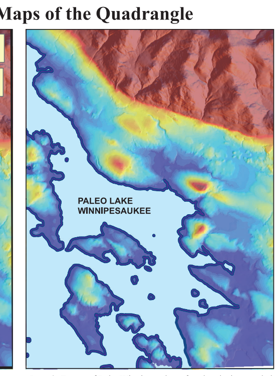


Photo 4: Copps Pond Wetland

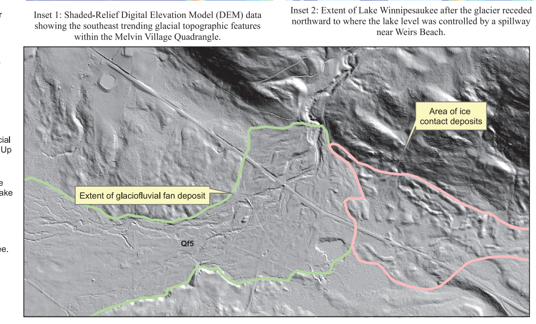
DEM and LiDAR Maps of the Quadrangle



Inset 1: Shaded-Relief Digital Elevation Model (DEM) data showing the southeast trending glacial topographic features within the Melvin Village Quadrangle.

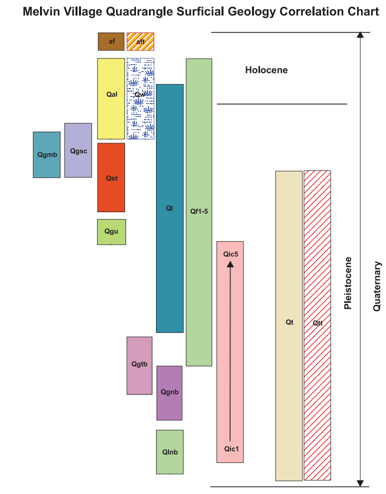


Inset 2: Extent of Lake Winnipesaukee after the glacier receded northward to where the lake level was controlled by a spillway near Weirs Beach.



Inset 3: LiDAR data showing braided stream morphology of fan deposit Qf5 and an area of ice contact deposits along the south side of the Ossipee Mountains. Extent of Inset 3 is displayed as red box in Inset 1.

Melvin Village Quadrangle Surficial Geology Correlation Chart



Glacial Geology of the Melvin Village Quadrangle

The surficial geologic map of the Melvin Village, New Hampshire, 7.5-minute Quadrangle shows the lateral distribution of the unconsolidated surficial materials (e.g., alluvium, glacial till, sand and gravel) and bedrock exposed at the ground surface. The unconsolidated sediments largely reflect deposition related to the most recent period of continental glaciation (which ended approximately 14,000 years ago) and post-glacial deposition within fans and along streams and rivers. The advance and retreat of the glacial ice resulted in the deposition of an assortment of surficial deposits and the formation of a variety of landforms.

As the continental glacier advanced through the area, it scoured the paleo-landscape, mobilizing vast quantities of pre-glacial sediment and bedrock fragments. These materials were entrained at the bottom of the glacier, where they were crushed and then re-deposited directly beneath the ice mass as till deposits, which are present as a thin veneer of poorly-sorted sediments over a majority of the Melvin Village Quadrangle. Some of the till was deposited as streamlined hills, the orientation of which (approximately 120 – 130 degrees east of north) indicates the direction of glacial advancement through the Quadrangle.

As the glacial period ended, the ice sheet began to melt and retreat through the Melvin Village Quadrangle. During this retreat, glacial meltwater and precipitation remobilized much of the sediment that was previously entrained within the advancing glacial ice.

Due to the depression of the land surface beneath the continental glacier, the overall ground surface within the Quadrangle was tilted during the glacial period (sloped) approximately 4.8 feet/mile in a N25W direction (Koteff et.al., 1993). As a result, the northwestern portion of the Quadrangle was approximately 50 feet lower than the current elevation.

As the glacier retreated through the Quadrangle, Glacial Lake New Durham remained in contact with the front of the ice sheet as it flooded lowlands of the Winnipesaukee Valley (Tinkham and Brooks, 2004; Brooks and Tinkham, 2008; Goldsmith, 1994). After the glacier retreated north of Belknap Point, in Gilford, New Hampshire the water in the Lake gradually emptied through Winnipesaukee River to a level (513') controlled by a nick point at Weirs Beach (Brooks and Tinkham, 2012). A number of the glacial deposits within the Melvin Village Quadrangle are associated with the paleo-shoreline of Lake Winnipesaukee.

A number of the glacial "ice-contact" deposits appear to have been bounded by active or stagnant ice blocks. Because these deposits were laid down within or on the melting ice sheet, the present day ground surface within the deposits is typically highly irregular, hilly, and hummocky (Photos 1 and 2).

Syn- to post-glacial alluvial fan deposits developed from sediments derived directly from the glaciers or from post-glacial streams which eroded into the glacial till and other deposits (Photo 3). The largest of these fans emanate from valleys on the south side of the Ossipee Mountains.

As the water level in Lake Winnipesaukee lowered to its current level, post-glacial erosion and reworking of glacial sediments along the receding shoreline of Lake Winnipesaukee resulted in the local development of wave washed sediments and tills. More recent reworking of glacial deposits (largely till) has resulted in the development of numerous sandy "pocket" beaches in coves along the shoreline of Lake Winnipesaukee.

Post-glacial fluvial processes have also eroded and modified the glacial topography and landforms. Sediments remobilized during the erosion were deposited as alluvial deposits within numerous streams and rivers. In addition, wetlands and ponds have formed throughout the irregular glacial landscape and poorly-drained till areas, and within lowlands that were filled with stagnant ice during deposition of the surrounding glacial deposits.

References:

Brooks, John A. and Tinkham, Daniel J., 2008, Surficial geologic map of the Wolfeboro Quadrangle, Belknap, Carroll, and Strafford Counties, New Hampshire: N.H. Geological Survey and U.S. Geological Survey, color, scale 1:24,000. New Hampshire Geological Survey Number Geo-113-024000-SMOF.

Brooks, John A. and Tinkham, Daniel J., 2012, Surficial geologic map of the Center Harbor Quadrangle, Belknap and Carroll Counties, New Hampshire: N.H. Geological Survey and U.S. Geological Survey, color, scale 1:24,000. New Hampshire Geological Survey Number Geo-198-024000-SMOF.

Goldsmith, R., 1994, Surficial Geologic Map of the Alton Quadrangle, Belknap and Carroll Counties, New Hampshire, 1:24,000, N.H. Department of Environmental Services Open File Map: OFR-95-1.

Tinkham, Daniel J. and Brooks, John A., 2004, Surficial Geologic Map of the West Alton 7.5 minute quadrangle, New Hampshire: STATEMAP 2003, color, scale 1:24,000. New Hampshire Geological Survey Number Geo-112-024000-SMOF.

Koteff, C., Robinson, G. R., Goldsmith, R., and Thompson, W.B., 1993, Delayed Postglacial Uplift and Synglacial Sea Levels in Coastal Central New England. Quaternary Research, 40: 46 – 54.

Other Sources of Data:

Swamp deposits and boundaries of lakes were modified from NH GRANIT GIS database layers for the National Wetland Inventory (NWI) and surface water (NHarea), respectively. Soil distributions from the Soil Survey Geographic (SSURGO) database for New Hampshire were also referenced. Well information was obtained from the NHGS Water Well Inventory.

Goldthwait, R.P., 1968, Surficial Geology of the Wolfeboro-Winnipesaukee Area, New Hampshire: 60 p. with illus. and map, color, scale 1:62500. New Hampshire Geological Survey Number Geo-034-062500-SBSM.

Surficial Geologic Map of the Melvin Village Quadrangle Carroll and Belknap Counties, New Hampshire

By John A. Brooks and Daniel J. Tinkham

2015
Surficial Geologic Map Open-File Series GEO-099-024000-SMOF
Digital Compilation By: Emery & Garrett Groundwater Investigations, LLC

Funding for the preparation and digitization of this map was provided by the U.S. Geological Survey STATEMAP Program Announcement Number G14AC00427, and by the New Hampshire Geological Survey, New Hampshire Department of Environmental Services.

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Concord, NH 03302-0095
Phone: 603-271-1976
E-mail: geology@des.nh.gov

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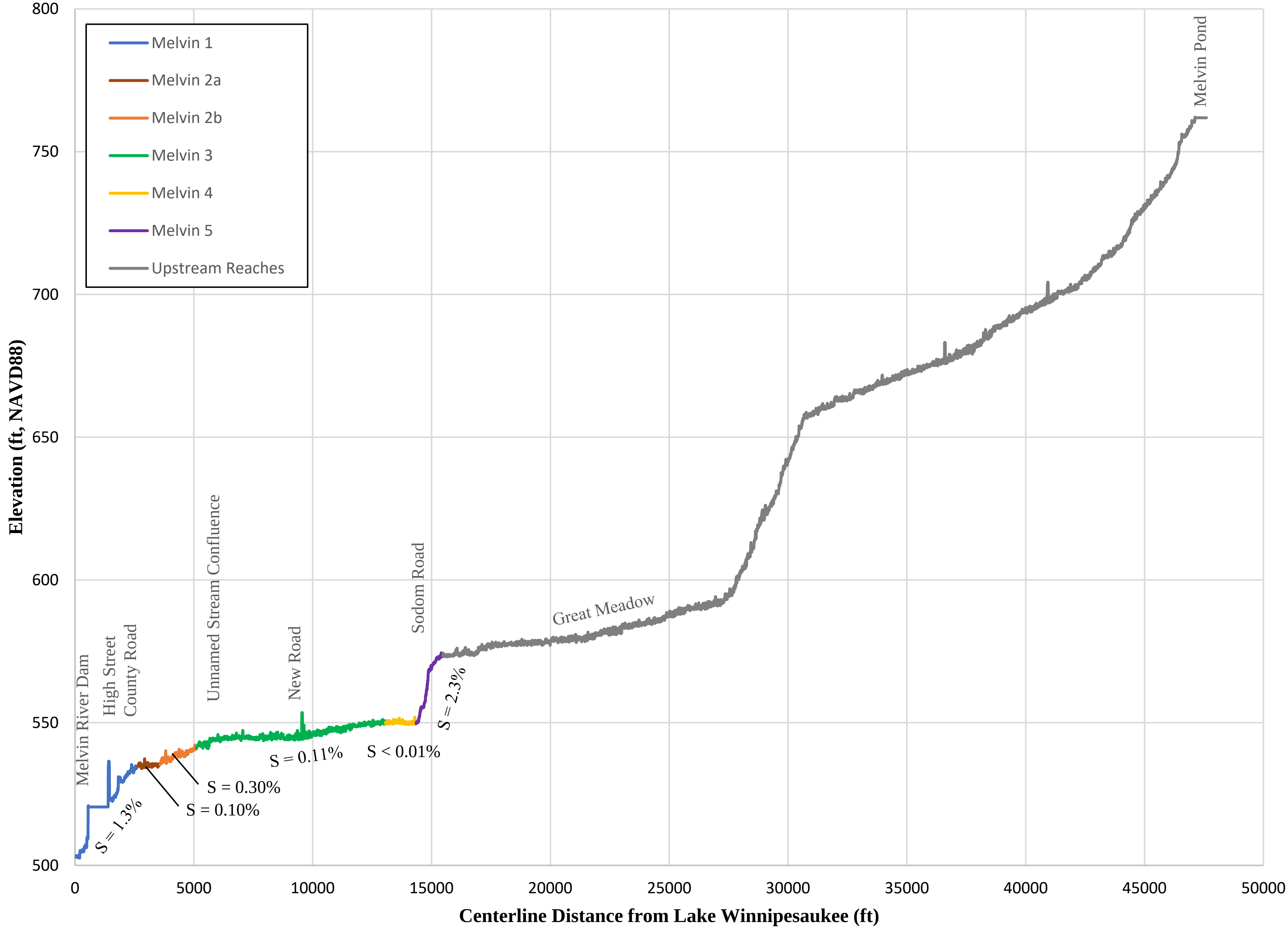
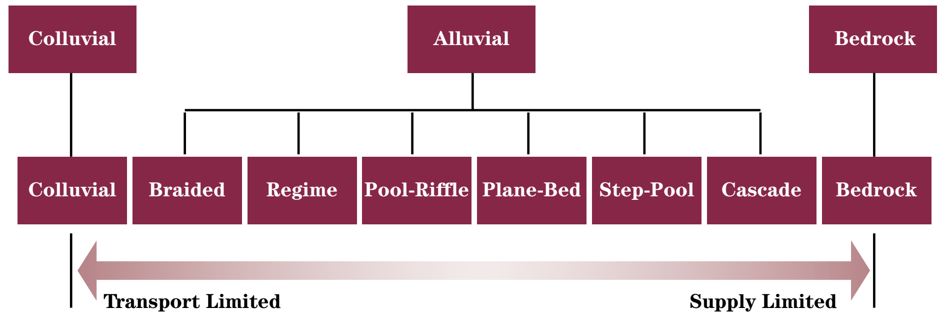


Exhibit 2 - Longitudinal Profile of Melvin River

Melvin River Geomorphic and Habitat Assessment

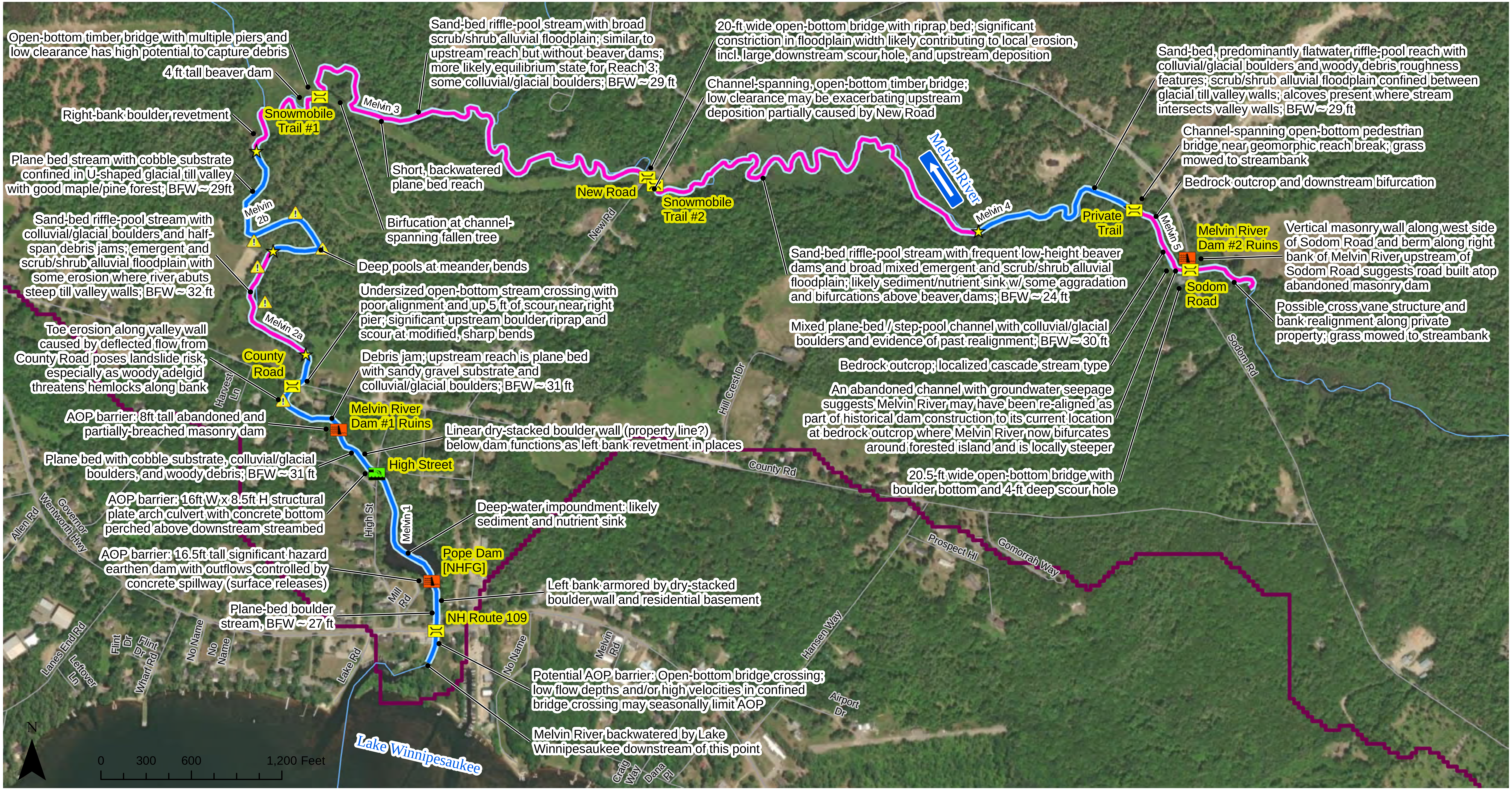
Rapid Geomorphic Assessment



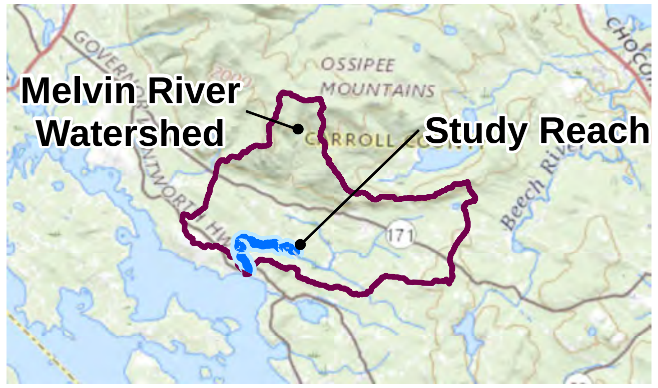
	Braided	Regime	Pool-Riffle	Plane-Bed	Step-Pool	Cascade	Bedrock	Colluvial
Typical Bed Material	Variable	Sand	Gravel	Gravel, cobble	Cobble, boulder	Boulder	N/A	Variable
Bedform Pattern	Laterally oscillary	Multi-layered	Laterally oscillary	None	Vertically oscillary	None	•	Variable
Reach Type	Response	Response	Response	Response	Transport	Transport	Transport	Source
Dominant Roughness Elements	Bedforms (bars, pools)	Sinuosity, bedforms (dunes, ripples, bars) banks	Bedforms (bars, pools), grains, LWD, sinuosity, banks	Grains, banks	Bedforms (steps, pools), grains, LWD, banks	Grains, banks	Boundaries (bed & banks)	Grains, LWD
Dominant Sediment Sources	Fluvial, bank failure, debris flow	Fluvial, bank failure, inactive channel	Fluvial, bank failure, inactive channel, debris flows	Fluvial, bank failure, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Fluvial, hillslope, debris flow	Hillslope, debris flow
Sediment Storage Elements	Overbank, bedforms	Overbank, bedforms, inactive channel	Overbank, bedforms, inactive channel	Overbank, inactive channel	Bedforms	Lee & stoss sides of flow obstructions	•	Bed
Typical Slope (m/m)	$S < 0.03$	$S < 0.001$	$0.001 < S$ and $S < 0.02$	$0.01 < S$ and $S < 0.03$	$0.03 < S$ and $S < 0.08$	$0.08 < S$ and $S < 0.30$	Variable	$S > 0.20$
Typical Confinement	Unconfined	Unconfined	Unconfined	Variable	Confined	Confined	Confined	Confined
Pool Spacing (Channel Widths)	Variable	5 to 7	5 to 7	none	1 to 4	< 1	Variable	Variable

Source: Montgomery and Buffington, 1993.

Exhibit 3 - Montgomery and Buffington (1993) Stream Classification System (Reproduced from NRCS [2007] National Engineering Handbook)



Geomorphic Reach Break
Bridge
Culvert
Dam
Streambank Erosion
Geomorphic Reaches
Other Drainage
Melvin River Watershed
Town Boundary
Waterbody

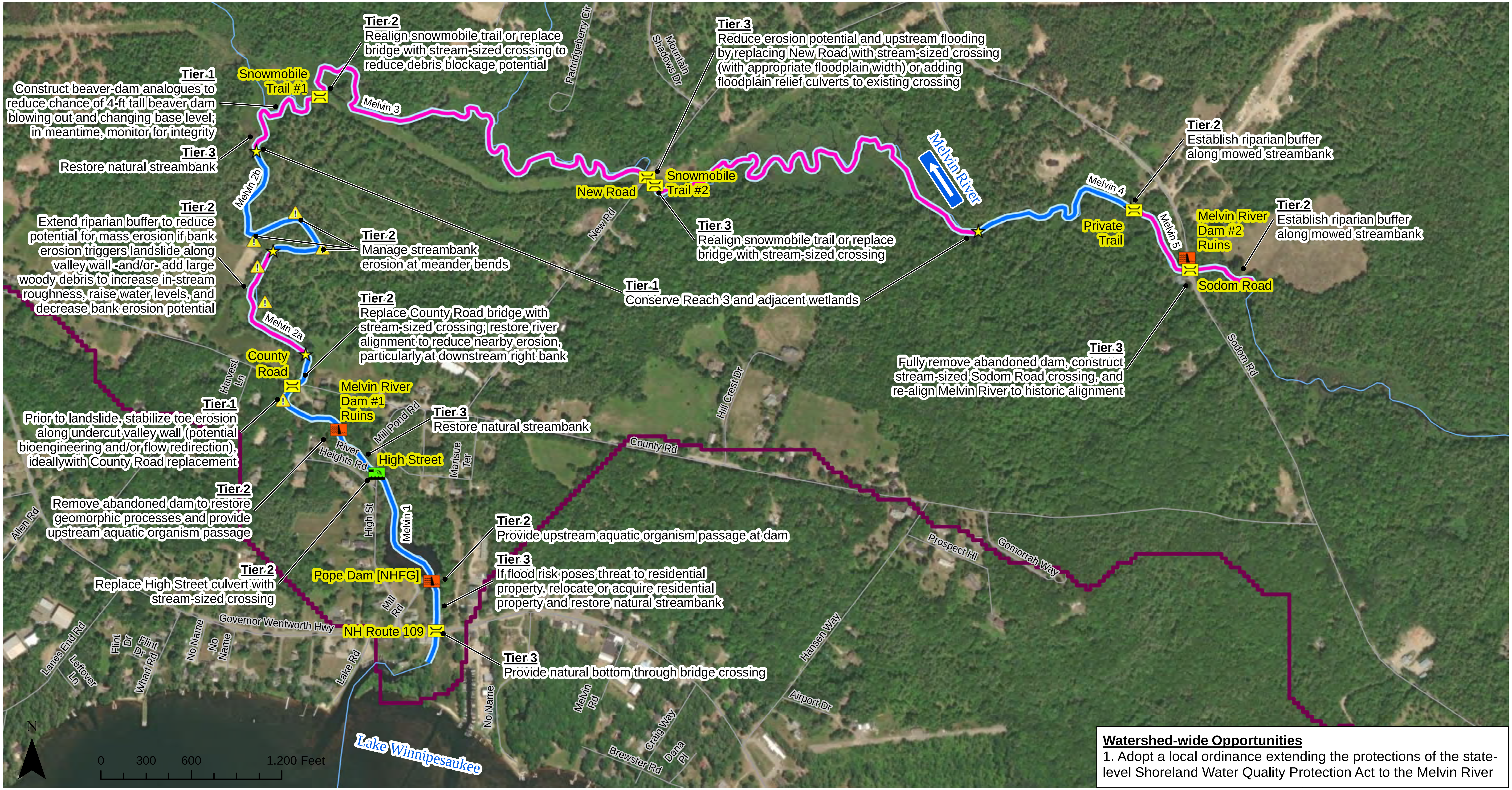


4. Geomorphic Summary

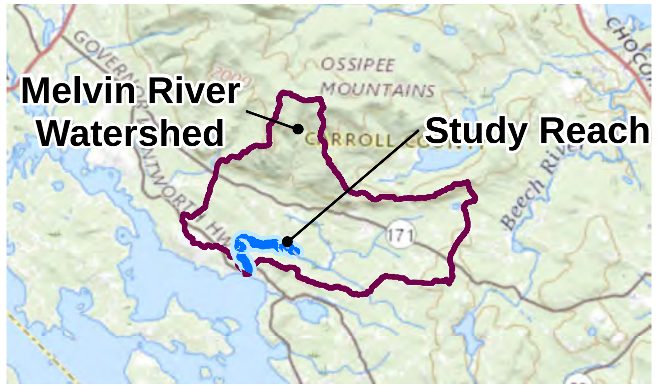
Melvin River (Lake Winni to Sodom Rd)

HUC 12-010700020104

Data Source: ESRI DigitalGlobe, NH GRANIT, USGS
Created By: J Woidt / Streamworks
Date Created: December 7, 2023
Map for planning purposes only.



- Geomorphic Reach Break
- Bridge
- Culvert
- Dam
- Streambank Erosion
- Geomorphic Reaches
- Other Drainage
- Melvin River Watershed
- Town Boundary
- Waterbody



5. Potential Actions

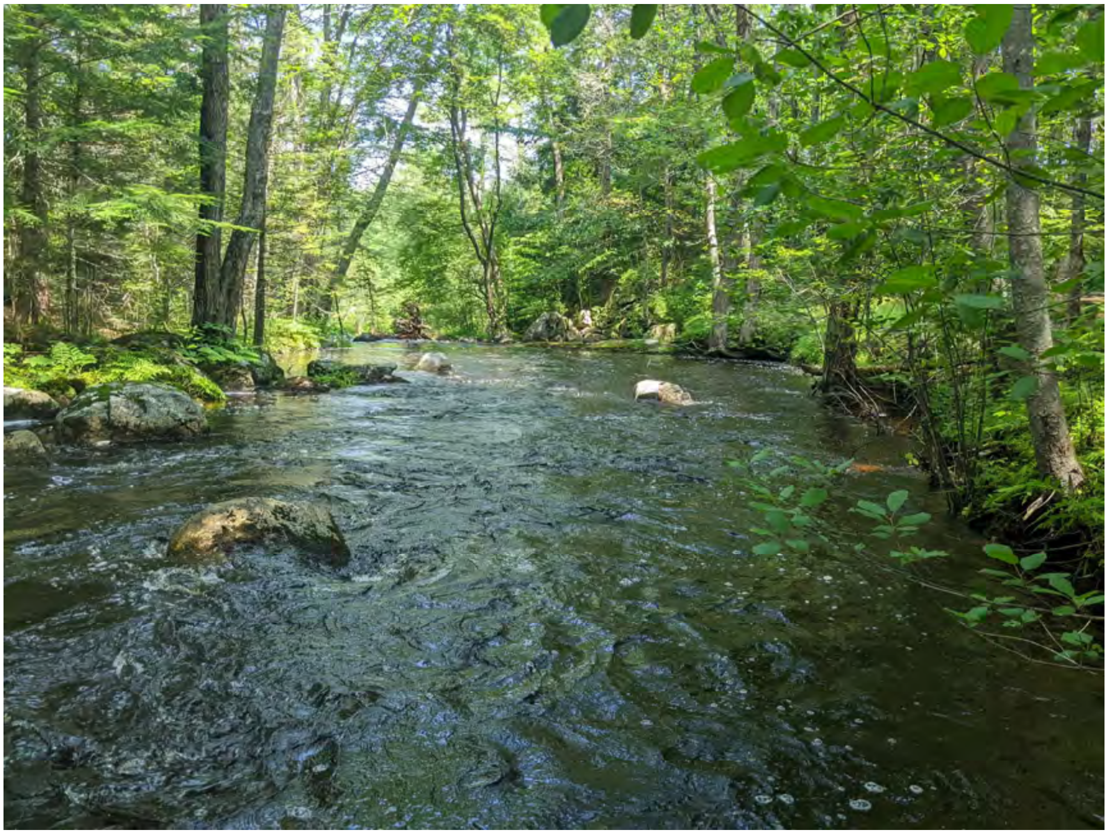
Melvin River (Lake Winni to Sodom Rd)

HUC 12-010700020104

Data Source: ESRI DigitalGlobe, NH GRANIT, USGS
Created By: J Woidt / Streamworks
Date Created: October 12, 2023
Map for planning purposes only.

Appendix A

Representative Photographs



Photograph 1: Representative photograph of Melvin 5, downstream of bifurcation / realignment

Photograph 2: Downstream end of bifurcation / realignment below Sodom Road

Photograph 3: Representative photograph of Melvin 4, note flatwater

Photograph 4: Representative photograph of colluvial material and woody debris throughout Melvin 4

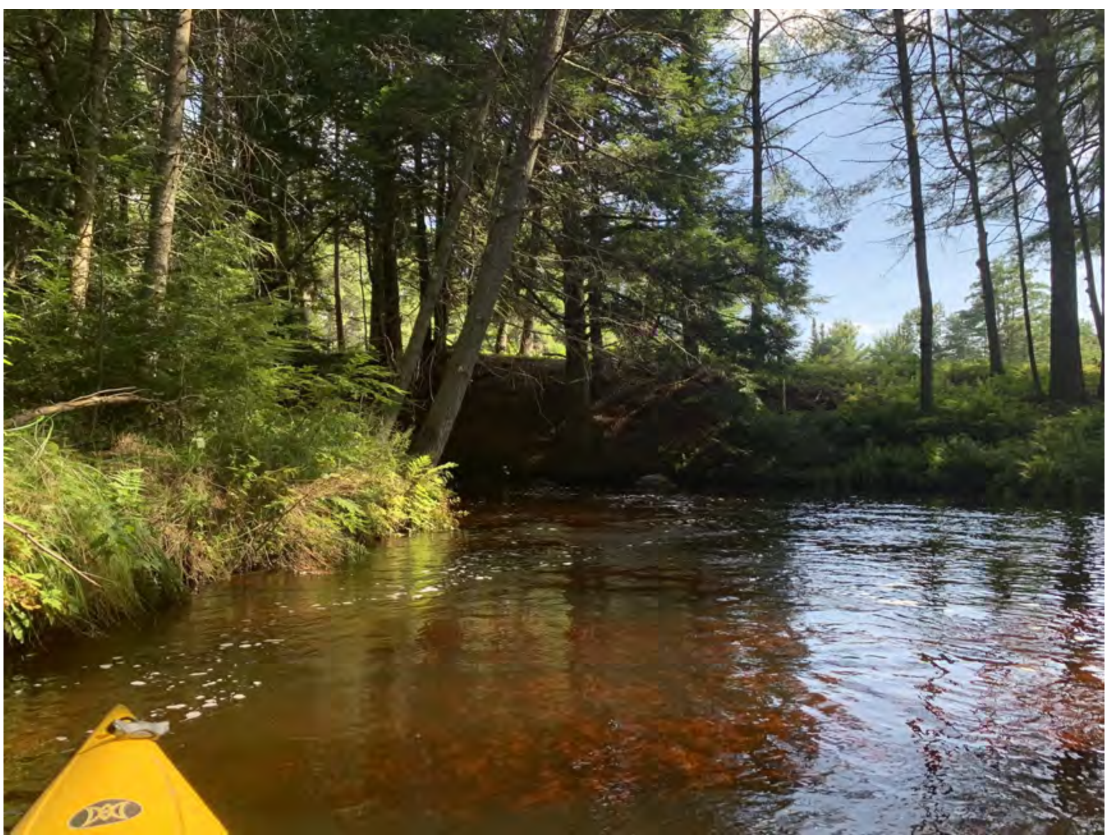
Photograph 5: Representative photograph of Melvin 3 upstream of New Road

Photograph 6: Typical beaver dam frequent across Melvin 3 upstream of New Road

Photograph 7: Representative photograph of Melvin 3 downstream of New Road

Photograph 8: Beaver dam controlling water levels of much of Melvin 4 downstream of New Road

Photograph 9: Representative photograph of Melvin 2b



Photograph 10: Typical pool at meander bend / valley wall contact in Melvin 2b

Photograph 11: Representative photograph of Melvin 2a, note woody debris

Photograph 12: Representative photograph of Melvin 2a, note variable water depths

Photograph 13: Representative photograph of Melvin 1a, upstream of Melvin River Dam #1

Photograph 14: Representative photograph of Melvin 1a, upstream of NH Route 109

Photograph 15: Modified section of Melvin 5 and mowed lawn, upstream of Sodom Road

Photograph 16: Sodom Road crossing of Melvin River

Photograph 17: Masonry on downstream slope of Sodom Road, potentially former dam

Photograph 18: Trail crossing at upstream end of Melvin 4

Photograph 19: Snowmobile crossing upstream of New Road

Photograph 20: New Road crossing of Melvin River, note erosion on left side (right bank)

Photograph 21: Snowmobile crossing at downstream end of Melvin 3

Photograph 22: Revetment at downstream end of Melvin 3

Photograph 23: County Road crossing of Melvin River, note poor alignment with river

Photograph 24: Undercut streambanksstabilized by hemlocks downstream of County Road

Photograph 25: Culvert conveying Melvin River beneath High Street

Photograph 26: Pope Dam impoundment

Photograph 27: Pope Dam

Photograph 28: NH Route 109 crossing of Melvin River

Appendix B

Rapid Geomorphic Assessment Data Forms

VT RAPID GEOMORPHIC ASSESSMENT ----- PLANE BED STREAMS

Typically found in semi-confined to narrow valley types (confinement ratio ≥ 3 and ≤ 5)

Reminder: This RGA form should only be used on streams which are plane bed systems by reference. Many existing plane bed streams in Vermont represent a departure from another stream type.

Stream Name: Melvin River

Location: Melvin Village (Lake Winne to 550 feet downstream of County Rd)

Observers: M. Kelly-Boyd / S. Large / B. Rossiter / J. Woidt

Organization /Agency: FBE / FBE / WPA / Streamworks

Reference Stream Type: B (Plane Bed) ☐ Modified

(If alluvial fan or naturally braided system see Handbook Protocols)

Segment I.D: 1a

Date: July 12, 2023

Town: Tuftonboro, NH

Elevation: 500 +/- ft.

Weather: Sunny

Rain Storm within past 7 days: [Y] / N

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.1 Channel Degradation (Incision)	☐ Little evidence of localized slope increase or nickpoints.	☑ Minor localized slope increase or nickpoints.	☐ Sharp change in slope, head cuts present, and/or tributaries rejuvenating.	☐ Sharp change in slope and / or multiple head cuts present. Tributaries rejuvenating.
• Exposed till or fresh substrate in the stream bed and exposed infrastructure (bridge footings). • New terraces or recently abandoned floodplains.	☐ Incision ratio ≥ 1.0 < 1.2 **and** Where channel slope > 2% Entrenchment ratio > 1.4; Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 1.2 < 1.4 **and** Where channel slope > 2% Entrenchment ratio > 1.4; Where channel slope ≤ 2% Entrenchment ratio > 2.0	☑ Incision ratio ≥ 1.4 < 2.0 **and** Where channel slope > 2% Entrenchment ratio > 1.4; Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **and** Where channel slope > 2% Entrenchment ratio ≤ 1.4; Where channel slope ≤ 2% Entrenchment ratio ≤ 2.0
• Headcuts, or nickpoints that are 2-3 times steeper than typical riffle. • Freshly eroded, vertical banks.	☐ No significant human-caused change in channel confinement or valley type.	☑ Only minor human-caused change in channel confinement but no change in valley type.	☐ Significant human-caused change in channel confinement enough to change valley type, but still not narrowly confined.	☐ Human-caused change to a narrowly confined valley type.
• Alluvial (river) sediments that are imbricated (stacked like dominoes) high in bank. • Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary.	☐ No evidence of historic or present channel straightening, gravel mining, dredging and/or channel avulsions.	☑ Evidence of minor mid-channel bar scalping and/or channel avulsion, but minor to no historic channel straightening, gravel mining or dredging.	☐ Evidence of significant historic channel straightening, dredging, gravel mining and/or channel avulsions.	☐ Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsion.
Stream Type Departure ☐ **Type of STD:**	☑ No known flow alterations (i.e., increases in flow or decreases in sediment supply).	☐ Minor flow alterations, some flow increase and/or minor reduction of sediment load.	☐ Major historic flow alterations, greater flows and/or reduction of sediment load.	☐ Major existing flow alterations, greater flows and/or reduction of sediment load.
Score: **Historic** ☑	20 19 18 17 16	15 14 13 [12] 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Reference	Good	Fair	Poor
7.2 Channel Aggradation	☐ Minor side, point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☑ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
• Very shallow pocket pools around and below boulders. • Abundant sediment deposition on side, point and mid-channel bars and extensive sediment deposition at obstructions, channel constrictions, and at the upstream end of tight bendways. Islands may be present.	☑ No apparent increase in fine gravel/sand substrates (pebble count).	☐ Some increase in fine gravel/sand substrates that may comprise over 50% of the sediments.	☐ Large increase in fine gravel/sand substrates that may comprise over 70% of the sediments. Fine sediment feels soft underfoot.	☐ Homogenous fine gravel/sand substrates may comprise over 90% of the sediments. Fine sediment feels soft underfoot.
• Most of the channel bed is exposed during typical low flow periods.	☑ Low width/depth ratio W/d ≤ 20	☐ Low to moderate W/d ratio W/d >20 ≤ 30	☐ Moderate to high W/d ratio W/d >30 ≤ 40	☐ High width/depth ratio W/d >40
• Increased frequency of woody debris in channel.	☑ No known flow alterations (i.e., decrease in flow or increase in sediment supply).	☐ Minor reduction in flow and/or increase in sediment load. Flood-related sediment working through reach, seen as enlarged bars.	☐ Major historic flow alterations, reduction in flows and / or increase in sediment load.	☐ Major existing flow alterations, extreme reduction in flows and / or increase in sediment load.
• Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel. **Stream Type Departure** ☐ **Type of STD:** aggrading at dam	☐ No human-made constrictions causing upstream deposition.	☑ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive upstrm / dwnstrm deposition and flow bifurcation.
Score: **Historic** ☐	20 19 [18] 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.3 Widening Channel • Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together. • Erosion on both right and left banks in riffle sections. • Recently exposed tree roots (fresh roots are ‘green’ and do not break easily, older roots are brittle and will break easily in your hand). • Fracture lines at the top of the bank that appear as cracks parallel to the river. • Mid-channel bars and side bars may be present. • Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.	☑ Low width/depth ratio W/d ≤ 20	☐ Low to moderate W/d ratio W/d >20 ≤ 30	☐ Moderate to high W/d ratio W/d >30 ≤ 40	☐ High width/depth ratio W/d >40
	☐ Little to no scour and erosion at the base of both banks. Negligible bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	☑ Minimal to moderate scour and erosion at the base of both banks. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Moderate to high scour and erosion at the base of both banks. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Continuous and laterally extensive scour and erosion at the base of both banks. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
	☐ Incision Ratio ≥ 1.0 < 1.2 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.2 < 1.4 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☑ Incision Ratio ≥ 1.4 < 2.0 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **and** Where channel slope > 2% Entrenchment ratio ≤ 1.4 Where channel slope ≤ 2% Entrenchment ratio ≤ 2.0
	☑ Minor side, point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☑ No known channel and / or flow alterations (i.e., increase in flow and/or change in sediment supply).	☐ Minor increase in watershed input of flows or sediment. Episodic (flood) discharges through reach resulting in short-term enlargement.	☐ Major channel and / or flow alterations, increase in flows and/or change in sediment load (increase or decrease).	☐ Major and extensive -channel and/or flow alterations, increase in flows and / or change in sediment load (increase or decrease).
Score: Historic ☐	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.4 Change in Planform • Flood chutes may be present. • Channel avulsions may be evident or impending. • Change or loss in bed form structure, sometimes resulting in a mix of plane bed and riffle- pool forms. • Island formation and/or multiple thread channels.	☑ Low bank erosion on outside bends, little or no change in sinuosity within the reach.	☐ Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	☐ Moderate to high lateral bank erosion on most outside bends, may include moderate change in sinuosity.	☐ Extensive lateral bank erosion on most outside bends, may include major change in sinuosity within the reach.
	☑ Little evidence of flood chutes crossing inside of bends, only minor side, point, or delta bars.	☐ Minor flood chutes crossing inside of bends, evidence of single to multiple unvegetated mid-channel, delta, or diagonal bars. Some potential for channel avulsion.	☐ Historic or active flood chutes crossing inside of bends, evidence of channel avulsion, islands, and multiple unvegetated mid-channel, delta, or diagonal bars.	☐ Active large flood chutes, evidence of recent channel avulsion, multiple thread channels, islands, and multiple unvegetated mid-channel, delta, or diagonal bars.
	☐ No human-caused alteration of channel planform and / or the width of the floodprone area.	☑ Minor to moderate alteration of channel planform and/or width of the floodprone area resulting from floodplain encroachment, channel straightening, or dredging.	☐ Major alteration of channel planform and/or the width of the floodprone area resulting from historic floodplain encroachment, dredging, or channel straightening.	☐ Major alteration of channel planform and width of the floodprone area resulting from recent and extensive floodplain encroachment, dredging, and/or channel straightening.
	☐ Human-made constrictions causing only negligible upstream deposition.	☑ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive and major upstrm / downstrm deposition and flow bifurcation.
Score: Historic ☑	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1

7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition Departure	Reference N/S	Good Minor	Fair Major	Poor Extreme	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Degradation		12				✓	0.76	II (F CEM)
Aggradation	18							
Widening	17						**7.6 Stream Condition:** Good	
Planform		14				✓		
Sub-totals:					**Total Score:**	61		

Channel Adjustment Processes: Arrested or slowly advancing degradation after encroachments (aggradation at dam, but not representative of reach)

7.7 Stream Sensitivity: Very Low / Low / (Moderate) / High / Very High / Extreme

* Channel Condition “default” to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Channel Condition default to poor - Due to channel alterations from work in channel after flood: **Y/N**

* Stream Sensitivity “default” to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Stream Sensitivity “default” to **poor** Due to channel alterations from work in channel after flood: **Y/N**

VT RAPID GEOMORPHIC ASSESSMENT ----- UNCONFINED STREAMS

For narrow and broad to very broad valley types (confinement ratio ≥ 4) Typically Riffle-pool and Dune-Ripple Stream Types

Stream Name: Melvin River
Location: Above County Road
(~ 300 ft to 1,200 feet u/s of County Rd)
Observers: M. Kelly-Boyd / S. Large / J. Woidt
Organization /Agency: FBE / FBE / Streamworks
Reference Stream Type C (Riffle-pool) ☐ Modified
(If alluvial fan or naturally braided system see Handbook Protocols)

Segment I.D: 2a
Date: August 9, 2023
Town: Tuftonboro, NH
Elevation: 550 +/- ft.
Weather: Sunny
Rain Storm within past 7 days: (Y) / N

Adjustment Process	Condition Category			
	Reference	**Good**	**Fair**	**Poor**
7.1 Channel Degradation (Incision) • Exposed till or fresh substrate in the stream bed and exposed infrastructure(bridge footings) • New terraces or recently abandoned floodplains. • Headcuts, or nickpoints that are 2-3 times steeper than typical riffle. • Freshly eroded, vertical banks. • Alluvial (river) sediments that are imbricated (stacked like dominoes) high in bank. • Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary. • Bars with steep faces, usually occurring on the downstream end of a bar.	☑ Little evidence of localized slope increase or nickpoints.	☐ Minor localized slope increase or nickpoints.	☐ Sharp change in slope, head cuts present, and/or tributaries rejuvenating.	☐ Sharp change in slope and / or multiple head cuts present. Tributaries rejuvenating.
	☐ Incision Ratio ≥ 1.0 < 1.2 **and** Entrenchment ratio > 2.0	☑ Incision Ratio ≥ 1.2 < 1.4 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **OR** Entrenchment ratio ≤ 2.0
	☐ Riffle heads complete and comprised of courser sediments (≥D80). Full complement of expected bed features.	☑ Riffle heads mostly complete. Riffle lengths may appear shorter. Full complement of expected bed features.	☐ Riffles or dunes may appear incomplete; bed profile dominated by runs.	☐ Riffle-pool or ripple-dune features replaced by plane bed features.
	☑ No significant human-caused change in channel confinement or valley type.	☐ Only minor human-caused change in channel confinement but no change in valley type.	☐ Significant human-caused change in channel confinement enough to change valley type, but still unconfined.	☐ Human-caused change in valley type, unconfined or narrow changed to confined.
	☑ No evidence of historic / present channel straightening, gravel mining, dredging and/or channel avulsions.	☐ Evidence of minor bar scalping on a point bar and/or channel avulsion; but minor to no historic channel straightening, gravel mining, or dredging.	☐ Evidence of significant historic channel straightening, dredging, gravel mining and/or channel avulsions.	☐ Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsion.
Stream Type Departure ☐ **Type of STD:**________	☑ No known flow alterations (i.e., increases in flow or decreases in sediment supply).	☐ Minor flow alterations, some flow increase and/or reduction of sediment load.	☐ Major historic flow alterations, greater flows and/or reduction of sediment load.	☐ Major existing flow alterations, greater flows and/or reduction of sediment load.
Score: Historic ☐	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.2 Channel Aggradation • Shallow pool depths. • Abundant sediment deposition on point bars and mid-channel bars and extensive sediment deposition at obstructions, channel constrictions, and at the upstream end of tight meander bends. Islands may be present. • Most of the channel bed is exposed during typical low flow periods. • High frequency of debris jams. • Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel.	☐ Complete riffle heads and deep pools in riffle-pool systems.** Full complement of expected bed features.	☑ Mostly complete riffles and/or some filling of pools with fine sediment. Pools may only be slightly deeper and wider than runs.**	☐ Incomplete riffles or dunes and dominated by runs. Significant filling of pools with sediment, pools may be absent with runs prevailing.	☐ Riffle-pool or ripple-dune features replaced by plane bed features.
	☐ Minor point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☑ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Major sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☐ No apparent increase in fine gravel/sand substrates (pebble count).**	☐ Some increase in fine gravel/sand substrates that may comprise over 50% of the sediments.	☑ Large incr. in fine gravel/ sand substrates that may comprise over 70% of the sediments. Sediment feels soft underfoot.	☐ Homogenous fine gravel/ sand substrates may comprise over 90% of the sediments. Sediment feels soft underfoot.
	☑ Low width/depth ratio ≤ 20 for C or B type channels ≤ 10 for E type channels	☐ Low to moderate W/d ratio >20 ≤ 30 for C or B channels >10 ≤ 12 for E channels	☐ Moderate to high W/d ratio >30 ≤ 40 for C or B channels >12 ≤ 20 for E channels	☐ High width/depth ratio >40 for C or B type channels >20 for E type channels
** This parameter may be a difficult to infeasible to evaluate in ripple-dune stream types	☑ No known flow alterations (i.e., decrease in flow or increase in sediment supply).	☐ Minor reduction in flow and/or increase in sediment load. Flood-related sediment working through reach, seen as enlarged bars.	☐ Major historic flow alterations, reduction in flows and / or increase in sediment load.	☐ Major existing flow alterations, extreme reduction in flows and / or increase in sediment load.
Stream Type Departure ☐ **Type of STD:**________	☐ No human-made constrictions causing upstream deposition.	☑ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive upstrm / dwnstrm deposition and flow bifurcation.
Score: Historic ☐	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.3 Widening Channel • Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together. • Erosion on both right and left banks in riffle sections. • Recently exposed tree roots (fresh roots are 'green' and do not break easily, older roots are brittle and will break easily in your hand). • Fracture lines at the top of the bank that appear as cracks parallel to the river. • Mid-channel bars and side bars may be present. • Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.	☑ Low width/depth ratio $\leq$ 20 for C or B type channels $\leq$ 10 for E type channels	☐ Low to moderate W/d ratio >20 $\leq$ 30 for C or B channels >10 $\leq$ 12 for E channels	☐ Moderate to high W/d ratio >30 $\leq$ 40 for C or B channels >12 $\leq$ 20 for E channels	☐ High width/depth ratio >40 for C or B type channels >20 for E type channels
	☑ Little to no scour and erosion at the base of both banks at the riffle section. Negligible bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	☐ Minimal to moderate scour and erosion at the base of both banks at the riffle section. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Moderate to high scour and erosion at the base of both banks at the riffle section. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Continuous and laterally extensive scour and erosion at the base of both banks at the riffle section. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
	☐ Incision Ratio $\geq$ 1.0 < 1.2 **and** Entrenchment ratio > 2.0	☑ Incision Ratio $\geq$ 1.2 < 1.4 **and** Entrenchment ratio > 2.0	☐ Incision Ratio $\geq$ 1.4 < 2.0 **and** Entrenchment ratio > 2.0	☐ Incision ratio $\geq$ 2.0 **OR** Entrenchment ratio $\leq$ 2.0
	☐ Minor point or delta bars present. Depositional features less than half bankfull stage in height.	☑ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Major sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☑ No known channel and / or flow alterations (i.e., increase in flow and / or change in sediment supply).	☐ Minor increase in watershed input of flows or sediment. Episodic (flood) discharges through reach resulting in short-term enlargement.	☐ Major channel and/or flow alterations, increase in flows and/or change in sediment load (increase or decrease).	☐ Major and extensive channel and/or flow alterations, increase in flows and/or change in sediment load (increase or decrease).
Score: Historic ☐	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.4 Change in Planform • Flood chutes or neck cut-offs may be present. • Channel avulsions may be evident or impending. • Change or loss in bed form structure, sometimes resulting in a mix of plane bed and riffle- pool forms. • Island formation and/or multiple thread channels. • In meandering streams the thalweg, or deepest part of the channel, typically travels from the outside of a meander bend to the outside of the next meander bend. Pools are located on downstream third of the concave bends. Riffles are at the cross-over between the pools on successive bends. During planform adjustments, the thalweg may not line up with or follow this pattern. As a result of the lateral extension of meander bends, additional deposition and scour features may be in a channel length typically occupied by a single riffle-pool sequence.	☐ Low bank erosion on outside bends, little or no change in sinuosity within the reach.	☑ Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	☐ Moderate to high lateral bank erosion on most outside bends, may include potential neck cut-offs and moderate change in sinuosity.	☐ Extensive lateral bank erosion on most outside bends, may include impending neck cut-offs and major change in sinuosity within the reach.
	☑ Little evidence of flood chutes crossing inside of meander bends, only minor point or delta bars.	☐ Minor flood chutes crossing inside of meander bends, evidence of minor to moderate unvegetated mid-channel, delta, or diagonal bars. Some potential for channel avulsion.	☐ Historic or active flood chutes crossing inside of meander bends, evidence of channel avulsion, islands, and unvegetated mid-channel, delta, or diagonal bars.	☐ Active large flood chutes crossing inside of most meander bends, evidence of recent channel avulsion, multiple thread channels, islands, and unvegetated mid-channel, delta, or diagonal bars.
	☐ No additional deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg lined up with planform.	☑ Additional minor deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.	☐ Additional large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg not lined up with planform.	☐ Multiple sequences of large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.
	☑ No human-caused alteration of channel planform and / or the width of the floodprone area.	☐ Minor to moderate alteration of channel planform and/or width of the floodprone area resulting from floodplain encroachment, channel straightening, or dredging.	☐ Major alteration of channel planform and/or the width of the floodprone area resulting from historic floodplain encroachment, dredging, or channel straightening.	☐ Major alteration of channel planform and width of the floodprone area resulting from recent and extensive floodplain encroachment, dredging, and/or channel straightening.
	☐ Human-made constrictions causing only negligible upstream deposition.	☑ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive and major upstrm / downstrm deposition and flow bifurcation.
Score: Historic ☐	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition Departure	Reference N/S	Good Minor	Fair Major	Poor Extreme	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Degradation	17						0.82	I (F CEM)
Aggradation		15						
Widening	17						**7.6 Stream Condition:** Good	
Planform	16							

Channel Adjustment Processes: Dynamically stable

7.7 Stream Sensitivity: Very Low / Low / Moderate / (High) / Very High / Extreme

* Channel Condition "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Channel Condition default to poor - Due to channel alterations from work in channel after flood: **Y/N**

* Stream Sensitivity "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Stream Sensitivity "default" to **poor** Due to channel alterations from work in channel after flood: **Y/N**

VT RAPID GEOMORPHIC ASSESSMENT ----- PLANE BED STREAMS

Typically found in semi-confined to narrow valley types (confinement ratio ≥ 3 and ≤ 5)

Reminder: This RGA form should only be used on streams which are plane bed systems by reference. Many existing plane bed streams in Vermont represent a departure from another stream type.

Stream Name: Melvin River
Location: Below Wetland
(~ 1,200 ft to 2,700 feet upstream of County Rd)
Observers: M. Kelly-Boyd / S. Large / J. Woidt
Organization /Agency: FBE / FBE / Streamworks
Reference Stream Type B (Plane Bed) ☐ Modified
(If alluvial fan or naturally braided system see Handbook Protocols)

Segment I.D: 2b
Date: August 9, 2023
Town: Tuftonboro, NH
Elevation: 550 +/- ft.
Weather: Sunny
Rain Storm within past 7 days: (Y) / N

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.1 Channel Degradation (Incision) • Exposed till or fresh substrate in the stream bed and exposed infrastructure (bridge footings). • New terraces or recently abandoned floodplains. • Headcuts, or nickpoints that are 2-3 times steeper than typical riffle. • Freshly eroded, vertical banks. • Alluvial (river) sediments that are imbricated (stacked like dominoes) high in bank. • Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary. **Stream Type Departure** ☐ **Type of STD:**______________	☑ Little evidence of localized slope increase or nickpoints.	☐ Minor localized slope increase or nickpoints.	☐ Sharp change in slope, head cuts present, and/or tributaries rejuvenating.	☐ Sharp change in slope and / or multiple head cuts present. Tributaries rejuvenating.
	☑ Incision ratio ≥ 1.0 < 1.2 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 1.2 < 1.4 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 1.4 < 2.0 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **and** Where channel slope > 2% Entrenchment ratio ≤ 1.4 Where channel slope ≤ 2% Entrenchment ratio ≤ 2.0
	☑ No significant human-caused change in channel confinement or valley type.	☐ Only minor human-caused change in channel confinement but no change in valley type.	☑ Significant human-caused change in channel confinement enough to change valley type, but still not narrowly confined.	☐ Human-caused change to a narrowly confined valley type.
	☑ No evidence of historic or present channel straightening, gravel mining, dredging and/or channel avulsions.	☐ Evidence of minor mid-channel bar scalping and/or channel avulsion, but minor to no historic channel straightening, gravel mining or dredging.	☑ Evidence of significant historic channel straightening, dredging, gravel mining and/or channel avulsions.	☐ Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsion.
	☑ No known flow alterations (i.e., increases in flow or decreases in sediment supply).	☐ Minor flow alterations, some flow increase and/or minor reduction of sediment load.	☐ Major historic flow alterations, greater flows and/or reduction of sediment load.	☐ Major existing flow alterations, greater flows and/or reduction of sediment load.
Score: **Historic** ☐	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.2 Channel Aggradation • Very shallow pocket pools around and below boulders. • Abundant sediment deposition on side, point and mid-channel bars and extensive sediment deposition at obstructions, channel constrictions, and at the upstream end of tight bendways. Islands may be present. • Most of the channel bed is exposed during typical low flow periods. • Increased frequency of woody debris in channel. • Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel. **Stream Type Departure** ☐ **Type of STD:**______________	☑ Minor side, point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☑ No apparent increase in fine gravel/sand substrates (pebble count).	☐ Some increase in fine gravel/sand substrates that may comprise over 50% of the sediments.	☐ Large increase in fine gravel/sand substrates that may comprise over 70% of the sediments. Fine sediment feels soft underfoot.	☐ Homogenous fine gravel/sand substrates may comprise over 90% of the sediments. Fine sediment feels soft underfoot.
	☑ Low width/depth ratio W/d ≤ 20	☐ Low to moderate W/d ratio W/d >20 ≤ 30	☐ Moderate to high W/d ratio W/d >30 ≤ 40	☐ High width/depth ratio W/d >40
	☑ No known flow alterations (i.e., decrease in flow or increase in sediment supply).	☐ Minor reduction in flow and/or increase in sediment load. Flood-related sediment working through reach, seen as enlarged bars.	☐ Major historic flow alterations, reduction in flows and / or increase in sediment load.	☐ Major existing flow alterations, extreme reduction in flows and / or increase in sediment load.
	☑ No human-made constrictions causing upstream deposition.	☐ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive upstrm / dwnstrm deposition and flow bifurcation.
Score: **Historic** ☐	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.3 Widening Channel	☑ Low width/depth ratio W/d ≤ 20	☐ Low to moderate W/d ratio W/d >20 ≤ 30	☐ Moderate to high W/d ratio W/d >30 ≤ 40	☐ High width/depth ratio W/d >40
• Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together. • Erosion on both right and left banks in riffle sections. • Recently exposed tree roots (fresh roots are 'green' and do not break easily, older roots are brittle and will break easily in your hand). • Fracture lines at the top of the bank that appear as cracks parallel to the river. • Mid-channel bars and side bars may be present. • Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.	☐ Little to no scour and erosion at the base of both banks. Negligible bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	☑ Minimal to moderate scour and erosion at the base of both banks. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Moderate to high scour and erosion at the base of both banks. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Continuous and laterally extensive scour and erosion at the base of both banks. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
	☑ Incision Ratio ≥ 1.0 < 1.2 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.2 < 1.4 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **and** Where channel slope > 2% Entrenchment ratio ≤ 1.4 Where channel slope ≤ 2% Entrenchment ratio ≤ 2.0
	☑ Minor side, point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☑ No known channel and / or flow alterations (i.e., increase in flow and/or change in sediment supply).	☐ Minor increase in watershed input of flows or sediment. Episodic (flood) discharges through reach resulting in short-term enlargement.	☐ Major channel and / or flow alterations, increase in flows and/or change in sediment load (increase or decrease).	☐ Major and extensive channel and/or flow alterations, increase in flows and / or change in sediment load (increase or decrease).
Score: **Historic** ☐	20 (19 circled) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.4 Change in Planform	☐ Low bank erosion on outside bends, little or no change in sinuosity within the reach.	☑ Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	☐ Moderate to high lateral bank erosion on most outside bends, may include moderate change in sinuosity.	☐ Extensive lateral bank erosion on most outside bends, may include major change in sinuosity within the reach.
• Flood chutes may be present. • Channel avulsions may be evident or impending. • Change or loss in bed form structure, sometimes resulting in a mix of plane bed and riffle- pool forms. • Island formation and/or multiple thread channels.	☑ Little evidence of flood chutes crossing inside of bends, only minor side, point, or delta bars.	☐ Minor flood chutes crossing inside of bends, evidence of single to multiple unvegetated mid-channel, delta, or diagonal bars. Some potential for channel avulsion.	☐ Historic or active flood chutes crossing inside of bends, evidence of channel avulsion, islands, and multiple unvegetated mid-channel, delta, or diagonal bars.	☐ Active large flood chutes, evidence of recent channel avulsion, multiple thread channels, islands, and multiple unvegetated mid-channel, delta, or diagonal bars.
	☑ No human-caused alteration of channel planform and / or the width of the floodprone area.	☐ Minor to moderate alteration of channel planform and/or width of the floodprone area resulting from floodplain encroachment, channel straightening, or dredging.	☐ Major alteration of channel planform and/or the width of the floodprone area resulting from historic floodplain encroachment, dredging, or channel straightening.	☐ Major alteration of channel planform and width of the floodprone area resulting from recent and extensive floodplain encroachment, dredging, and/or channel straightening.
	☑ Human-made constrictions causing only negligible upstream deposition.	☐ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive and major upstrm / downstrm deposition and flow bifurcation.
Score: **Historic** ☐	20 19 (18 circled) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition Departure	Reference N/S	Good Minor	Fair Major	Poor Extreme	STD*	Historic
Degradation	20					
Aggradation	20					
Widening	19					
Planform	18					
Sub-totals:					**Total Score:** 77	

Condition Rating: (Total Score / 80) 0.96

7.6 Stream Condition: Reference

Channel Evolution Stage: I (F CEM)

Channel Adjustment Processes: Dynamically stable

7.7 Stream Sensitivity: Very Low / Low / Moderate (circled) / High / Very High / Extreme

* Channel Condition "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Channel Condition default to poor - Due to channel alterations from work in channel after flood: **Y/N**

* Stream Sensitivity "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Stream Sensitivity "default" to **poor** Due to channel alterations from work in channel after flood: **Y/N**

VT RAPID GEOMORPHIC ASSESSMENT ----- UNCONFINED STREAMS

For narrow and broad to very broad valley types (confinement ratio ≥ 4) Typically Riffle-pool and Dune-Ripple Stream Types

Stream Name: Melvin River
Location: Wetland (~ 4,400 ft d/s to 3,500 feet u/s of New Rd)
Observers: M. Kelly-Boyd / S. Large / J. Woidt
Organization /Agency: FBE / FBE / Streamworks
Reference Stream Type E (Riffle-pool) ☐ Modified
(If alluvial fan or naturally braided system see Handbook Protocols)

Segment I.D: 3
Date: August 9, 2023
Town: Tuftonboro, NH
Elevation: 550 +/- ft.
Weather: Sunny
Rain Storm within past 7 days: (Y) / N

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.1 Channel Degradation (Incision)	☐ Little evidence of localized slope increase or nickpoints.	☑ Minor localized slope increase or nickpoints. Beaver dams	☐ Sharp change in slope, head cuts present, and/or tributaries rejuvenating.	☐ Sharp change in slope and / or multiple head cuts present. Tributaries rejuvenating.
• Exposed till or fresh substrate in the stream bed and exposed infrastructure(bridge footings)	☑ Incision Ratio ≥ 1.0 < 1.2 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.2 < 1.4 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **OR** Entrenchment ratio ≤ 2.0
• New terraces or recently abandoned floodplains. • Headcuts, or nickpoints that are 2-3 times steeper than typical riffle.	☐ Riffle heads complete and comprised of courser sediments (≥D80). Full complement of expected bed features.	☑ Riffle heads mostly complete. Riffle lengths may appear shorter. Full complement of expected bed features.	☐ Riffles or dunes may appear incomplete; bed profile dominated by runs.	☐ Riffle-pool or ripple-dune features replaced by plane bed features.
• Freshly eroded, vertical banks. • Alluvial (river) sediments that are imbricated (stacked like dominoes) high in bank.	☐ No significant human-caused change in channel confinement or valley type.	☑ Only minor human-caused change in channel confinement but no change in valley type.	☐ Significant human-caused change in channel confinement enough to change valley type, but still unconfined.	☐ Human-caused change in valley type, unconfined or narrow changed to confined.
• Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary. • Bars with steep faces, usually occurring on the downstream end of a bar.	☐ No evidence of historic / present channel straightening, gravel mining, dredging and/or channel avulsions.	☑ Evidence of minor bar scalping on a point bar and/or channel avulsion; but minor to no historic channel straightening, gravel mining, or dredging.	☐ Evidence of significant historic channel straightening, dredging, gravel mining and/or channel avulsions.	☐ Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsion.
Stream Type Departure ☐ **Type of STD:**______________	☑ No known flow alterations (i.e., increases in flow or decreases in sediment supply).	☐ Minor flow alterations, some flow increase and/or reduction of sediment load.	☐ Major historic flow alterations, greater flows and/or reduction of sediment load.	☐ Major existing flow alterations, greater flows and/or reduction of sediment load.
Score: Historic ☐	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.2 Channel Aggradation	☐ Complete riffle heads and deep pools in riffle-pool systems.** Full complement of expected bed features.	☑ Mostly complete riffles and/or some filling of pools with fine sediment. Pools may only be slightly deeper and wider than runs.**	☐ Incomplete riffles or dunes and dominated by runs. Significant filling of pools with sediment, pools may be absent with runs prevailing.	☐ Riffle-pool or ripple-dune features replaced by plane bed features.
• Shallow pool depths. • Abundant sediment deposition on point bars and mid-channel bars and extensive sediment deposition at obstructions, channel constrictions, and at the upstream end of tight meander bends. Islands may be present.	☐ Minor point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☑ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Major sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
• Most of the channel bed is exposed during typical low flow periods.	☑ No apparent increase in fine gravel/sand substrates (pebble count).**	☐ Some increase in fine gravel/sand substrates that may comprise over 50% of the sediments.	☐ Large incr. in fine gravel/ sand substrates that may comprise over 70% of the sediments. Sediment feels soft underfoot.	☐ Homogenous fine gravel/ sand substrates may comprise over 90% of the sediments. Sediment feels soft underfoot.
• High frequency of debris jams.	☑ Low width/depth ratio ≤ 20 for C or B type channels ≤ 10 for E type channels	☐ Low to moderate W/d ratio >20 ≤ 30 for C or B channels >10 ≤ 12 for E channels	☐ Moderate to high W/d ratio >30 ≤ 40 for C or B channels >12 ≤ 20 for E channels	☐ High width/depth ratio >40 for C or B type channels >20 for E type channels
• Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel.	☑ No known flow alterations (i.e., decrease in flow or increase in sediment supply).	☐ Minor reduction in flow and/or increase in sediment load. Flood-related sediment working through reach, seen as enlarged bars.	☐ Major historic flow alterations, reduction in flows and / or increase in sediment load.	☐ Major existing flow alterations, extreme reduction in flows and / or increase in sediment load.
** This parameter may be a difficult to infeasible to evaluate in ripple-dune stream types **Stream Type Departure** ☐ **Type of STD:**______________	☑ No human-made constrictions causing upstream deposition.	☐ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive upstrm / dwnstrm deposition and flow bifurcation.
Score: Historic ☐	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.3 Widening Channel • Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together. • Erosion on both right and left banks in riffle sections. • Recently exposed tree roots (fresh roots are 'green' and do not break easily, older roots are brittle and will break easily in your hand). • Fracture lines at the top of the bank that appear as cracks parallel to the river. • Mid-channel bars and side bars may be present. • Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.	☑ Low width/depth ratio ≤ 20 for C or B type channels ≤ 10 for E type channels	☐ Low to moderate W/d ratio >20 ≤ 30 for C or B channels >10 ≤ 12 for E channels	☐ Moderate to high W/d ratio >30 ≤ 40 for C or B channels >12 ≤ 20 for E channels	☐ High width/depth ratio >40 for C or B type channels >20 for E type channels
	☑ Little to no scour and erosion at the base of both banks at the riffle section. Negligible bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	☐ Minimal to moderate scour and erosion at the base of both banks at the riffle section. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Moderate to high scour and erosion at the base of both banks at the riffle section. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Continuous and laterally extensive scour and erosion at the base of both banks at the riffle section. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
	☑ Incision Ratio ≥ 1.0 < 1.2 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.2 < 1.4 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **OR** Entrenchment ratio ≤ 2.0
	☑ Minor point or delta bars present. Depositional features less than half bankfull stage in height.	☐ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Major sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☑ No known channel and / or flow alterations (i.e., increase in flow and / or change in sediment supply).	☐ Minor increase in watershed input of flows or sediment. Episodic (flood) discharges through reach resulting in short-term enlargement.	☐ Major channel and/or flow alterations, increase in flows and/or change in sediment load (increase or decrease).	☐ Major and extensive channel and/or flow alterations, increase in flows and/or change in sediment load (increase or decrease).
Score: Historic ☐	**(20)** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.4 Change in Planform • Flood chutes or neck cut-offs may be present. • Channel avulsions may be evident or impending. • Change or loss in bed form structure, sometimes resulting in a mix of plane bed and riffle- pool forms. • Island formation and/or multiple thread channels. • In meandering streams the thalweg, or deepest part of the channel, typically travels from the outside of a meander bend to the outside of the next meander bend. Pools are located on downstream third of the concave bends. Riffles are at the cross-over between the pools on successive bends. During planform adjustments, the thalweg may not line up with or follow this pattern. As a result of the lateral extension of meander bends, additional deposition and scour features may be in a channel length typically occupied by a single riffle-pool sequence.	☑ Low bank erosion on outside bends, little or no change in sinuosity within the reach.	☐ Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	☐ Moderate to high lateral bank erosion on most outside bends, may include potential neck cut-offs and moderate change in sinuosity.	☐ Extensive lateral bank erosion on most outside bends, may include impending neck cut-offs and major change in sinuosity within the reach.
	☐ Little evidence of flood chutes crossing inside of meander bends, only minor point or delta bars.	☑ Minor flood chutes crossing inside of meander bends, evidence of minor to moderate unvegetated mid-channel, delta, or diagonal bars. Some potential for channel avulsion.	☐ Historic or active flood chutes crossing inside of meander bends, evidence of channel avulsion, islands, and unvegetated mid-channel, delta, or diagonal bars.	☐ Active large flood chutes crossing inside of most meander bends, evidence of recent channel avulsion, multiple thread channels, islands, and unvegetated mid-channel, delta, or diagonal bars.
	☐ No additional deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg lined up with planform.	☑ Additional minor deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.	☐ Additional large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg not lined up with planform.	☐ Multiple sequences of large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.
	☐ No human-caused alteration of channel planform and / or the width of the floodprone area.	☑ Minor to moderate alteration of channel planform and/or width of the floodprone area resulting from floodplain encroachment, channel straightening, or dredging.	☐ Major alteration of channel planform and/or the width of the floodprone area resulting from historic floodplain encroachment, dredging, or channel straightening.	☐ Major alteration of channel planform and width of the floodprone area resulting from recent and extensive floodplain encroachment, dredging, and/or channel straightening.
	☐ Human-made constrictions causing only negligible upstream deposition.	☑ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive and major upstrm / downstrm deposition and flow bifurcation.
Score: Historic ☑	20 19 18 17 16	15 14 **(13)** 12 11	10 9 8 7 6	5 4 3 2 1

7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition Departure	Reference N/S	Good Minor	Fair Major	Poor Extreme	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Degradation	16						0.80	I
Aggradation		15						(F CEM)
Widening	20						**7.6 Stream Condition:** Good	
Planform		13				✓		

Channel Adjustment Processes: Dynamically stable (in part due to beaver dams)

7.7 Stream Sensitivity: Very Low / Low / Moderate / **(High)** / Very High / Extreme

* Channel Condition "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Channel Condition default to poor - Due to channel alterations from work in channel after flood: **Y/N**

* Stream Sensitivity "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Stream Sensitivity "default" to **poor** Due to channel alterations from work in channel after flood: **Y/N**

VT RAPID GEOMORPHIC ASSESSMENT ----- UNCONFINED STREAMS

For narrow and broad to very broad valley types (confinement ratio ≥ 4) Typically Riffle-pool and Dune-Ripple Stream Types

Stream Name: Melvin River	Segment I.D: 4
Location: Transition to wetland (~ 1,400 ft to 2,700 feet downstream of Sodom Rd)	Date: August 9, 2023
	Town: Tuftonboro, NH
Observers: M. Kelly-Boyd / S. Large / J. Woidt	Elevation: 550 +/- ft.
Organization /Agency: FBE / FBE / Streamworks	Weather: Sunny
Reference Stream Type C (Riffle-pool) ☐ Modified (If alluvial fan or naturally braided system see Handbook Protocols)	Rain Storm within past 7 days: (Y) / N

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.1 Channel Degradation (Incision) • Exposed till or fresh substrate in the stream bed and exposed infrastructure(bridge footings) • New terraces or recently abandoned floodplains. • Headcuts, or nickpoints that are 2-3 times steeper than typical riffle. • Freshly eroded, vertical banks. • Alluvial (river) sediments that are imbricated (stacked like dominoes) high in bank. • Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary. • Bars with steep faces, usually occurring on the downstream end of a bar.	☑ Little evidence of localized slope increase or nickpoints.	☐ Minor localized slope increase or nickpoints.	☐ Sharp change in slope, head cuts present, and/or tributaries rejuvenating.	☐ Sharp change in slope and / or multiple head cuts present. Tributaries rejuvenating.
	☑ Incision Ratio ≥ 1.0 < 1.2 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.2 < 1.4 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **OR** Entrenchment ratio ≤ 2.0
	☐ Riffle heads complete and comprised of courser sediments (≥D80). Full complement of expected bed features.	☐ Riffle heads mostly complete. Riffle lengths may appear shorter. Full complement of expected bed features.	☑ Riffles or dunes may appear incomplete; bed profile dominated by runs.	☐ Riffle-pool or ripple-dune features replaced by plane bed features.
	☑ No significant human-caused change in channel confinement or valley type.	☐ Only minor human-caused change in channel confinement but no change in valley type.	☐ Significant human-caused change in channel confinement enough to change valley type, but still unconfined.	☐ Human-caused change in valley type, unconfined or narrow changed to confined.
	☑ No evidence of historic / present channel straightening, gravel mining, dredging and/or channel avulsions.	☐ Evidence of minor bar scalping on a point bar and/or channel avulsion; but minor to no historic channel straightening, gravel mining, or dredging.	☐ Evidence of significant historic channel straightening, dredging, gravel mining and/or channel avulsions.	☐ Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsion.
Stream Type Departure ☐ **Type of STD:**______________	☑ No known flow alterations (i.e., increases in flow or decreases in sediment supply).	☐ Minor flow alterations, some flow increase and/or reduction of sediment load.	☐ Major historic flow alterations, greater flows and/or reduction of sediment load.	☐ Major existing flow alterations, greater flows and/or reduction of sediment load.
Score: Historic ☐	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Reference	Good	Fair	Poor
7.2 Channel Aggradation • Shallow pool depths. • Abundant sediment deposition on point bars and mid-channel bars and extensive sediment deposition at obstructions, channel constrictions, and at the upstream end of tight meander bends. Islands may be present. • Most of the channel bed is exposed during typical low flow periods. • High frequency of debris jams. • Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel. ** This parameter may be a difficult to infeasible to evaluate in ripple-dune stream types	☐ Complete riffle heads and deep pools in riffle-pool systems.** Full complement of expected bed features.	☑ Mostly complete riffles and/or some filling of pools with fine sediment. Pools may only be slightly deeper and wider than runs.**	☐ Incomplete riffles or dunes and dominated by runs. Significant filling of pools with sediment, pools may be absent with runs prevailing.	☐ Riffle-pool or ripple-dune features replaced by plane bed features.
	☑ Minor point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Major sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☑ No apparent increase in fine gravel/sand substrates (pebble count).**	☐ Some increase in fine gravel/sand substrates that may comprise over 50% of the sediments.	☐ Large incr. in fine gravel/ sand substrates that may comprise over 70% of the sediments. Sediment feels soft underfoot.	☐ Homogenous fine gravel/ sand substrates may comprise over 90% of the sediments. Sediment feels soft underfoot.
	☑ Low width/depth ratio ≤ 20 for C or B type channels ≤ 10 for E type channels	☐ Low to moderate W/d ratio >20 ≤ 30 for C or B channels >10 ≤ 12 for E channels	☐ Moderate to high W/d ratio >30 ≤ 40 for C or B channels >12 ≤ 20 for E channels	☐ High width/depth ratio >40 for C or B type channels >20 for E type channels
	☑ No known flow alterations (i.e., decrease in flow or increase in sediment supply).	☐ Minor reduction in flow and/or increase in sediment load. Flood-related sediment working through reach, seen as enlarged bars.	☐ Major historic flow alterations, reduction in flows and / or increase in sediment load.	☐ Major existing flow alterations, extreme reduction in flows and / or increase in sediment load.
Stream Type Departure ☐ **Type of STD:**______________	☑ No human-made constrictions causing upstream deposition.	☐ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive upstrm / dwnstrm deposition and flow bifurcation.
Score: Historic ☐	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.3 Widening Channel	☑ Low width/depth ratio ≤ 20 for C or B type channels ≤ 10 for E type channels	☐ Low to moderate W/d ratio >20 ≤ 30 for C or B channels >10 ≤ 12 for E channels	☐ Moderate to high W/d ratio >30 ≤ 40 for C or B channels >12 ≤ 20 for E channels	☐ High width/depth ratio >40 for C or B type channels >20 for E type channels
• Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together. • Erosion on both right and left banks in riffle sections. • Recently exposed tree roots (fresh roots are 'green' and do not break easily, older roots are brittle and will break easily in your hand). • Fracture lines at the top of the bank that appear as cracks parallel to the river. • Mid-channel bars and side bars may be present. • Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.	☐ Little to no scour and erosion at the base of both banks at the riffle section. Negligible bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	☑ Minimal to moderate scour and erosion at the base of both banks at the riffle section. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Moderate to high scour and erosion at the base of both banks at the riffle section. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Continuous and laterally extensive scour and erosion at the base of both banks at the riffle section. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
	☑ Incision Ratio ≥ 1.0 < 1.2 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.2 < 1.4 **and** Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **OR** Entrenchment ratio ≤ 2.0
	☑ Minor point or delta bars present. Depositional features less than half bankfull stage in height.	☐ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Major sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
	☑ No known channel and / or flow alterations (i.e., increase in flow and / or change in sediment supply).	☐ Minor increase in watershed input of flows or sediment. Episodic (flood) discharges through reach resulting in short-term enlargement.	☐ Major channel and/or flow alterations, increase in flows and/or change in sediment load (increase or decrease).	☐ Major and extensive channel and/or flow alterations, increase in flows and/or change in sediment load (increase or decrease).
Score: Historic ☐	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.4 Change in Planform	☐ Low bank erosion on outside bends, little or no change in sinuosity within the reach.	☑ Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	☐ Moderate to high lateral bank erosion on most outside bends, may include potential neck cut-offs and moderate change in sinuosity.	☐ Extensive lateral bank erosion on most outside bends, may include impending neck cut-offs and major change in sinuosity within the reach.
• Flood chutes or neck cut-offs may be present. • Channel avulsions may be evident or impending. • Change or loss in bed form structure, sometimes resulting in a mix of plane bed and riffle- pool forms. • Island formation and/or multiple thread channels. • In meandering streams the thalweg, or deepest part of the channel, typically travels from the outside of a meander bend to the outside of the next meander bend. Pools are located on downstream third of the concave bends. Riffles are at the cross-over between the pools on successive bends. During planform adjustments, the thalweg may not line up with or follow this pattern. As a result of the lateral extension of meander bends, additional deposition and scour features may be in a channel length typically occupied by a single riffle-pool sequence.	☑ Little evidence of flood chutes crossing inside of meander bends, only minor point or delta bars.	☐ Minor flood chutes crossing inside of meander bends, evidence of minor to moderate unvegetated mid-channel, delta, or diagonal bars. Some potential for channel avulsion.	☐ Historic or active flood chutes crossing inside of meander bends, evidence of channel avulsion, islands, and unvegetated mid-channel, delta, or diagonal bars.	☐ Active large flood chutes crossing inside of most meander bends, evidence of recent channel avulsion, multiple thread channels, islands, and unvegetated mid-channel, delta, or diagonal bars.
	☐ No additional deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg lined up with planform.	☑ Additional minor deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.	☐ Additional large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence. Thalweg not lined up with planform.	☐ Multiple sequences of large deposition and scour features in the channel length typically occupied by a single riffle-pool sequence.
	☑ No human-caused alteration of channel planform and / or the width of the floodprone area.	☐ Minor to moderate alteration of channel planform and/or width of the floodprone area resulting from floodplain encroachment, channel straightening, or dredging.	☐ Major alteration of channel planform and/or the width of the floodprone area resulting from historic floodplain encroachment, dredging, or channel straightening.	☐ Major alteration of channel planform and width of the floodprone area resulting from recent and extensive floodplain encroachment, dredging, and/or channel straightening.
	☑ Human-made constrictions causing only negligible upstream deposition.	☐ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive and major upstrm / downstrm deposition and flow bifurcation.
Score: Historic ☐	20 19 18 (17) 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition / Departure	Reference / N/S	Good / Minor	Fair / Major	Poor / Extreme	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Degradation	19						0.91	I (F CEM)
Aggradation	18							
Widening	19						**7.6 Stream Condition:** Reference	
Planform	17							

Channel Adjustment Processes: Dynamically stable

7.7 Stream Sensitivity: Very Low / Low / Moderate / (High) / Very High / Extreme

* Channel Condition "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Channel Condition default to poor - Due to channel alterations from work in channel after flood: **Y/N**

* Stream Sensitivity "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Stream Sensitivity "default" to **poor** Due to channel alterations from work in channel after flood: **Y/N**

VT RAPID GEOMORPHIC ASSESSMENT ----- PLANE BED STREAMS

Typically found in semi-confined to narrow valley types (confinement ratio ≥ 3 and ≤ 5)

Reminder: This RGA form should only be used on streams which are plane bed systems by reference. Many existing plane bed streams in Vermont represent a departure from another stream type.

Stream Name: Melvin River
Location: At Sodom Road
(~ 1,400 ft downstream to 500 ft upstream)
Observers: M. Kelly-Boyd / S. Large / B. Rossiter / J. Woidt
Organization /Agency: FBE / FBE / WPA / Streamworks
Reference Stream Type B (Plane Bed) ☐ Modified
(If alluvial fan or naturally braided system see Handbook Protocols)

Segment I.D: 5
Date: July 12, 2023
Town: Tuftonboro, NH
Elevation: 550 +/- ft.
Weather: Sunny
Rain Storm within past 7 days: (Y) / N

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.1 Channel Degradation (Incision)	☐ Little evidence of localized slope increase or nickpoints.	☑ Minor localized slope increase or nickpoints.	☐ Sharp change in slope, head cuts present, and/or tributaries rejuvenating.	☐ Sharp change in slope and / or multiple head cuts present. Tributaries rejuvenating.
• Exposed till or fresh substrate in the stream bed and exposed infrastructure (bridge footings). • New terraces or recently abandoned floodplains.	☐ Incision ratio ≥ 1.0 < 1.2 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☑ Incision ratio ≥ 1.2 < 1.4 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 1.4 < 2.0 **and** yes @ road Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **and** Where channel slope > 2% Entrenchment ratio ≤ 1.4 Where channel slope ≤ 2% Entrenchment ratio ≤ 2.0
• Headcuts, or nickpoints that are 2-3 times steeper than typical riffle. • Freshly eroded, vertical banks.	☐ No significant human-caused change in channel confinement or valley type.	☐ Only minor human-caused change in channel confinement but no change in valley type.	☑ Significant human-caused change in channel confinement enough to change valley type, but still not narrowly confined.	☐ Human-caused change to a narrowly confined valley type.
• Alluvial (river) sediments that are imbricated (stacked like dominoes) high in bank. • Tributary rejuvenation, observed through the presence of nickpoints at or upstream of the mouth of a tributary.	☐ No evidence of historic or present channel straightening, gravel mining, dredging and/or channel avulsions.	☐ Evidence of minor mid-channel bar scalping and/or channel avulsion, but minor to no historic channel straightening, gravel mining or dredging.	☑ Evidence of significant historic channel straightening, dredging, gravel mining and/or channel avulsions.	☐ Extensive historic channel straightening, commercial gravel mining, and/or recent channel avulsion.
Stream Type Departure ☐ **Type of STD:**______	☑ No known flow alterations (i.e., increases in flow or decreases in sediment supply).	☐ Minor flow alterations, some flow increase and/or minor reduction of sediment load.	☐ Major historic flow alterations, greater flows and/or reduction of sediment load.	☐ Major existing flow alterations, greater flows and/or reduction of sediment load.

Score: Historic ☑	20	19	18	17	16	15	14	13	(12)	11	10	9	8	7	6	5	4	3	2	1

Adjustment Process	Reference	Good	Fair	Poor
7.2 Channel Aggradation • Very shallow pocket pools around and below boulders.	☐ Minor side, point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☑ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
• Abundant sediment deposition on side, point and mid-channel bars and extensive sediment deposition at obstructions, channel constrictions, and at the upstream end of tight bendways. Islands may be present.	☑ No apparent increase in fine gravel/sand substrates (pebble count).	☐ Some increase in fine gravel/sand substrates that may comprise over 50% of the sediments.	☐ Large increase in fine gravel/sand substrates that may comprise over 70% of the sediments. Fine sediment feels soft underfoot.	☐ Homogenous fine gravel/sand substrates may comprise over 90% of the sediments. Fine sediment feels soft underfoot.
• Most of the channel bed is exposed during typical low flow periods.	☑ Low width/depth ratio W/d ≤ 20	☐ Low to moderate W/d ratio W/d >20 ≤ 30	☐ Moderate to high W/d ratio W/d >30 ≤ 40	☐ High width/depth ratio W/d >40
• Increased frequency of woody debris in channel.	☑ No known flow alterations (i.e., decrease in flow or increase in sediment supply).	☐ Minor reduction in flow and/or increase in sediment load. Flood-related sediment working through reach, seen as enlarged bars.	☐ Major historic flow alterations, reduction in flows and / or increase in sediment load.	☐ Major existing flow alterations, extreme reduction in flows and / or increase in sediment load.
• Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel. **Stream Type Departure** ☐ **Type of STD:**______	☐ No human-made constrictions causing upstream deposition.	☑ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / dwnstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive upstrm / dwnstrm deposition and flow bifurcation.

Score: Historic ☐	20	19	(18)	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Adjustment Process	Condition Category: Reference	Good	Fair	Poor
7.3 Widening Channel	☑ Low width/depth ratio W/d ≤ 20	☐ Low to moderate W/d ratio W/d >20 ≤ 30	☐ Moderate to high W/d ratio W/d >30 ≤ 40	☐ High width/depth ratio W/d >40
• Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together. • Erosion on both right and left banks in riffle sections.	☐ Little to no scour and erosion at the base of both banks. Negligible bank overhangs, fracture lines at top of banks, leaning trees or freshly exposed tree roots.	☑ Minimal to moderate scour and erosion at the base of both banks. Some overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Moderate to high scour and erosion at the base of both banks. Many bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.	☐ Continuous and laterally extensive scour and erosion at the base of both banks. Continuous bank overhangs, fracture lines at top of banks, leaning trees and freshly exposed tree roots.
• Recently exposed tree roots (fresh roots are 'green' and do not break easily, older roots are brittle and will break easily in your hand).	☐ Incision Ratio ≥ 1.0 < 1.2 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☑ Incision Ratio ≥ 1.2 < 1.4 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision Ratio ≥ 1.4 < 2.0 **and** Where channel slope > 2% Entrenchment ratio > 1.4 Where channel slope ≤ 2% Entrenchment ratio > 2.0	☐ Incision ratio ≥ 2.0 **and** Where channel slope > 2% Entrenchment ratio ≤ 1.4 Where channel slope ≤ 2% Entrenchment ratio ≤ 2.0
• Fracture lines at the top of the bank that appear as cracks parallel to the river. • Mid-channel bars and side bars may be present.	☐ Minor side, point or delta bars present. Minor depositional features typically less than half bankfull stage in height.	☑ Single to multiple mid-channel or diagonal bars present. Minor depositional features typically less than half bankfull stage in height.	☐ Multiple unvegetated mid-channel or diagonal bars present. Sediment buildup at the head of bendways leading to steep riffles and flood chutes.	☐ Multiple unvegetated mid-channel or diagonal bars present splitting or braiding flows even under low flow conditions.
• Urbanization and stormwater outfalls leading to higher rate and duration of runoff and channel enlargement.	☑ No known channel and / or flow alterations (i.e., increase in flow and/or change in sediment supply).	☐ Minor increase in watershed input of flows or sediment. Episodic (flood) discharges through reach resulting in short-term enlargement.	☐ Major channel and / or flow alterations, increase in flows and/or change in sediment load (increase or decrease).	☐ Major and extensive channel and/or flow alterations, increase in flows and / or change in sediment load (increase or decrease).
Score: Historic ☐	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7.4 Change in Planform	☐ Low bank erosion on outside bends, little or no change in sinuosity within the reach.	☑ Low to moderate lateral bank erosion on outside bends, may include minor change in sinuosity within the reach.	☐ Moderate to high lateral bank erosion on most outside bends, may include moderate change in sinuosity.	☐ Extensive lateral bank erosion on most outside bends, may include major change in sinuosity within the reach.
• Flood chutes may be present. • Channel avulsions may be evident or impending. • Change or loss in bed form structure, sometimes resulting in a mix of plane bed and riffle- pool forms. • Island formation and/or multiple thread channels.	☐ Little evidence of flood chutes crossing inside of bends, only minor side, point, or delta bars.	☐ Minor flood chutes crossing inside of bends, evidence of single to multiple unvegetated mid-channel, delta, or diagonal bars. Some potential for channel avulsion.	☑ Historic or active flood chutes crossing inside of bends, evidence of channel avulsion, islands, and multiple unvegetated mid-channel, delta, or diagonal bars.	☐ Active large flood chutes, evidence of recent channel avulsion, multiple thread channels, islands, and multiple unvegetated mid-channel, delta, or diagonal bars.
	☐ No human-caused alteration of channel planform and / or the width of the floodprone area.	☐ Minor to moderate alteration of channel planform and/or width of the floodprone area resulting from floodplain encroachment, channel straightening, or dredging.	☑ Major alteration of channel planform and/or the width of the floodprone area resulting from historic floodplain encroachment, dredging, or channel straightening.	☐ Major alteration of channel planform and width of the floodprone area resulting from recent and extensive floodplain encroachment, dredging, and/or channel straightening.
	☐ Human-made constrictions causing only negligible upstream deposition.	☑ Human-made constrictions smaller than floodprone width, causing minor to moderate upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than floodprone width, causing major upstrm / downstrm deposition.	☐ Human-made constrictions significantly smaller than bankfull width, causing extensive and major upstrm / downstrm deposition and flow bifurcation.
Score: Historic ☑	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1

7.5 Channel Adjustment Scores – Stream Condition – Channel Evolution Stage

Condition / Departure	Reference / N/S	Good / Minor	Fair / Major	Poor / Extreme	STD*	Historic	Condition Rating: (Total Score / 80)	Channel Evolution Stage:
Degradation		12				✓	0.68	II (F CEM)
Aggradation	18							
Widening		15					**7.6 Stream Condition:** Good	
Planform			10			✓		
Sub-totals:					**Total Score:** 55			

Channel Adjustment Processes: Arrested / armored degradation after historic planform change

7.7 Stream Sensitivity: Very Low / (Low) / Moderate / High / Very High / Extreme

* Channel Condition "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Channel Condition default to poor - Due to channel alterations from work in channel after flood: **Y/N**

* Stream Sensitivity "default" to **poor** – significant flood damage (not able to get accurate channel data) **Y/N ;**

* Stream Sensitivity "default" to **poor** Due to channel alterations from work in channel after flood: **Y/N**

VIII. APPENDIX C. NH FISH AND GAME DEPARTMENT'S FISH COMMUNITY SURVEY & WATER TEMPERATURE MONITORING REPORT

New Hampshire Fish and Game (NHFG) has conducted nine electrofishing surveys within the Melvin River Watershed since 2010. Eight surveys were along the Melvin River mainstem and one survey was along a tributary to the mainstem named Fields Brook. This surveys were conducted for a variety of reasons including collecting baseline information, evaluating fish communities for potential instream wood addition projects, and requests for information to complement an ongoing hydrological assessment.

NHFG Electrofishing Locations within the Melvin River Watershed

Site Number	Stream Name	Town	Date	Latitude	Longitude	Site Description
1	Melvin River	Tuftonboro	6/9/2010	43.69551	-71.25107	Accessed from Old Woods Rd
2	Melvin River	Tuftonboro	6/9/2010	43.7061	-71.23385	Downstream of Canaan Rd
3	Fields Brook	Tuftonboro	6/14/2010	43.71095	-71.29211	Upstream of Rt. 171
4	Melvin River	Tuftonboro	7/22/2022	43.69624	-71.2589	Great Meadows CE
5	Melvin River	Tuftonboro	7/22/2022	43.69649	-71.26042	Great Meadows CE
6	Melvin River	Tuftonboro	8/8/2022	43.69568	-71.25712	Great Meadows CE
7	Melvin River	Tuftonboro	9/19/2023	43.692943	-71.306456	Downstream of Colony Rd
8	Melvin River	Tuftonboro	9/19/2023	43.68908	-71.30334	Rt. 109 to dam
9	Melvin River	Tuftonboro	9/19/2023	43.695439	-71.284202	Downstream of Sodom Rd

The Number of Fish Species Captured at Electrofishing Sites within the Melvin River Watershed

Site	Blacknose Dace	Creek Chub	Common Shiner	Common Sunfish	Brook Trout (Wild)	Brook Trout (Hatchery)	Fallfish	Golden Shiner	Largemouth Bass	Longnose Dace	Rock Bass	White Sucker
1	20				58							1
2	44				7							
3					27							
4	70	1			124			11				24
5	100				132		1					34
6	51				119			3				12
7	67		27		1	1				69		29
8				15		10	11		1	6	2	3
9	15		20		17	1				42		15

Eleven different fish species are documented in the Melvin River Watershed. The presence of these species indicate a variety of cold water and wetland riverine ecosystem types and an influence of Lake Winnipesaukee in the lower portion of the drainage. Wild brook trout were found at most Melvin River survey locations (7). Blacknose dace and white suckers were both found at six Melvin River survey locations. All other resident fish species were found at three or less locations in the Melvin River. NHFG routinely supplies between 500 and 750 hatchery yearling and 20 two year old brook trout to the Melvin River on an annual basis to enhance fishing opportunities. These stocked fish were only documented in the three most downstream survey locations in the river. Only wild brook trout were found at the Fields Brook survey location.

All or the majority of common sunfish, fallfish, largemouth bass, and rock bass were captured downstream of the Pope Dam. The presence of these species is likely a function of these fish dropping downstream from the Pope Dam impoundment or ascending the Melvin River from Lake Winnipesaukee. Mature adults of several fish species in Lake Winnipesaukee utilize the lower portion of the Melvin River for spawning. Fallfish, rainbow smelt, some strains of rainbow trout, white perch, and white sucker are likely present at different times in the spring to spawn. How far upstream these species ascend the river is likely based on swimming ability and flow rate. Landlocked salmon and some strains of rainbow trout utilize the lower portion of the Melvin River to attempt to spawn in the fall. Natural recruitment of salmon and rainbow trout from spawning in all tributaries to Lake Winnipesaukee are documented to have an insignificant contribution to the lake populations. With the exception of the Fields Brook subwatershed which drains a steeper portion of the western Ossipee Mountains, the topography of the Melvin River Watershed results in mostly low gradient rivers and streams. Low gradient systems tend to be slower flowing and often have a strong association with adjacent wetlands. Streambanks are less confining, providing the ability for higher flows to expand laterally into wetlands to store excess flow. Common fish species found in these stream habitats include: blacknose dace, creek chub, common shiner, fallfish, golden shiner, longnose dace, and white suckers. These species are habitat generalists and are able to occupy a wide variety of stream types and conditions, making their presence fairly common and secure in New Hampshire. They are all somewhat tolerable of warmer summer water temperatures often associated with aquatic systems having high exchange rates with wetlands. Although a natural condition, wetlands and adjacent rivers often lack a riparian area which supports shading and filtration of sunlight, increasing water temperatures. This has the potential to establish a summer thermal barrier to fish species being more sensitive to water temperature and reduced dissolved oxygen in both the site specific area and downstream stream reaches.

Brook trout rely on a fairly consistent supply of cool water throughout the summer to survive. It is difficult to establish a specific upper thermal limit for the species because conditions, length of exposure, and nearby groundwater seepage can be highly variable. Even before lethal impacts, brook trout can exhibit stress effecting health and body condition. The species can migrate to preferred stream reaches in order to find more tolerable temperatures. Dams and some stream crossing structures (e.g., culverts) can impede this migration, jeopardizing the ability to access these preferred habitats. Given the percentages of wetlands associated with the Melvin River, the documented rate of wild brook trout distribution throughout the mainstem is striking. The numbers of wild brook trout located within or near the Great Meadows Conservation Easement is particularly impressive (fish survey sites 1, 4, 5, and 6). This river reach is between two large wetland complexes but still supports a presumable high quality brook trout population. Ground water contribution seeping into the river is likely strong enough to offset warmer water temperatures to support year round residency for the species. Fortunately, a significant portion of the high quality brook trout area in Melvin River is conserved. Exploring the ability to protect riparian areas upstream of the Great Meadows Easement to the wetlands below Rt. 171 would be a positive step in ensuring the population is resilient moving into the future. Another opportunity to ensure brook trout remain self-sustaining is to ensure fish passage at stream crossing locations. Reviewing Aquatic Organism Passage (AOP) scores from recently surveyed stream crossing structures (usually in the form of culverts) will reveal locations which restrict access for brook trout and other aquatic species. Stream crossing structures which preclude AOP are often undersized and present other problems for infrastructure stability. Flows are forced through the constriction of the undersized structure and exit with increased energy. Overtime, streambed material at the outlet of these structures is scoured, creating a drop (or waterfall) between the structure outlet and the streambed. Brook trout and other fish have difficulty navigating these outlet drops and may not have the ability to access more desirable habitats for spawning, foraging, and finding thermal refuge. Stream crossings which limit AOP are often unable to accommodate elevated flows and are vulnerable to failure. They also alter natural river processes of sediment conveyance. Generally, if a problematic culvert is replaced with a larger crossing structure sized and designed to accommodate greater flows and natural sediment conveyance, AOP will be ensured.

Summer Water Temperature Monitoring

The New Hampshire Fish and Game Department (NHFGD) deployed water temperature data loggers in the Melvin River (Tuftonboro) during the summer of 2023. Prior to making management decisions or initiating and monitoring implemented restoration projects, it is important to understand water temperature profiles for those rivers and streams sustaining or having the potential to sustain populations of salmonids. Water temperatures influence growth, behavior, survival, and distribution of salmonids (trout and salmon). The objectives of this study were to (1) examine stream temperature ranges during the months of July and August; and (2) determine the duration and extent of stream temperatures considered to present physiological stress ($\geq$ 70.0°F) on wild brook trout populations. Water temperature parameters were also examined with corresponding species occurrence information (when available) to evaluate the likelihood of young-of-the-year wild brook trout *Salvelinus fontinalis* presence.

HOBO Pendant Temperature/Light 64K data loggers or HOBO Water Temp Pro v2 data loggers (Onset Computer Corp©) were deployed four locations throughout the Melvin River between July and August, 2023. These data loggers were programmed to record temperature values at 1-hour intervals.

The locations (upstream to downstream) where data loggers were deployed in the Melvin River between July and August, 2023

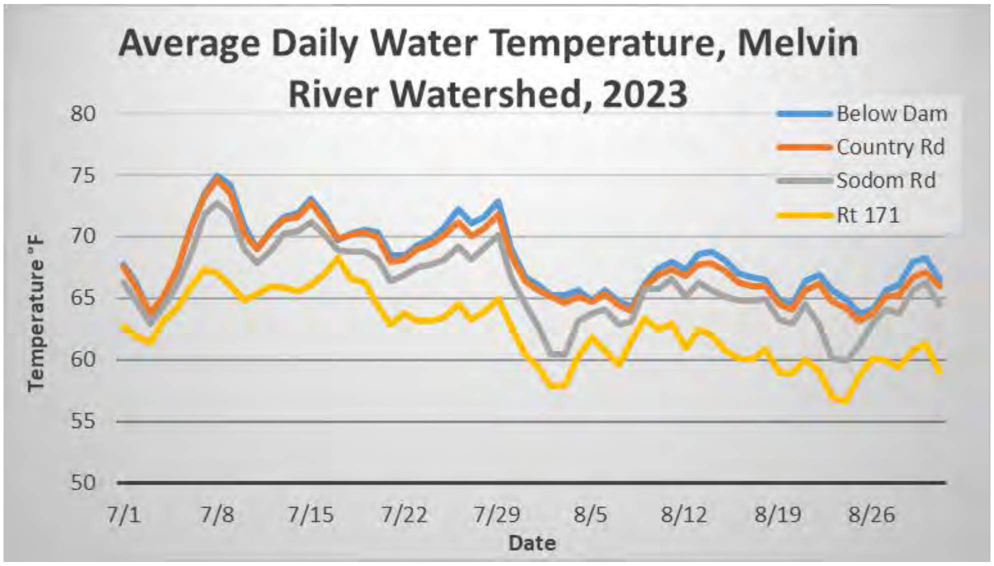
River Name	Town	Location	Latitude	Longitude
Melvin River	Tuftonboro	Below Rt. 171	43.7029	-71.24428
		Below Sodom Rd	43.6955	-71.28421
		Above Country Rd	43.69353	-71.30668
		Below Pope Dam	43.68972	-71.30321

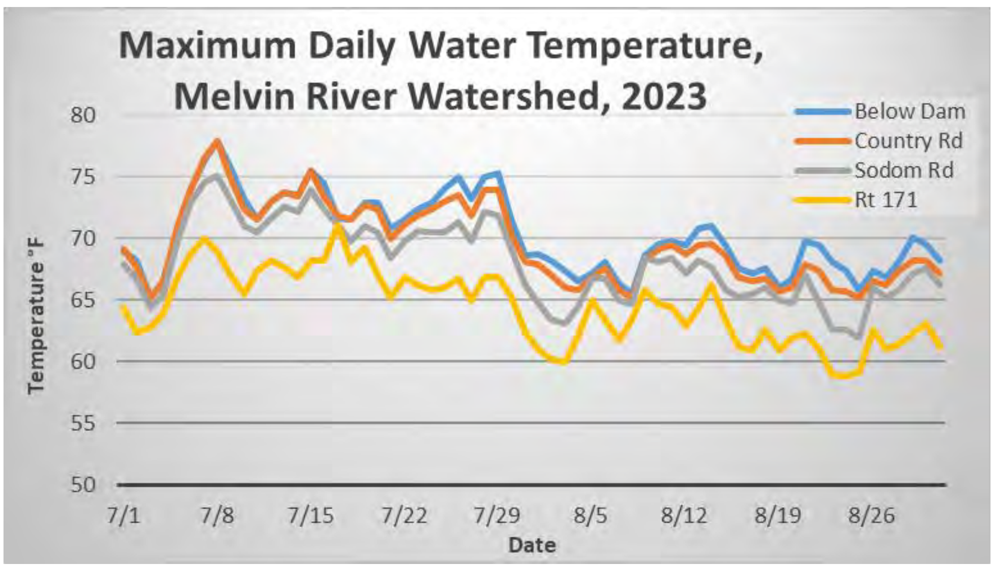
In 2023, mean summer water temperature values increased in the Melvin River as the size of the drainage area increased. The most upstream monitoring location Below Rt. 171 exhibited the coolest mean summer water temperature (62.38°F) while the most downstream monitoring location displayed the greatest water temperatures for July and August (68.16°F). The three most downstream monitoring locations are all below wetland complexes associated with the Great Meadows Conservation area and the lower portion of Fields Brook. These three locations contained mean summer water temperature values between 3.66°F and 5.78°F greater than the upper portion of the watershed. This may be indicative of the wetland area influence on overall water temperature values in the lower portion of the Melvin River.

Although observing a slightly greater mean summer water temperature at the Below Pope Dam monitoring location, both the Below Pope Dam and Above Country Rd locations exhibited identical ranges (minimum and maximum) in temperature for the summer. The mean summer water temperature for the Above Country Rd monitoring location (slightly upstream of the Pope Dam impoundment) was only 0.48°F less than the value below the impoundment. This suggests, in 2023, the impoundment had minimal influence on water temperature.

The Mean Value of July and August Combined Water Temperature (MJAWT), Mean Value of July Water Temperatures (MJWT), and Mean Value of August Water Temperature (MAWT) and ranges observed in the Melvin River, 2023

Location	MJAWT (SD) Range	MJWT (SD) Range	MAWT (SD) Range
Below Rt. 171	62.38 (+3.1) 54.3-71.2	64.59 (+2.3) 58.3-71.2	60.17 (+2.1) 54.3-66.2
Below Sodom Rd	66.04 (+3.4) 56.4-75.1	68.28 (+2.8) 61.7-75.1	63.81 (+2.3) 56.4-66.2
Above Country Rd	67.68 (+3.2) 61.6-77.9	69.75 (+2.9) 62.6-77.9	65.61 (+1.7) 61.6-68.4
Below Pope Dam	68.16 (+3.2) 61.6-77.9	70.11 (+3.0) 62.6-77.9	66.2 (+1.9) 61.6-71.0





The frequency of days in which stream temperatures may have presented physiological stress on wild brook trout (≥70°F) during the months of July and August are presented in the table below. All monitoring locations exceeded 70°F in the month of July. The Below Rt. 171 site only exceeded the threshold for single day for a duration of 6 hours. The most downstream location exceeded 70°F most frequently for 26 days, lasting between 2 and 24 hours. The most downstream location was the only site to exceed 70°F in the month of August. This occurred on 2 days for a duration between 5 and 8 hours.

The frequency of days and average daily duration in hours in which water temperature may have presented physiological stress on wild brook trout (≥70°F) for salmonids for the months of July and August observed in the Melvin River, 2023.

Location	July Days ≥70°C	Average Duration (Range)	August Days ≥70°C	Average Duration (Range)
Below Rt. 171	1 day	6.0 hours (n.a.)	0 days	n.a.
Below Sodom Rd	21 days	10.0 hours (3.0-24.0)	0 days	n.a.
Above Country Rd	25 days	13.9 hours (1.0-24.0)	0 days	n.a.
Below Pope Dam	26 days	15.3 hours (2.0-24.0)	2 days	6.5 hours (5.0-8.0)

A comparison of locations throughout New Hampshire with both average monthly water temperature values and concurrent fish species presence information indicates young-of-the-year brook trout are not *generally* found in waters which exceed mean July water temperatures of 67.1°C (NHFGD unpublished data). This was corroborated in fish surveys at the two most downstream monitoring locations. No young-of-the-year brook trout were captured at the Above Country Rd and Below Pope Dam locations. However, at least two young-of-the-year brook trout were captured at the Below Sodom Rd site.

The Melvin River reach between the Great Meadows area and the wetland complex downstream of Rt. 171 was not monitored in 2023. Electrofishing surveys from 2022 indicate this area supports a robust population of wild brook trout despite being directly downstream of a large wetland. Future water temperature monitoring in this location would be helpful to explain the level of influence potential groundwater infusion has in this area. Meteorological records from Concord NH indicate the air temperature during the summer of 2023 was 0.2°F cooler than the long term mean. Precipitation amounts were 4.50 inches greater than the long term summer average. Future temperature monitoring throughout the watershed may help illustrate different water temperature variations based on seasonal weather patterns.