FUSS & O'NEILL

# MEMORANDUM

**TO**: Don Humason, Town Administrator, Town of Chester

**FROM**: Julianne Busa, Ph.D., PWS, Certified Senior Ecologist; Michael Soares
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1550 Main Street, Suite 400
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**DATE**: June 29, 2023

**RE**: FY23/FY24 MVP Action Grant – Towns of Chester, Middlefield, and Blandford
**Beaver Assessment Technical Memorandum—Town of Chester**

## 1 Introduction

Beaver activity and beaver management is often a contentious topic, evoking strong feelings among land owners and managers. There is a long history of human-beaver conflict. As increasing development has moved the built environment closer to wetland systems and preferred beaver habitat, the likelihood of a beaver impoundment affecting infrastructure or property rises significantly. This potential for conflict has increased in recent decades as beaver populations have recovered from extensive trapping in the 1700's and 1800's, which nearly rendered the species extinct.

Beaver impoundments can contribute to road flooding and washout hazards or other property damage if they are located close to road-stream crossings or developed areas. Potential risks stem from two distinct scenarios: 1) dam failure which causes a sudden release of impounded water that floods downstream areas, and 2) backwater flooding of upstream areas which can cause ongoing inundation of property and infrastructure in the absence of mitigative action. More intense and less predictable precipitation events expected under medium to high emissions climate change scenarios may cause impoundments to expand rapidly, or cause beaver dams to fail, leading to unpredictable flooding in unexpected locations.

However, beavers also play an important positive role in the environment and may have an even more important role in building resiliency against climate change impacts. Beaver activity provides a number of specific benefits that increase the ability of riparian and aquatic systems to react dynamically to climate impacts, particularly those related to both flooding and drought. Beaver dams are often built in series, with many small dams scattered along a reach of stream. These dams operate much like a series of man-made check-dams, slowing water at numerous points and providing ponded storage and velocity control. Hydrologic modeling of beaver dam systems has shown that a series of five beaver ponds in sequence can dampen peak flows during a storm event by 14% (Beedle 1991). Beaver dams also slow

Financial assistance was provided by the Executive Office of Energy & Environmental Affairs (EEA) under the FY23/FY24 Municipal Vulnerability Preparedness (MVP) Grant Program. The MVP Action Grant offers financial resources to municipalities that are seeking to advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, inland and coastal flooding, severe heat, and other climate impacts.

snowmelt runoff, which helps to maintain perennial flow in streams that might otherwise become intermittent; they also create ponds and wetlands which provide valuable habitat functions for native fish, amphibians, and small mammals and birds. They trap sediment, preventing its transport and accumulation downstream and reconnecting incised streams with their floodplains, facilitate groundwater recharge and water filtration by allowing water to slow down sufficiently to infiltrate, lower the potential for bank erosion due to high-velocity flows, and reduce flood force.

Healthy wetlands and riparian areas are particularly important in the context of predicted climate change impacts, because precipitation is expected to increase in both intensity and volume, but consecutive dry days are also expected to increase. Thus, having capacity to slow peak flows and store water for recharge or slow release will both be increasingly important traits of resilient systems and communities.

In support of a regional FY23/24 MVP Action Grant focused on "Evaluating and Planning for Resilient Dirt Roads" in the Towns of Chester, Middlefield, and Blandford, Fuss & O'Neill assessed beaver activity at key sites where impacts related to beaver activity were identified by staff and project steering committee members from the Town of Chester. The primary goal of the overall project is to increase resilience to flooding, washouts, and storm damages along dirt roads throughout the three Towns. To that end, the beaver assessment component of the project sought to analyze beaver activity to determine where the nature of such activity may be supportive of greater resilience and where it may be threatening to dirt road infrastructure. The work of this task drew on methodology developed by Fuss & O'Neill in 2019 for a similar MVP-funded assessment in the Town of Belchertown. Our beaver assessment protocol is not meant to cover an exhaustive Town-wide assessment, but typically focuses on specific areas based on known areas of substantial beaver activity, historic or ongoing impacts, complaints, etc.

This memorandum summarizes the methods and results of the beaver management field surveys and recommended management approaches based on field observations and the vulnerability assessment and prioritization process and presents a protocol for assessing new sites and assigning them to one of three management categories to guide selection of appropriate management strategies. This memorandum is intended to serve as an ongoing guidance document for future use by the Town, and to provide both recommendations for specific sites, as well as more general observations and a systematic, evidence-based process to guide management decision-making when new beaver activity or potential impacts are reported.

## 2 Beaver Assessment Field Surveys

### 2.1 Selection of Priority Field Sites

Fuss & O'Neill met with the Chester Town Administrator, as well as members of the Board of Selectmen and Conservation Commission in early February, 2023 to discuss areas of known current or past beaver activity in the Town, particularly in proximity to any of Chester's dirt roads. The goals for the beaver management planning effort were also discussed during this initial kickoff meeting, and a number of additional areas of dirt roads or potential beaver activity were identified for further review, first via imagery, and later in the field. Based on this local knowledge of historically-impacted areas and review of current and historic aerial imagery, we identified five sites as focus areas for beaver management planning assessments. The highest priority areas of focus were determined to be:

- Lyman Road, where the roadway lies only inches above the typical water level in the adjacent impoundment
- Areas of current and past activity along Skyline Trail which used to have regular issues with inundation of driveways
- A section of Middlefield Road north of Town Hall and downtown Chester where the river is confined between the roadway and railroad bed
- Areas on Fisk Road and Kinnebrook
- And E. River Road which experienced issues in the past, and where beaver dams have been removed several times to date

Satellite imagery of these areas from approximately 2006 to present was examined to further refine the scope of field work and identify specific areas where current beaver activity was expected to be found. Imagery was also used to review the surrounding topography and understand the extent of potential flooding or damages at a given location. The review identified potential beaver dams and impoundments, field access points and potential concerns related to private property access, connected wetlands, and potentially-impacted infrastructure or property near the assessment sites.

## 2.2 Field Data Collection

Field surveys were intended to identify areas of nuisance beaver activity; flooding/blockage of infrastructure; areas where such impacts are potentially possible but not presently occurring; undesirable beaver-driven habitat impacts, such as tree harvesting; and areas where beaver activity may be expected to proceed as part of a nature-based flood resiliency solution without negative societal impacts. The field assessment protocol was therefore developed to collect data that would provide a framework for determining the flood resiliency benefits of an impoundment and, conversely, its current or potential threat to nearby infrastructure and/or property.

Detailed field assessments were conducted by Fuss & O'Neill over the course of February 22nd and May 10th 2023, with additional scouting of dirt roads conducted over multiple days in the intervening period to confirm presence or absence of beaver activity along some dirt roads for which recent, high-quality aerial imagery was not available. Roads that were scouted throughout the study included:

- Johnson Hill Road
- Ingell Road
- Abbott Hill Road
- Crane Road
- Mica Mill Road
- Maynard Road
- Bromley Road
- Smith Road
- Fisk Road
- Round Hill Road
- State Road
- Sanderson Brook Road
- Kinnebrook Road
- Skyline Trail
- Middlefield Road
- Higgins Road
- S Worthington Road

When evidence of beaver activity was encountered or pre-selected sites were reached, staff documented observations and conducted assessments using a digital field form designed for this study.

Field assessments followed a standardized procedure to evaluate and collect data on the type and scale of beaver activities, and to assess whether observed activity at each site was recent/ongoing. Protocols for documenting beaver activity followed methodology developed by Fuss & O'Neill in 2019 which incorporated elements of the beaver survey methodology developed and tested by the Johnson Creek

Watershed Council (Portland, Oregon). Evidence of beaver activity included dams, impoundments, chewed sticks or stumps, canals, mud slides, scent mounds, and food caches. The extent and locations of dams and impoundments were mapped in the field using ESRI ArcCollector and refined in the office using additional aerial imagery and topographic data. Where intact dams were found, the height of impounded water relative to surface waters below a dam was recorded to allow for calculation of impounded water volume. In addition, where applicable, the overall quality of the surrounding stream and riparian system was evaluated based on a protocol modified from the Center for Watershed Protection's Unified Stream Assessment Manual (Kitchell and Schueler 2005). In particular, Fuss & O'Neill's protocol incorporated aspects of the Unified Stream Assessment's Impacted Buffer, Severe Bank Erosion, and Reach Level Assessment field protocols to evaluate components and conditions in riparian areas (vegetative cover, erosion, land use, floodplain conditions). All field data, assessment records, and supplementing photographs were geo-referenced in the field.

At particular sites, the standard field data was supported with additional site-specific information gathered from local residents who were either introduced to field staff by the Town or encountered in the field during the course of conducting assessments. At the Lyman Road site, the property owner provided a detailed tour and summary of beaver impacts and management in the vicinity. The historic narrative and enhanced access provided by residents led to additional valuable data and in-depth understanding of ongoing and historic impacts in assessed areas.

# 3 Management Categories

The adaptive management approach developed for Chester is modeled off of similar beaver management approaches and plans in other parts of the country (e.g., Wheaton 2013), which utilize management categories to guide municipal users to a suite of appropriate management tools. Management approaches are provided for each of three recommended management categories:

- **Beaver Restoration Zones**: Sites where beaver activity can be managed for climate resiliency and flood mitigation benefits with minimal human impacts.

- **Beaver Coexistence Zones:** Sites where beavers may potentially impact infrastructure, but impacts can be managed without displacing beavers and/or climate resiliency benefits outweigh impacts.

- **Beaver Restricted Zones:** Sites where potential or existing impacts to infrastructure pose unacceptable risk and are not able to be mitigated without removal or significant restriction of nuisance beaver structures, and, in some cases, beavers themselves.

## 3.1 Beaver Restoration Zones

The term "Beaver Restoration Zone" has dual meanings. These are sites where beavers are helping to accomplish habitat restoration, particularly restoration of streams, wetlands, and floodplains. These may also be sites in which ecological restoration techniques can be used to foster beaver populations and increase the scale of potential climate resiliency and flood resiliency benefits associated with beaver activity.

### 3.1.1 No Action

In many cases, beaver restoration zones require no active management. No detrimental impacts are anticipated at these sites, and beaver activity is anticipated to be beneficial for climate and flooding resiliency and/or habitat value. Monitoring is recommended every 1-2 years to assess any major changes to the extent of impoundments and track whether beaver activity is current/ongoing at the site.

### 3.1.2 Prevent Trapping

Trapping of beavers should be discouraged in areas that have been classified as beaver restoration zones and emergency permits for beaver removal or dam breaching should not be permitted in these areas.

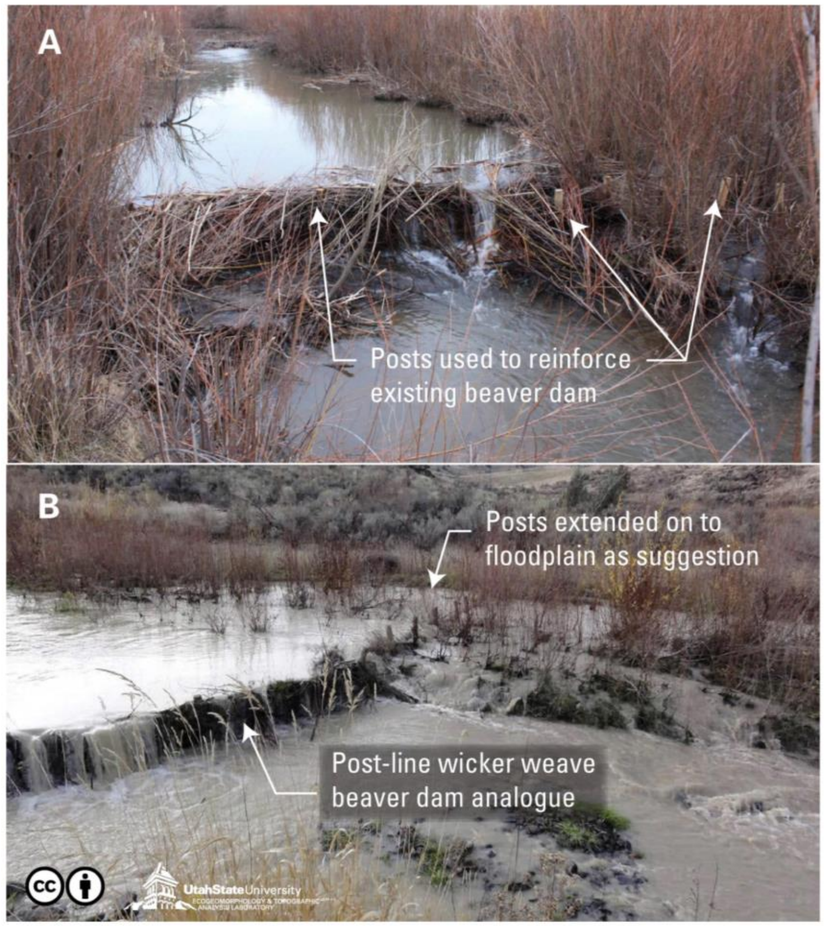


**Figure 1. Reinforced natural beaver dam (A) and human-constructed BDA (B). Reprinted from Shahverdian et al. 2019.**

### 3.1.3 Encouragement/ Establishment of New Populations

By definition, beaver restoration zones are classified as areas in which the beneficial aspects of beaver activity outweigh any potential impacts, and beavers should therefore be encouraged to continue inhabiting the site. As such, there may be instances in which it is appropriate to take steps to make beaver restoration zones more appealing to beaver populations. The simplest method of encouraging beaver activity is often to ensure that their preferred food supply is present. This can also be an effective means of encouraging beavers to stay in areas deemed restoration zones, and discourage relocation to less desirable sites. Willow and cottonwood are easy-to-grow species that are preferred by beaver and can be planted in riparian areas that are not fully inundated in order to encourage beaver habitation. Detailed propagation methods can be found in Hall et al. 2014.

### 3.1.4 Beaver Dam Analogs

Beaver Dam Analogs (BDAs) are human-built, channel-spanning structures that are intended to mimic and/or enhance the function and effect of beaver dams. As with natural beaver dams, BDAs reduce stream power, slowing flows and dispersing water into the floodplain. BDAs are built with the same materials used in natural beaver dams (e.g., mud, sediment, and woody material). Typical designs include driven posts as a frame through which additional branches and material are woven; post-less designs can also be constructed, mimicking the process of natural beaver dam construction (**Figures 1, 2**). Sediment and other naturally-sourced materials are piled against the upstream side of the BDA to form a structure that holds water (Pollock et al. 2015). BDAs are intended to be low-tech, "messy" structures that can be designed and deployed in the field with locally available materials (Shahverdian et al. 2019).

BDAs can also be used to either create additional water-holding capacity or provide a frame on which beavers can be encouraged to build additional height, thereby increasing impoundment size with subsequent benefits of increased floodplain connectivity and flood storage. Ongoing maintenance and repair will be required (as is the case for natural beaver dams), at least in the short term. Ultimately, BDAs are intended to encourage the adaptive

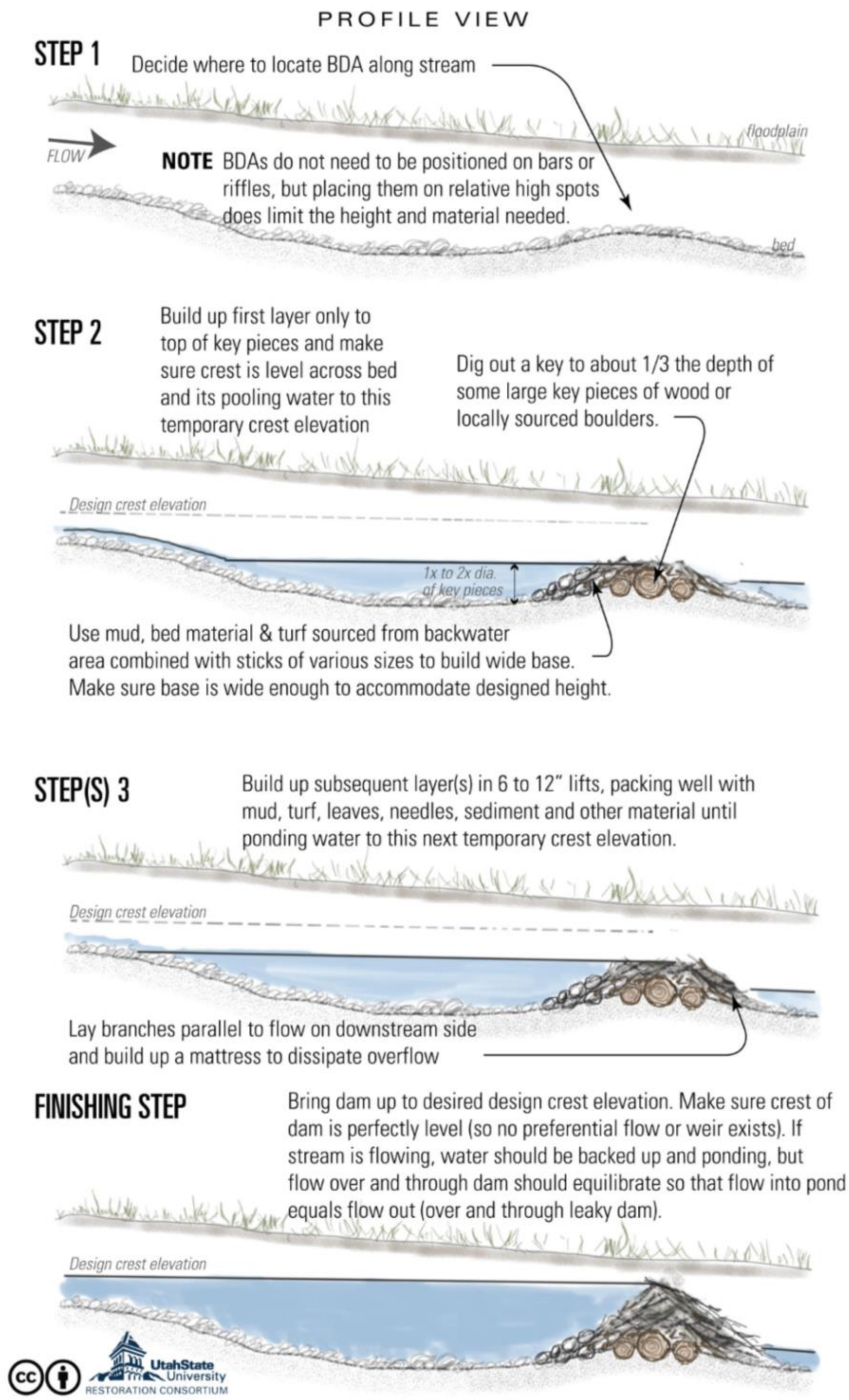


**Figure 2. Typical sequence for building postless BDAs. Reprinted from Shahverdian et al. 2019.**

development of natural systems with more advantageous geomorphic and riparian characteristics that are either self-sustaining, or managed by natural beaver populations. While BDAs are low-tech, all alterations to wetland resource areas in Massachusetts are subject to the Wetlands Protection Act; BDAs would need to be permitted, most likely as part of an Ecological Restoration Limited Project designed to enhance the interests of the Act.

## 3.2 Beaver Coexistence Zones

Management approaches in Beaver Coexistence Zones focus on tolerance of beaver activity, while seeking to limit human-beaver conflict. Appropriate management techniques include non-lethal deterrents and means of controlling water levels to limit flooding while still allowing beavers to inhabit a site.

### 3.2.1 Flow-control Devices

Flow-control devices, often called "pond levelers," allow water to bypass otherwise intact beaver dams, and can therefore be an effective solution for mitigating inundation and flooding by lowering water levels and decreasing the size of an impoundment (**Figure 3**). Typical designs feature flexible plastic piping with a protected, underwater inlet (i.e., surrounded by wire-mesh fencing) located just below the desired final water level depth and at least 3 meters upstream of the existing beaver dam. The plastic piping is run through the dam (partial breach is likely be required for installation) and outlets several meters downstream. Once in place, beavers can rebuild the dam around the plastic pipe, but flow through the leveling device is maintained as long as the inlet and outlet remain unobstructed. A study in Billerica showed that the average flow-control device costs $1,500 to install, with annualized costs of installation and maintenance associated with flow-control devices ranging from $229 to $375 per device (these values account for inflation since publishing dates of the related studies; Callahan et al. 2019, Simon 2006).

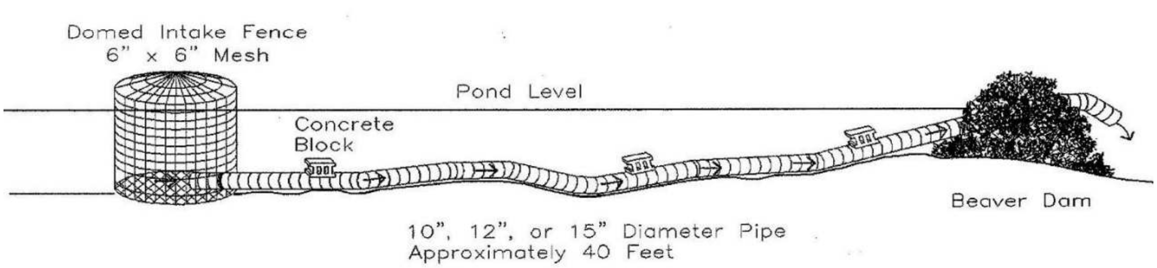


**Figure 3. Schematic of a typical flow-control device. Reproduced courtesy of Mike Callahan, Beaver Solutions LLC, "Working With Nature"**

### 3.2.2 Appropriate Road-Stream Crossing Design

Undersized road-stream crossing structures pose a number of problems for flood resiliency, and in areas where beavers are active, beaver activity can compound the problem. Undersized crossings are not only easier for beavers to block with dam construction, but they also tend to increase water velocity relative to the surrounding stream, which often contributes to an increase in the sound of running water at the crossing. Both of these features trigger beavers' dam-building instincts. Right-sized road-stream crossings ideally allow water to flow, unconstricted, through a channel and banks that are indistinguishable from the rest of the stream banks, reducing water noise and maintaining a consistent velocity. An empirical study of road-stream crossings in New York demonstrated that the probability of a culvert being blocked by beavers decreased exponentially as the crossing structure diameter increased, with a 3-foot diameter culvert having a nearly 75% chance of being blocked, versus a 7% chance of blockage by beavers for a 12-foot diameter culvert (Jensen et al. 1999). The same study showed that the annualized costs of culvert replacement and right-sizing were significantly higher than the annualized costs of installation and maintenance associated with flow-control devices (approximately $1,300 to $2,600 per structure after accounting for inflation since the time of the study). Road-stream crossing replacements generally range from $200,000 to $1 million or more for engineering design, permitting, and construction, depending on the size of the crossing and other site constraints. However, given the other benefits of right-sized structures (increased hydraulic capacity, decreased geomorphic risks, increased aquatic passability, and decreased risk of failure or overtopping), crossing replacement may be a cost-effective means of addressing multiple resiliency benefits at once.

### 3.2.3 Physical/Chemical Beaver Deterrents

A variety of deterrents can be utilized in beaver coexistence zones to manage human-beaver conflict at a finer geographic scale within a given site (e.g., keeping beavers out of particular areas or protecting specific trees). Chemical sprays or fencing can be used to protect particular trees from herbivory. Chemical sprays require repeated application to remain effective. Fencing is generally considered to be a better, longer-term solution. Fencing should be heavy-guage mesh with openings no greater than 6 inches and caging around trees should be spaced at least 6 inches to a foot from the tree trunk or trunks it encircles, extending to a minimum height of 3 feet (and higher where snow is expected to pile up beyond this height). After installation, fencing should be monitored to assess its effectiveness, and extended upward or outward as necessary if signs of herbivory are observed. Electric fencing can also be effective in discouraging beavers from infringing too closely on agricultural activity, and may be a simple solution for sites where electric fencing is already in use (e.g., farms), as this solution simply involves expanding the scope of fenced areas to include the potential beaver food source.

### 3.2.4 Behavioral Beaver Deterrents

Just as beaver habitat can be managed to encourage beaver activity in beaver restoration zones, habitat can also be managed to discourage detrimental beaver activity by capitalizing on an understanding of what drives beaver behavior. Beavers build dams in order to create sufficient water depth to maintain safe underwater access to their lodges even while ponds are frozen during the winter. They typically do not build dams in areas where water is already 2 to 3 feet deep. At existing lakes and ponds, controlling sediment accumulation to prevent waterbodies from becoming too shallow can help to maintain such ponds for use by both beavers and humans and decrease potential for human-beaver conflict. In stream and wetland systems, diversion dams can be used to encourage beavers to dam in areas where impacts will be minimized. Fencing or natural materials can be used to create cascading water noise which will encourage beaver activity at strategically placed locations away from areas that need to be protected (e.g., culvert inlets) or upstream of areas where inundation is to be avoided. To reduce human-beaver conflict related to undesirable vegetation loss and tree felling, restore beaver-damaged vegetation with native plants that are non-preferred food sources (e.g., spruce, elderberry, ninebark) or focus on plants that resprout quickly (e.g., cottonwood, aspen, willow, red-twig dogwood).

## 3.3 Beaver Restricted Zones

Beaver Restricted Zones are areas in which potential risks associated with beaver activity are too great to justify tolerance. This includes areas with ongoing or imminent risks to infrastructure, as well as activity in areas with direct impact to human health or livelihoods (e.g., flooding of water supply or wastewater treatment structures, or flooding of agricultural fields leading to loss of income). When considering management options in Beaver Restricted Zones, it is important to remember that the focus is on restricting large dams and associated impoundments that result in flooding impacts; restricting the presence of beavers themselves is not always necessary or desirable.

### 3.3.1 Dam Removal/Breaching

Breaching or removing beaver dams provides immediate relief from flooding impacts, and should be used when impacts are severe and ongoing. However, dam removal in areas where beavers are still active is typically a short-term solution; beavers can often rebuild dams within a matter of days. The initial breaching or removal of a dam is generally inexpensive but may require an excavator or other heavy equipment and access to remote sites. Regular inspections and follow-up will likely be required.

### 3.3.2 Trapping

Trapping and killing of beavers in Massachusetts requires a permit and is regulated to a season between November 1st and April 15th. Out of season trapping is permitted with an emergency permit from the Board of Health in cases of threats to property or human health and safety. It is recommended that any site that is identified as a Beaver Restricted Zone should be considered by the Town to warrant such a permit. However, trapping may also be a short-term solution. Without additional changes to the habitat conditions to deter beavers, it is likely that new individuals will move into the area, causing a recurrence of impacts – and management costs. Ongoing trapping may be appropriate and necessary at certain locations, but it is generally advised that trapping be used in association with other deterrents or habitat modifications to reinforce these areas as beaver restricted zones. Trapping has also been shown to be more expensive than installation and maintenance of flow-control devices, with annualized costs of management via trapping averaging $409 across sites in Billerica, MA (Callahan et al. 2019).

### 3.3.3 Fencing and Flow-Control Devices

Flow-control devices, as described in Section 5.2.1, can be used to help maintain flows through road-stream crossings as part of a management strategy in Beaver Restricted Zones. A pond-leveler device is currently installed in the dam of the impoundment at HB3 (see Section 5.3.1) , just below the outlet of the Warren Wright Road crossing where water is backed up through the existing structures.

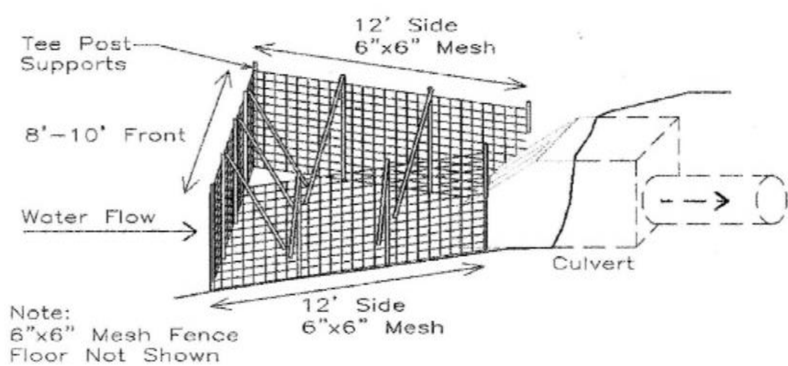


**Figure 4. Schematic of The Keystone Fence™ device. Reproduced courtesy of Mike Callahan, Beaver Solutions LLC, "Working With Nature"**

The leveler downstream of the crossing helps to ensure that water levels in the impoundment do not become high enough to overtop the road. Fencing can also be placed around culvert inlets (**Figure 4**), a design commonly referred to as a "beaver deceiver," as a cost-effective way to protect crossing structures by limiting beaver access to inlets. Such devices use configurations that discourage dam construction while maintaining adequate flow into culverts and/or enlarge the total area that must be dammed in order to stop water flow. This type of protective structure is installed at the WB4 site (see Section 5.3.5), where Rural Street crosses Weston Brook. Note, however, that such fencing does not always prevent blockages; it simply makes them easier to clean out. Fencing is subject to natural accumulation of sediment and debris in addition to beaver-engineered damming, and can be counter-productive to maintaining a structure's maximum hydraulic capacity for passing storm flows and woody debris. Any fencing installed at culvert inlets should be monitored and maintained to prevent blockages, especially when large precipitation events are anticipated. Recommended maintenance frequency is at least 3-4 times annually. Costs for culvert protection devices (fencing or flow-control devices) are typically $1,500 per device for installation, with annualized costs of installation and maintenance associated with flow-control devices ranging from $229 to $375 per device (these values account for inflation since publishing dates of the related studies; Callahan et al. 2019, Simon 2006).

### 3.3.4 Site Modification

Modifications to the site, including both habitat modifications and/or infrastructure modifications, are often a more effective long-term solution for restricting beavers from certain areas. Modifications can also help to transition a Beaver Restricted Zone to a Beaver Coexistence Zone by reducing the potential for flooding impacts. Right-sizing road-stream crossings (see Section 5.2.2) should be considered at all locations where beaver activity threatens crossing infrastructure, roadway, or supporting material. Widening or deepening natural constriction points can be considered on a case-by-case basis to discourage damming. Removal of available food sources (e.g., by fencing, or in some cases, tree removal) may also be used to disincentivize colonization of a site by new individuals after a round of trapping. Costs for site modification vary widely, from inexpensive efforts to protect or modify vegetation to crossing replacements that require detailed engineering and permitting and can range from several hundred thousand to more than $1 million, depending on the site.

# 4 Management Category Classification and Prioritization

In developing the framework for our management approach, field survey data, USGS StreamStats data, GIS data, and aerial imagery were incorporated into a vulnerability assessment matrix to produce a score for each assessed impoundment. Scores were subsequently used to classify each impoundment into one of the three management categories identified in Section 3.

## 4.1 Assessment Method

Four individual components contribute to the overall score and classification for each assessed impoundment: 1) flood/climate resiliency, 2) impacts to roads/culverts/railway, 3) impacts to buildings/property, and 4) natural system quality. A summary of the scoring and criteria for each of these four metrics can be found in **Table 1**. Two additional factors were assessed to further quantify the potential flood resiliency benefits associated with each impoundment: 1) watershed ratio, and 2) impoundment volume.

- **Flood/Climate Resiliency:** Capacity to provide additional flood storage and thus mitigate the impacts of riverine flood events was estimated for each impoundment. Two criteria were developed to assess an impoundment's connection to suitable land areas that would allow for its expansion and temporary retention of floodwater without impacts to infrastructure or property. The first criterion was an evaluation of land types surrounding an impoundment. Field investigations and reviews of aerial imagery and DEP data layers available from MassGIS mapping services were used to determine if wetlands, floodplains, low-lying uplands, or similar natural areas are located adjacent to *and* are hydrologically connected to an impoundment. When such potential flood storage areas were identified, their percent-area was estimated as the approximate acreage of flood storage area divided by the approximate acreage of an impoundment (at its typical extent under normal water levels and flow conditions). When estimated flood storage areas were 25% or more of an impoundment, it was assessed as having some potential flood storage capacity (score: +1). Impoundments with flood storage estimates greater than 50% were assessed as having a high potential (score: +2).

  The second criterion focused on land use surrounding an impoundment, specifically the presence/absence of encroachment (encroachments are activities or construction including fill, new construction, substantial improvements, and other development. These activities can disrupt natural processes and reduce the floodplain's hydrologic capacity and function.). Again, information was gathered from field surveys, review of aerial imagery, and GIS data to locate areas of encroachment near an impoundment. Using an assessment method provided in the Center for Watershed Protection's Unified Stream Assessment Manual (Kitchell and Schueler 2005), floodplain encroachment was assessed using a scale (1-10) to estimate the degree of impact on connected floodplains. This value was converted to a score representing no impact (0), some impact (-1), or significant impact (-2) (see **Appendix B**).

- **Impacts to Roads/Culverts/Railway**: Current, historical, and potential impact(s) of an impoundment on nearby infrastructure were assessed using three criteria. An "impact" is identified as either: 1) flooding of infrastructure caused by an impoundment; 2) erosion or other soil disturbance of fill material by impounded water; 3) beaver activities that cause or are likely to cause flooding or other damage to infrastructure (e.g., tree felling, construction of lodges, canals, dams). The criteria to assess current and historical impact(s) relied on direct observations in the field by Fuss & O'Neill staff of damaged/compromised infrastructure or conditions that are known to cause damage or impairment. To verify an assessment of historical impacts at specific locations, observational records were supplemented with reports from Town staff, residents, and contractors of impacts in recent years. Where current impacts were not present, it was assumed that any infrastructure (roads, culverts, railway) within 200 feet upstream or downstream of the impoundment had a high potential for detrimental impacts. The stream channel was reviewed via aerial imagery for 200 feet in the upstream and downstream directions from an impoundment in order to assess these potential impacts.

- **Impacts to Buildings/Property:** Current, historical, and potential impact(s) of an impoundment on nearby buildings and other property were assessed using three criteria. An "impact" is identified as: 1) flooding of infrastructure caused by an impoundment; 2) erosion or other soil disturbance of fill material by impounded water; 3) beaver activities that cause or are likely to cause flooding or other damage to infrastructure (e.g., tree felling, construction of lodges, canals, dams). The criteria to assess current and historical impact(s) relied on direct observations in the field by Fuss & O'Neill staff of damaged/compromised buildings/property or conditions that are likely to cause damage or impairment. To verify an assessment of historical impacts at specific locations, observational records were supplemented with reports from property owners and Town staff of impacts in recent years. Where current impacts were not present, it was assumed that any buildings or developed property (e.g., farm fields) within 200 feet upstream or downstream of the impoundment had a high potential for detrimental impacts. The stream channel was reviewed via aerial imagery for 200 feet in the upstream and downstream directions from an impoundment in order to assess these potential impacts.

- **Natural System Integrity:** Stream and riparian characteristics were incorporated into the matrix as qualitative markers of riparian ecosystem quality and the potential value of each site's habitat relative to nature-based flooding solutions or restoration. Field assessment protocols were modified from the Center for Watershed Protection's Unified Stream Assessment Manual (Kitchell and Schueler 2005) to capture indicators of land cover, protective vegetative cover in the surrounding riparian area, and severity of bank erosion using qualitative scales (see **Appendix B**).

- **Watershed Ratio:** Where intact beaver dams were present, a watershed ratio was estimated for each dam to quantify the ratio of watershed area to impoundment area. Watershed ratio provides a rough quantitative measure of an impoundment's flood storage potential, and therefore an assessment of flood risk versus flood mitigation potential. A large watershed ratio indicates an impoundment is small in relation to the size of the watershed, and thus is less likely to provide significant flood protection to downstream properties and infrastructure, while a small ratio indicates that the impoundment is more likely to provide some level of flood mitigation.

- **Impoundment Volume:** Flood storage volume associated with each impoundment was evaluated using the methodology of Karran et al. 2017, which is intended specifically for rapid estimation of beaver impoundment volumes for use in land use planning and decision-making. Impoundment surface area and maximum height of the dam are used to estimate impoundment volume as follows:

$$Maximum\ impoundment\ volume = \frac{Maximum\ impoundment\ area\ \times Maximum\ dam\ height}{1 + 2/0.91}$$

**Table 1. Summary of criteria and scoring for each beaver assessment metric.**

| | | Score | | | | |
|---|---|---|---|---|---|---|
| | | **-2** | **-1** | **0** | **1** | **2** |
| **Metric** | **Flood/ Climate Resiliency** | | | No or minimal potential for flood storage capacity, AND/OR moderate to significant encroachment in connected floodplains; surrounding land use has moderate to significant effect on floodplain function. | Potential for some flood storage capacity, AND/OR minor to moderate encroachment in connected floodplains; surrounding land use has little to moderate effect on floodplain function. | Potential for substantial flood storage capacity, AND/OR no encroachment in connected floodplains or minor encroachment/ surrounding land use has little to no effect on floodplain function. |
| | **Impacts to Roads/Culverts/Railway (R/C/R)** | Current impacts observed, *OR* historical impacts observed within the last 2 years, *OR* infrastructure located within 200’ of impoundment (upstream or downstream). | | No impacts within last 2 years, *AND* no infrastructure located within 200’ of impoundment (upstream or downstream). | | |
| | **Impacts to Buildings/Property (B/P)** | Current impacts observed, *OR* historical impacts observed in the last 2 years, *OR infrastructure* located within 200’ of the impoundment (upstream or downstream). | No current or historical impacts, *AND* B/P are located within 200’ of the impoundment *AND* are at an elevation less than 5’ above impoundment’s surface. | No current or historical impacts, *AND* none located within 200’ of the impoundment (upstream or downstream). | | |
| | **Natural System Integrity** | | | Floodplains are dominated by non-forest (i.e., abandoned field, turf, cropland), *AND* bank vegetation is partly to severely disturbed by bare soils, invasive species, or mowing/browsing, *AND* active bank erosion is impacting banks, water quality, or infrastructure/property. | Floodplains are dominated by forest, *AND* bank vegetation is native species with no or minimal mowing/browsing, *AND* bank erosion is minimal or absent. | |

## 4.2 Classification and Prioritization

The overall vulnerabilities associated with a given beaver impoundment are defined as the combined potential impacts captured in the two assessments related to infrastructure (roads, culverts, and roadways) and buildings/property. Scores for these individual assessments were purposefully designed to give the highest weight to impacts associated with infrastructure, as such impacts pose the highest risk to the greatest number of individuals, as well as potential costs (both labor and monetary) to the Town. The potential ecological benefits provided by beaver activity and intact impoundments in healthy riparian areas are also an important consideration in the overall classification and prioritization process, as represented by the flood/climate resiliency and natural system integrity assessments.

Risks and benefits were combined in a *Summed Assessment Score* by tallying the respective scores from the Flood/Climate Resiliency, Impacts to Roads/Culverts/Railway, Impacts to Buildings/Property, and Natural System Integrity assessments. Each site was then assigned to a category based on the criteria in **Table 2**. The scoring systems for each individual assessment were carefully calibrated to ensure that no impoundment with a high potential for impacts would be assigned to the Beaver Restoration Zone. In other words, potentially high risks could not be fully canceled out by potentially high benefits. This approach ensures that the classification system gives preference to risk-avoidance whenever public infrastructure could potentially be impacted.

**Table 2. Breakdown of beaver site classification system based on assessment scoring.**

| Summed Assessment Score | Management Category |
|---|---|
| <0 | Beaver Restriction Zone |
| 0 to 1 | Beaver Coexistence Zone |
| >1 | Beaver Restoration Zone |

For those sites classified as Beaver Restoration Zones or Beaver Coexistence Zones, watershed ratios and impoundment volumes were examined as quantitative indicators of the extent to which a given impoundment could potentially contribute to flood mitigation and climate resiliency. Sites with larger values for these metrics were prioritized more highly relative to those with lower values. While this portion of the prioritization protocol does not affect the overall management category classification, these priority rankings influence site recommendations. Sites that offer limited value for flooding and climate resiliency are less likely to warrant financial investment or active restoration.

## 4.3 Assessment and Prioritization Results

Our team completed full assessments of five prioritized locations, documenting a total of 3 impoundments in the field (recent or past beaver activity but not impoundments were observed at the other two locations). Each location was assessed for flood resiliency, threat to or potential to threaten infrastructure and property, and natural system integrity. Assessment results for the impoundments that were identified in the field are presented in **Table 3,** which summarizes the scores assigned as well as the watershed ratio and estimated impoundment volume and the assigned management category. Of these 5 locations, two were classified as Beaver Restoration Zones, and three were classified as Beaver Coexistence Zones; none of the five were classified as Beaver Restricted Zones.

Detailed descriptions of each site, maps showing the location and impoundment (where applicable), assessment criteria, and recommendations are presented in **Section 5**.

A Priority Ranking is included for each impounded site under their respective sections that summarize the management strategies recommended by Fuss & O'Neill. The purpose of the ranking is to provide guidance on future management decisions by identifying the need for monitoring and/or management actions at each site as a high, medium, or low priority. Site prioritization considered all of the conditions that were assessed: flood resiliency, current and potential impacts to infrastructure, current and potential impacts to developed private property, and natural system integrity.

Table 3. Summary of site assessment scoring and management category classification for all assessed beaver impoundments.

| Site ID | Associated Waterbody | Latitude | Longitude | Ratio, Watershed Area/ Impoundment Area | Impoundment Volume (ft$^3$) | *Assessment Score* | | | | | Management Category |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Flood Resiliency | Impacts to Roads, Culverts, Railway | Impacts to Buildings/ Property | Natural System Integrity | TOTAL | |
| Lyman Road | Tributary to Roaring Brook | 42.2877 | -72.9256 | 13.2 | 280,065.35 | 2 | -2 | 0 | 1 | 1 | ***Coexistence*** |
| East River Road | Unnamed Stream | 42.3334 | -72.9356 | 27.4 | 19,615.47 | 0 | -2 | 0 | 0 | -2 | ***Coexistence**** |
| Kinnebrook Road | Kinne Brook | 42.3310 | -72.9144 | 474.7 | 247,917.77 | 2 | 0 | 0 | 1 | 3 | ***Restoration*** |
| Middlefield Road | West Branch, Westfield River | 42.2891 | -72.9845 | N/A | N/A | 0 | 0 | 0 | 0 | 0 | ***Coexistence*** |
| Skyline Trail | Roaring Brook | 42.3358 | -72.9121 | N/A | N/A | 2 | -2 | 0 | 1 | 1 | ***Restoration*** |

* Scoring for East River Road places it in a beaver-restriction zone, however, impact potential scoring is inconsistent with observations of topography and potential for flooding.

## 5 Site-Specific Assessments and Recommendations

The results below are based on the information collected during field investigations of the four sites where detailed field assessments were conducted and the subsequent analysis of that data. Each impoundment is described and evaluated with specific focus on the following assessment conditions described in Section 4.1:

- Flood resiliency
- Current and potential impacts to infrastructure (roads, culverts, railway)
- Current and potential impacts to developed private property (homes, farm fields, etc.)
- Natural system integrity.

These conditions are the criteria that were used to evaluate, score, and classify the impoundments to one of the three recommended management categories outlined above. The discussion below is organized according to those categories. A summary of recommendations and prioritization is presented in **Appendix A**.

### 5.1 Assessed Sites with Existing/Active Impoundments

#### 5.1.1 Lyman Road (42.28775, -72.9256)

The impoundment on Lyman Road is located at a low-lying dirt section of the road approximately half-way between Skyline Trail and Mica Mill Road. At the roadway, the impoundment is very close to the road surface in both the horizontal and vertical planes (Figure 5), and the culvert passing under Lyman Road is submerged due to the backwater from the impoundment. As seen in the image at right, a sinkhole had formed at the existing road-stream crossing at the time of our field assessment in February 2023.

**Figure 5. Looking downstream toward the impoundment at Lyman Road, February 22, 2023. Note the sinkhole at the existing road-stream crossing.**

The primary beaver impoundment at Lyman Road was estimated to be 5.1 acres, with an approximately 65-70 acre total contributing drainage area. Water flows from the north side to the south side of the road. At the south end of the impoundment, the private landowner had installed a flow leveling device and makeshift spillway to manage the water level at the beaver dam. Beyond this point, the primary impoundment led to a cascade of at least four additional dams and impoundments.

Note that since our February assessment, funding was acquired to install an upgraded, formalized flow leveling device to better maintain water levels at the primary impoundment; this installation was completed in spring 2023.

*Flood/Climate Resiliency (high):* The impounded tributary to Roaring Brook that forms this series of impoundments is surrounded by undeveloped land. The nearest downstream road is nearly 2 miles to the south, where Roaring Brook crosses Skyline Trail (see detailed description of the Skyline Trail site in section 5.2.2). Within those intervening two miles, the tributary stream, and ultimately Roaring Brook, traverse through a series of intact forest and wetland habitats. These wetlands – and the impoundments – are also connected to significant undeveloped land upstream. Floodplain encroachment was rated as minor, having little effect on floodplain function.

*Current and Potential Impacts (medium):* As noted above, the surrounding landscape is primarily undeveloped. Lyman Road itself is the only infrastructure that would be expected to experience impacts from beaver activity at this location and should be the focus of management efforts. One adjacent residence, at 19 Lyman Road, is positioned at a significantly higher elevation above the roadway and impoundment, where it is protected from flooding. Due to the significant area of undeveloped forest and wetlands downstream, downstream impacts to infrastructure or property are not expected; downstream wetlands would provide a buffer in the event of any large release of water due to a breach in one of the beaver dams.

**Figure 6. View of the impoundment, looking north. At the foreground, fencing protects the flow leveling pipes installed by the property owner. February, 2023.**

**Figure 7. Spillway/stop logs installed at the south end of the impoundment by the landowner to help maintain water levels below the elevation of Lyman Road to prevent overtopping. February, 2023.**

*Natural System Integrity (high):* The banks and floodplains surrounding the impoundment, as well as the downstream area are well vegetated with established and diverse plant communities. Banks are stable with little to no signs of erosion, and significant change or degradation is not expected. The connected wetland complex, both to the north and south of Lyman Road, appear to offer high value habitat.

*Management Strategies for Lyman Road impoundment(s):*

Priority Ranking: **HIGH**

This is a large beaver wetland complex with little to no downstream impact risks and high value habitat and flood storage capacity. Given the benefits to beaver activity at this site, the potential impacts to Lyman Road from overtopping should be managed according to a beaver coexistence strategy. At the time of our site visit, the adjacent property owner who owns both sides of the roadway was already actively involved in management and maintenance of the existing flow leveling device and beaver deceiver. During our field assessment, we spoke with the property owner about steps that could be taken to improve upon the improvised water level management strategy already being employed at the site, and these recommendations seem to have been implemented. Risks to the roadway and access should be managed via water level controls at the dam. Improvements to the Lyman Road culvert may also be necessary. Upsizing the culvert, and potentially raising this section of Lyman Road would provide further resilience at the roadway itself, which is vulnerable at its lowest lying point, and provide additional freeboard during large storm events.

- Replace and right-size the existing crossing to convey existing peak flows and those expected as a result of climate change projections for increased storm intensity and peak flows; this will simultaneously help to discourage blockages of the culvert (both active damming by beavers and passive blockages from sediment and debris accumulation).
- Following replacement, continue to maintain and monitor the existing (newly installed) flow-control device and assess beaver response.

In order to maintain the additional habitat and flood resilience benefits provided by beavers, conditions for continued beaver activity should be encouraged or at least maintained in order to:

- Prevent trapping and other control strategies (e.g., breaching)
- Continue to support the landowner by partnering on management goals, providing funding and assistance where possible for future restoration projects and maintenance of the newly installed flow-leveling device.

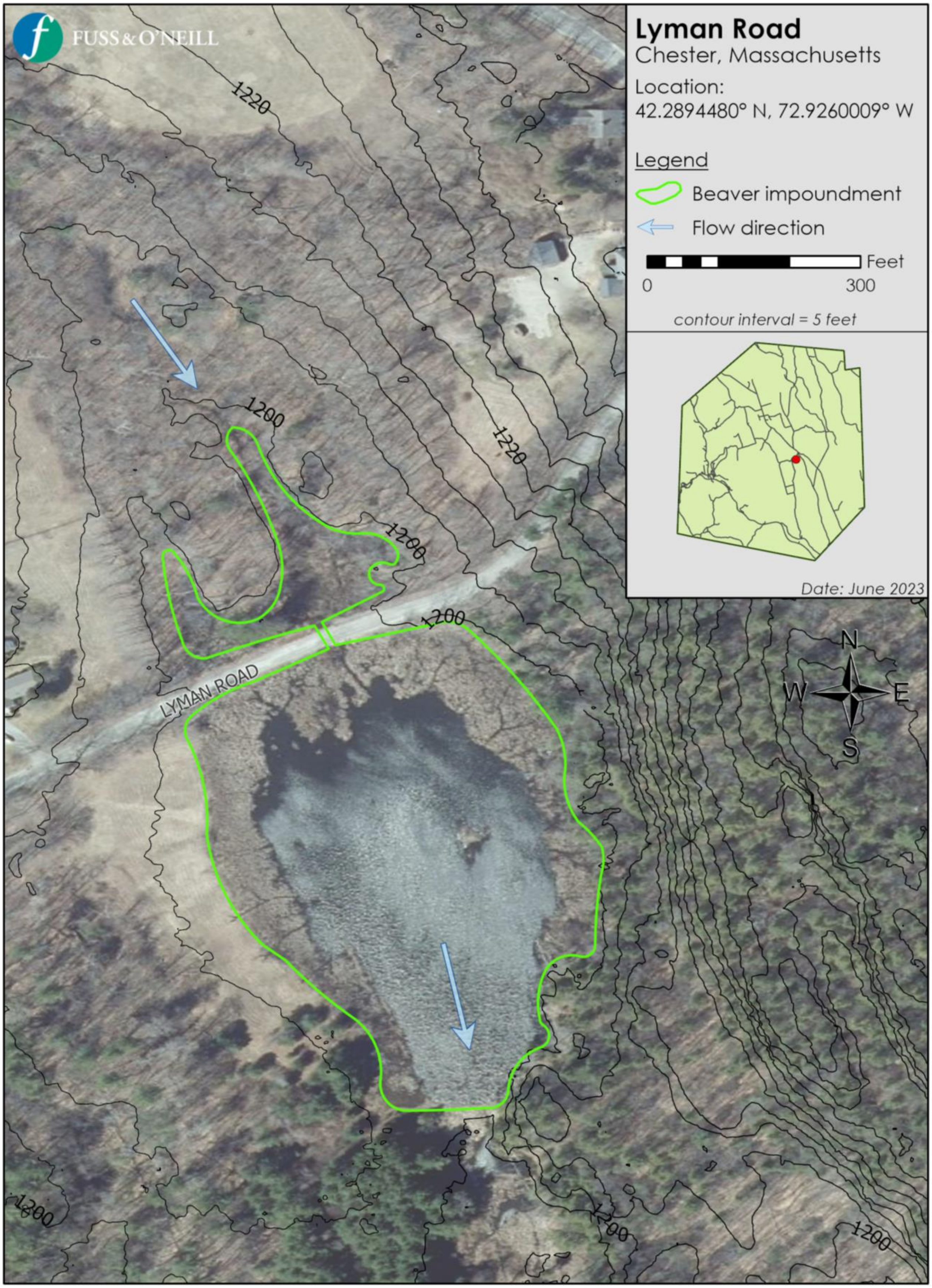


**Figure 8. Map of assessed beaver impoundment at Lyman Road.**

### 5.1.2 East River Road (42.33343, -72.9356)

**Figure 9. View of the impoundment and proximity to E. River Road, looking south. May, 2023.**

Similar to the Lyman Road site, the impoundment at East River Road is very close in horizontal and vertical proximity to the existing roadway. The roadway is paved, and the impoundment level is within one foot or less of the road elevation. There is evidence of an old beaver deceiver but the original culvert under the road is no longer functional (it appears to have collapsed/broken or been purposely filled or blocked). The total impoundment area was estimated to be approximately 1.6 acres, with an approximately 40-45 acre contributing drainage area. Topography on the west side of the road, where water is impounded, is relatively flat; however, on the opposite side of the road, the topography drops off rapidly to the Middle Branch of the Westfield River. At the south end of the impoundment, it appeared that a relief channel had been dug to serve as an outlet from the impoundment and keep water flowing along the roadway without overtopping until it could be diverted into an existing stream channel which is culverted under the roadway and outlets to the Middle Branch of the Westfield River (Figure 10.)

*Flood/Climate Resiliency (low):* The opportunity for an impoundment at this location is driven in part by the presence of the fill upon which E. River Road is built. Without the road fill interrupting the slope of the natural topography, there would be no flat or bowl-shaped area to hold water. Similarly, there is no broad floodplain at this location. Given these conditions, this location does not have high potential to contribute to climate and flood resiliency even though there is significant forested and undeveloped land surrounding the site.

*Current and Potential Impacts (medium-low):* Despite the proximity to the roadway, potential impacts from beaver activity at this location are limited by the existing site topography. A resident we spoke with did indicate that the roadway periodically floods. However, given that the grade drops off substantially on the opposite side of the road, and continues to drop down to the elevation of the riverbed just to the east, there is little opportunity for ponded water to be confined in the landscape if the impoundment reaches the elevation of the road. We anticipate that overtopping events at this location would certainly result in a wet or potentially icy roadway, but we would not expect to see ponding to any depth that would be problematic. Further, there was no evidence on the east side of the road of any confining areas or evidence of ponding. The property across the street at 495 E. River Road likewise does not appear to be situated such that it would be impacted by overtopping of the road. An abandoned outfall or stream channel immediately south of the house on this property would direct water down toward the river and away from the home.

**Figure 10. View of the overflow/diversion channel that has been dug to direct water from the impoundment south along E. River Road to an existing stream. May, 2023.**

*Natural System Integrity (medium):* The site is flanked from the west by intact forests which are part of the Fox Den Wildlife Management Area. Land to the east consists of the roadway and rural residential properties with some intact woodlots at the edges of the road and connecting down to the West Branch of the Westfield River. The largest concern regarding the integrity of the natural system at this site was at the south end of the site where the site had been disturbed by humans to create an overflow/relief channel. Exposed soils and significant movement of sediment toward and into the natural stream to the south was observed through this recently disturbed channel. This sediment is likely then transported into the West Branch of the Westfield River via the culvert under E. River Road.

*Management Strategies for E. River Road impoundment(s):*
Priority Ranking: **MED-HIGH**
As noted above, there does not appear to be a significant threat from flooding at this location, even in the event that high water may overtop the road.

- The original failed culvert and beaver deceiver could be replaced and right-sized to maintain stream flow under the road; however this would likely not be a cost-effective solution given the limited benefits or risk reduction for infrastructure and property.
- Restoration of the excavated overflow/diversion channel is recommended to stabilize the exposed soils and prevent turbidity and sedimentation of the downgradient stream channel and river. Creating a broad, vegetated flow path through this area may help to achieve the same goal of providing an overflow outlet for the impoundment without having detrimental effects to the downstream waterways.
- Better understanding the sources of concern around overtopping may suggest other means of improving the roadway drainage to improve resilience and road safety while coexisting with the beaver impoundment.

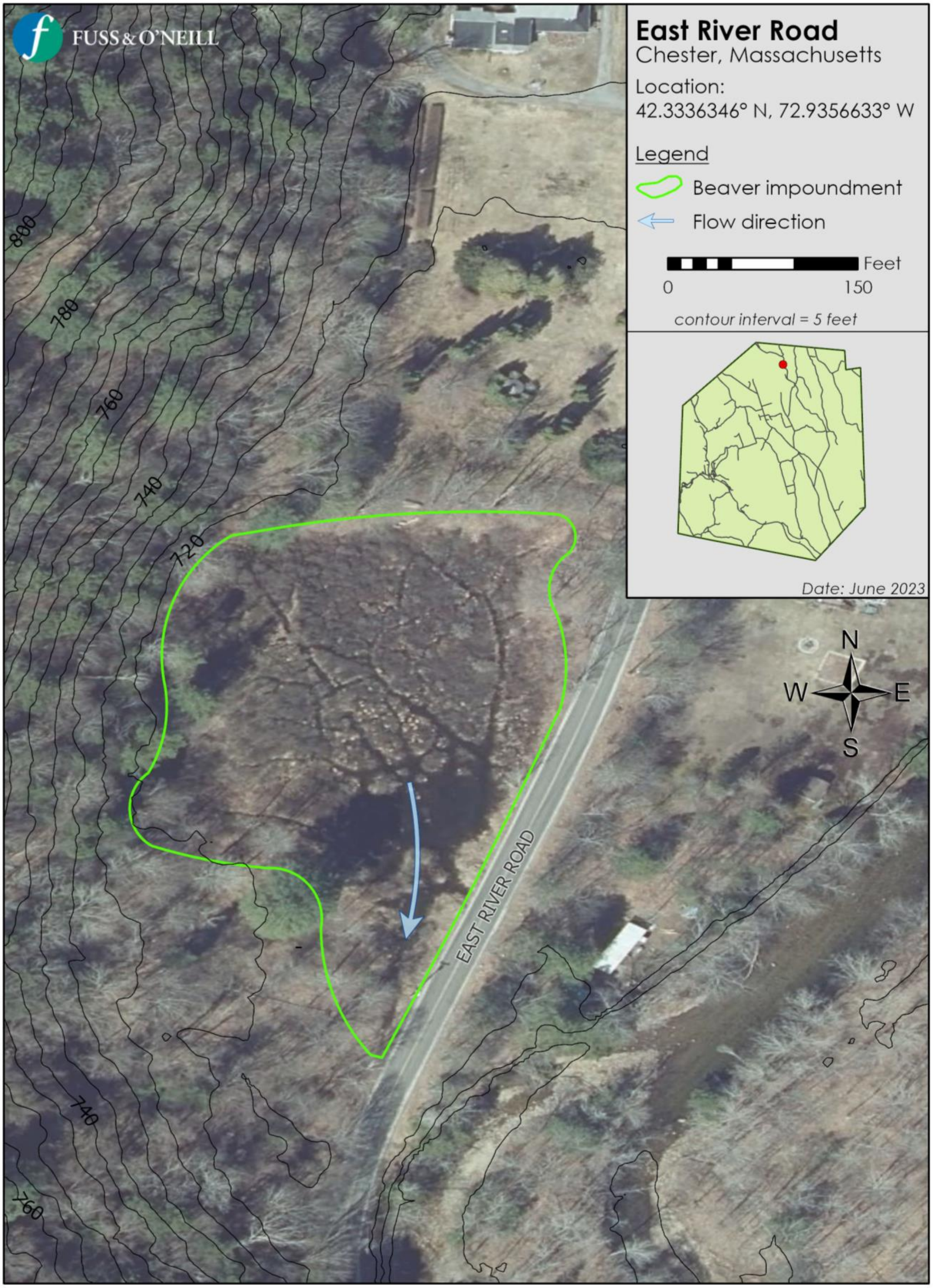


**Figure 11. Map of assessed beaver impoundment at East River Road.**

### 5.1.3 Kinnebrook Road (42.33096, -72.9144)

**Figure 12. View of the former area of impoundment along Kinne Brook as observed in May 2023. Areas of bare soil indicate the extent of the impoundment prior to dam breach.**

This site is located along a dirt road in an isolated and undeveloped area of town. At the time of our field visits an active logging operation was underway on the east side of the road, opposite the beaver activity on the west side of the road. During our February site visit, there were three impoundments at the site, one linear run-of-river impoundment following the path of the road and situated several feet below the road elevation, and two additional impoundments set further west, away from the roadway and higher up in the landscape on tributary streams. In May, our field crew passed this site a second time and observed that the primary dam had been breached. It was unclear whether this was a natural occurrence or if the dam had been breached with machinery. The upper dams and impoundments remained intact. When intact, the primary beaver impoundment at Kinnebrook Road was estimated to be 3.6 acres, with an approximately 2.57 square mile total contributing drainage area.

*Flood/Climate Resiliency (high):* The series of beaver impoundments at this location are connected to additional open wetlands and floodplain areas that would allow for further expansion and flood storage capacity without impact to infrastructure or property. Two of the three impoundments were set back at a significant distance from Kinnebrook Road and are surrounded by undeveloped forested land. Even during our initial field assessment when the impoundment along the road, which impounds Kinne Brook, was intact, we observed approximately four feet of freeboard between the impoundment water level and the road elevation, indicating ample additional flood storage capacity at this location. Given the recent clearcutting of the upgradient slope on the east side of the road, these wetlands may serve an important purpose in buffering the increase in stormwater runoff and potential erosion that could result until the slope is revegetated.

*Current and Potential Impacts (low):* As noted above, the surrounding landscape is primarily undeveloped. Kinne Brook flows for approximately 1.5 miles downstream of the impounded site before passing any developed property. In the intervening reach, ample wetlands and floodplain area exist that would likely be sufficient to absorb any downstream impacts in the case of a dam breach. Much of this land is protected as part of the Hiram H Fox Wildlife Management Area or under the Winer Conservation Restriction. Kinnebrook Road is the only nearby infrastructure; during the time of our field visits there was no evidence to suggest likely or imminent impacts to the road from beaver activity. Approximately four feet of freeboard was still available between the impoundment level and the roadway elevation.

Kinnebrook Road was experiencing some minor drainage problems and ponding during our site visits; these were attributed to rutting from logging vehicles and the recent increase in runoff caused by the clearcutting of the adjacent upgradient slope.

**Figure 13. View of the intact impoundment with approximately four feet of freeboard between the impoundment and roadway. February 2023.**

*Natural System Integrity (high/variable):* As described in the preceding sections, the immediate surrounding area to the north, south, and west consists of intact natural forests and wetlands, much of which are preserved lands. The area immediately east of the site is currently being logged and consisted largely of an exposed, disturbed slope at the time of our field assessments. When the initial field assessment was conducted in late February, the west side of the road was well vegetated and stable throughout. In May, after the dam breach, we observed bare soils and some scouring within the formerly impounded area. Additional erosion and channel modifications may be expected if the channel remains undammed at this location.

**Figure 14. Left: The intact beaver dam is visible at the fore of the image, with the main beaver lodge in the rear, surrounded by the active impoundment. February, 2023. Right: The same lodge is seen following the breach of the dam and draining of the impoundment. May, 2023.**

*Management Strategies for Kinnebrook Road impoundment(s):*
Priority Ranking: **HIGH**
This is a large beaver wetland complex with little to no downstream impact risks and high value habitat and flood storage capacity. Impacts to the roadway are unlikely and, based on our field observations, no immediate action is necessary to protect the road from damage or overtopping due to beaver activity (although erosion and drainage problems may occur due to the recent forest cutting immediately east and upgradient of the road). There are no culverts or other infrastructure at this location. The site should be managed as a beaver restoration site, where beaver activity is recognized as broadly beneficial for maintenance and restoration of wetland habitats, storm dampening, water filtration, and other ecosystem services. Further, given the surrounding landscape and topography, expansion or relocation of beavers to undesirable locations is not a concern. In order to maintain the additional habitat and flood resilience benefits provided by beavers, conditions for continued beaver activity should be encouraged or at least maintained in order to:

- Prevent trapping and other control strategies (e.g., breaching of dams)
- Support beaver populations at the site (i.e., plantings, BDAs), to enhance resiliency and encourage sustained beaver activity at the site.

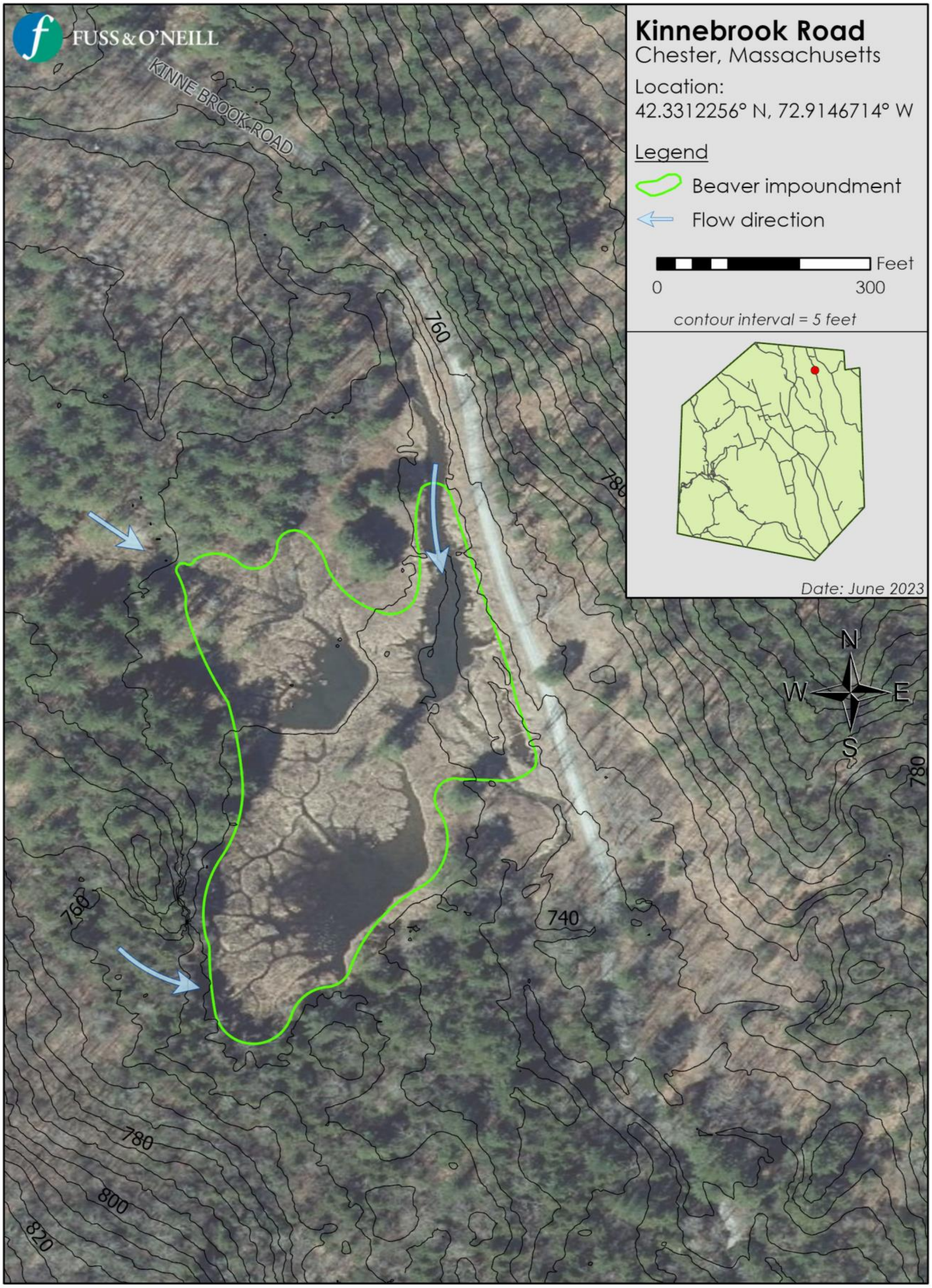


**Figure 15. Map of assessed beaver impoundment at Kinnebrook Road.**

## 5.2 Assessed Sites without Existing/Active Impoundments

In addition to the sites described above, where beaver activity was ongoing and active impoundments could be identified and delineated, we observed additional locations in the field where the Town reported knowledge of past or present beaver activity but where either no impoundment was present or evidence indicated past beaver activity without a current, active beaver population. Notes and recommendations regarding these sites are presented below.

### 5.2.1 Middlefield Road (42.28913, -72.9845)

During our initial site review meeting with the Town, staff noted an area with a recent uptick in beaver activity north of downtown along Middlefield Road where it closely parallels the West Branch of the Westfield River. At this location, the river is sandwiched between Middlefield Road (which varies from approximately 10 to 30 feet west of the river) and an active railroad line and associated rail embankment.

**Figure 16. Top left: Fresh beaver chew on the embankment of Middlefield Road. Top right: Active beaver lodge on the east side of the river adjacent to the floodplain. Bottom: Bedrock and large boulders along the road embankment on the river-right bank looking downstream. All photos: February, 2023.**

Located across from 166 Middlefield Road, this area is just upstream of an island in the river. Fresh beaver chew was observed on the road side of the river, and a lodge was observed on the opposite side of the river in the low floodplain area between the river and the rail embankment. On a smaller waterbody with lower flow, this would be a likely location for a beaver dam across one or both branches of the river. However, damming would be unlikely on a river the size of the West Branch of the Westfield, and should a dam be successfully built during a period of low flow, we would not anticipate that it would remain intact under normal river conditions.

Middlefield Road is in places located very close to the river, with a steep bank. Removal of trees by beaver may pose some concern of increased erosion, however the river channel appears to be controlled by bedrock on the river-right bank, and bedrock similarly appears to anchor the slope and roadway. There is low potential for beaver to have negative impacts on infrastructure at this location, and no management appears to be necessary.

### 5.2.2 Skyline Trail (42.26227, -72.90953)

Members of the Town project committee also identified a location on Skyline Trail as an area of former beaver activity which previously resulted in flooding impacts to one or more driveways. This location is located along Roaring Brook, where it crosses from west to east under a paved stretch of Skyline Trail via a small bridge. Aerial imagery clearly shows a series of former beaver impoundments across an approximately 1,000-foot long by 200-foot wide area contained within the road right-of-way and property of 127 Skyline Trail. Remnants of the breached beaver dams remain across the floodplain, which is now devoid of trees. Remnants of the former dams at this site indicate deep impoundments, with at least one dam standing at shoulder-height. Small shrubs are starting to grow in, following a typical early successional pattern; however, down cutting is evident throughout the site as the channel reforms through the former impoundment. A deeply incised channel now means that the brook will be disconnected from and unable to access its floodplain during most storm events. This will in turn limit or nullify the ability of the floodplain to slow or absorb flood waters. Given the proximity of the channel to the roadway at some meanders, the road may potentially be threatened by continued erosion and higher velocities in the absence of the impoundments which would formerly have resulted in significantly decreased flow velocities through this reach of Roaring Brook. We also noted that a dry hydrant which

**Figure 17. 2021 Aerial imagery from MassMapper captures the series of former beaver impoundments on the west side of Skyline Trail.**

used to reach into the beaver impoundment is no longer viable as its position is approximately 18-24" above the water level of the free-flowing brook.

Potential management or restoration activities at this location might include:

- Enlargement of the small bridge under Skyline Trail to accommodate the full bankfull width and stream banks, per the Massachusetts Stream Crossing Standards. The existing bridge has an approximately 25-foot span, making it the narrowest point in the river system through this reach, which will result in increased velocities and erosive forces on the downstream side of the crossing.
- Restoration of vegetation is recommended to accelerate succession and establish deeper rooting species for stabilization of banks and floodplain soils. Willow, dogwood, or other quick-growing wetlands and riparian species are recommended. Live stakes or plugs would be an inexpensive and effective option for this site.
- Active channel restoration may be beneficial to push flows away from the roadway. The existing channel includes a meander which is eroding towards the steep road embankment, high flow velocity at the outside of this meander will continue to cut away the bank which is currently only approximately 30 feet from edge of pavement. There may be potential to utilize relatively inexpensive nature-based bank stabilization approaches (e.g., rootwads and log vanes) to encourage the river to cut off the existing meander and shift its course deeper into the floodplain and away from the roadway.
- Beaver Dam Analogs (BDAs) or other large wood features could also be installed in the channel to slow flows, curb continued incision of the channel, and reconnect the brook to the floodplain. This strategy may be more palatable to neighbors with concerns about driveway flooding than would establishment of a new population of beavers.
- Should beavers re-establish at the site, flow leveling devices could be implemented to control water elevation at an acceptable level and maintain the size of the impoundment.

**Figure 18. The exposed dry hydrant at the crossing of Skyline Trail and Roaring Brook no longer offers fire protection as it does not reach the water. February 2023.**

## 5.3 Other Areas of Beaver Activity/General Observations

### 5.3.1 Fisk Road (42.33578, -72.9121)

**Figure 19. Expansive beaver wetlands east of Fisk Road. February 2023.**

An extensive beaver wetland was identified in aerial imagery and visited in the field along Fisk Road within the Hiram H Fox Wildlife Management Area. A formal assessment was not conducted at this site as observation revealed that the impounded area is both substantially set back from the roadway and downgradient of the road within an extensive area of undeveloped, protected lands. Any potential flood impacts would occur where Skunk Brook crosses an abandoned portion of the historic Fisk Road. This area serves as a de factor beaver restoration zone, with the active population maintaining healthy wetland ecosystems within protected lands.

**General Observations**

Beavers are certainly active in Chester; however, our assessment team identified a limited number of sites where activity was occurring in close proximity to dirt roadways. Further, while dirt roads were the primary focus of our inventory, we also note that relatively few active impoundments were observed along the paved roads we traveled. Chester contains a large proportion of undeveloped land, which means there are fewer stream crossings in Chester compared to other communities of similar geographic footprint, and forests, wetlands, and other potential beaver habitat is less fragmented than in more developed communities. Inherently, this means that since there is less infrastructure and property that could potentially be at risk from beaver activity, a larger proportion of the land area in Chester can be categorized in the beaver restoration zone for management. In these undeveloped areas, beavers should be considered an ecosystem asset.

# 6 Ongoing Monitoring and Assessment

The field observations and subsequent analysis performed for this study identified key indicators and characteristics that were used to create an assessment protocol. The main objectives of the assessment tool, which is presented in **Appendix B**, are that it can be applied quickly and easily for ongoing monitoring/assessments where beaver activity is reported, and that it can provide a basis of evidence for assigning a management category to newly assessed or re-assessed sites. This tool was created for Town administrators, staff, and volunteers to provide a systematic, empirical process which will guide decision-making when residents request management information or specific actions (e.g., permitting), or when the Town experiences impacts to infrastructure or needs an action plan to mitigate and prevent further impacts.

Note that Fuss & O'Neill field staff visited several locations where beaver activity has been problematic in the past but where no current impacts were observed, particularly at Skyline Trail, as well as locations where beaver activity may require ongoing monitoring and occasional adjustments to management strategies to maintain the desired conditions for coexistence between human and beaver populations (e.g., at Lyman Road).

Ongoing monitoring should include a general awareness of habitat quality and indicators throughout the Town, as areas of suitable habitat are likely to become inhabited by beavers in the future. Likewise, areas where beaver activity is currently occurring may become less attractive if food supplies diminish or other changes render these existing habitats less conducive to residency. Long-term planning, including open space planning and management of conservation areas, should consider the inclusion of specific recommendations for land management that are consistent with and encourage beaver management recommendations.

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# Appendix A

Summary of Management Recommendations

| Site ID | Associated Waterbody | Appropriate Management Tools | | | | | | | | | | | | Recommended Management Strategy | Relative Priority | Management Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No Action | Prevent Trapping | Encourage/Establish New Populations | Beaver Dam Analogs | Flow-Control Devices | Right-Size Culverts | Physical/Chemical Deterrents | Behavioral Deterrents | Dam Removal/Breaching | Trapping | Fencing and Flow-Control Devices | Site Modification | | | |
| Lyman Road | Tributary to Roaring Brook | | X | X | | X | X | | | | | X | | Continue to maintain and monitor the newly installed flow leveling device to maintain water level of the impoundment and provide freeboard before road overtopping. Replace and right-size the existing culvert under Lyman Road to both improve hydraulic capacity and discourage damming or passive blockages. Consider raising the road during culvert replacement. | High | *Coexistence* |
| East River Road | Unnamed Stream | | X | | | X | | | | | | | X | A flow leveling device is recommended through the dam at the relief channel to maintain an acceptable water level and avoid overtopping of the road. Restoration is needed to improve the condition of the excavated overflow ditch, stabilize exposed soils, and prevent downstream sedimentation. Alternatively, the original culvert under East River Road could be rebuilt and enlarged to accomodate the stream channel. | Medium-High | *Coexistence* |
| Kinnebrook Road | Kinne Brook | | X | X | X | | | | | | | | | Beaver activity should be not only tolerated but encouraged at this site as there is little potential for negative impacts and significant potential for resilience benefits. Beaver dam analogs may be useful to encourage reestablishment of the primary impoundmet which was recently breached. | High | *Restoration* |
| Middlefield Road | West Branch, Westfield River | X | X | | | | | | | | | | | No action is necessary; beaver activity at this location is unlikely to cause damage or result in changes to the river. Trapping should not be allowed. | Low | *Coexistence* |
| Skyline Trail | Roaring Brook | | | | X | | | | | | | | X | In the absence of beaver activity at this abandoned site, beaver dam analogs and other restoration actions should be taken to reengage the floodplain and prevent further downcutting of the channel. Bank stabilization measures should be employed at strategic locations to prevent further erosion of the channel toward the roadway and encourage meanders to form further into the site (away from the road embankment). | Medium | *Restoration* |

FUSS & O'NEILL

# Appendix B

Field Assessment Tool for Ongoing Monitoring/Classification of New Sites

**FIELD FORM**

**ASSESSMENT OF IMPACTS DUE TO BEAVER ACTIVITY**

| I. SITE INFORMATION | | | |
|---|---|---|---|
| Site Name/Description: | | | |
| Associated Stream: | | Date of Assessment: | |
| How is Site Accessed:<br>(e.g. enter from Orchard Street) | | | |
| Lead Field Staff: | | Asst. Field Staff: | |

## II. FLOOD/CLIMATE RESILIENCY

**Flood Storage Capacity**

| | | |
|---|---|---|
| 1. Does the impoundment connect to wetlands, floodplains, low-lying uplands, or similar natural areas that allow it to expand (i.e., increase flood storage) without impacting infrastructure or property? | ***YES*** | ***NO*** |

If **YES**, estimate the additional area available for flood storage as a percentage of the existing impoundment surface area (e.g., 10 acre existing impoundment that can expand 2 more acres = 20%):

*less than 25% (0)* *25-50% (+1)* *greater than 50% (+2)*

**Floodplain Encroachment Scale**

*Encroachments are activities or construction including fill, new construction, substantial improvements, and other development. These activities can disrupt natural processes and reduce the floodplain's hydrologic capacity and function.*

Assess the level of encroachment on floodplains associated with the impoundment:

| No evidence of floodplain encroachment. | | | Minor. Little effect on floodplain function. | | Moderate. Some effect on floodplain function. | | | Significant. Significant effect on floodplain function. | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |

Floodplain Encroachment Score (0-3 = 0; 4-7 = 1; 8-10 = 2):

**Section II Score:**

*(Enter only the larger of the 2 scores)*

## III. IMPACTS TO ROADS/CULVERTS/RAILWAY (R/C/R)

| | | |
|---|---|---|
| 1. Are R/C/R **currently impacted** by an impoundment? | ***YES*** | ***NO*** |
| *If **YES**, describe (road name, observations, photos):* | | |
| 2. Has the impoundment flooded or otherwise affected R/C/R in the past 2 years? | ***YES*** | ***NO*** |
| *If **YES**, explain:* | | |
| 3. Along the impounded stream, are R/C/R present: | | |
| • Less than 200 feet from the dam? | ***YES*** | ***NO*** |
| • Within the impoundment? | ***YES*** | ***NO*** |
| • Less than 200 feet upstream of the impoundment? | ***YES*** | ***NO*** |

**Section III Score:**

*(Score -2 if ANY question was answered YES)*

## IV. IMPACTS TO BUILDINGS & PROPERTY (B/P)

| | | | |
|---|---|---|---|
| 1. Are B/P **currently impacted** by an impoundment? | | ***YES*** | ***NO*** |
| *If **YES**, describe (address, observations, photos):* | | | |
| 2. Has the impoundment flooded or otherwise affected B/P in the past 2 years? | | ***YES*** | ***NO*** |
| *If **YES**, explain:* | | | |
| 3. Along the impounded stream, are B/P present: | | | |
| • Less than 200 feet from the dam? | | ***YES*** | ***NO*** |
| • Within the impoundment? | | ***YES*** | ***NO*** |
| • Less than 200 feet upstream of the impoundment? | | ***YES*** | ***NO*** |
| If ***YES***, are the B/P located at an elevation that is less than 5 feet above the impoundment's water surface? | | ***YES*** | ***NO*** |

**Section IV Score:**

*(Assign a score of -2 if Question 1. or 2. was YES; Assign a Score of -1 if only question 3 is YES, otherwise score a 0)*

## V. NATURAL SYSTEM INTEGRITY

**Floodplain Vegetation Scale** (Assess left and right banks looking downstream)

| | Dominated by mature forest | | Dominated by young forest | | Dominated by shrub (e.g., abandoned field) | | Dominated by turf grass or crop land | | |
|---|---|---|---|---|---|---|---|---|---|
| Left 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Right 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |

**Bank Vegetation Scale** (Assess left and right banks looking downstream)

| | Over 90% of the bank and immediate riparian zone covered by native vegetation, including trees, understory, shrubs or non-woody species. Plants can grow naturally (disruption by mowing/ grazing minimal or not observed). | | 70-90% of bank covered by native vegetation, but one class of plants is not well represented. Disruption observed but it is not greatly limiting plant growth. More than half of the potential plant stubble height remaining. | | 50-70% of bank covered by native vegetation. Disruption of plant growth is obvious, patches of bare soils or closely cropped vegetation are common. Less than half of the potential plant stubble height remaining. | | Less than 50% of streambank surfaces are covered by native vegetation. Disruption of plant growth is very high, and bare soil is common. Less than 2" of the potential plant stubble height remaining. | | |
|---|---|---|---|---|---|---|---|---|---|
| Left 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Right 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |

**Bank Erosion Scale** (Assess left and right banks looking downstream)

| | Banks are stable and evidence of erosion or bank failure is absent or minimal. Less the 5% of bank affected. | | Grade and width stable, with isolated areas of bank failure/erosion likely caused by outfall, local scour, impaired riparian area, or adjacent use. | | Past downcutting evident, and banks actively eroding and widening stream. No threat to infrastructure or property. | | Active downcutting, and tall banks eroding at a fast rate. Erosion contributes significant sediment to stream. Infrastructure or property is threatened. | | |
|---|---|---|---|---|---|---|---|---|---|
| Left 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Right 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |

**Section V Score:**

*(Sum all selections and score as follows: less than or equal to 55 = 0; greater than 55 = 1.)*

## VI. RANKING

**Total Score:**
Add scores from each section (with

| Total Score | Management Category | Notes: |
|---|---|---|
| Less than zero | Restriction Zone | |
| 0-1 | Co-existence Zone | |
| 2-3 | Restoration Zone | Recommended Management Category: |