Lake Morey
Lake and Watershed Action Plan (LWAP)
Fairlee, Vermont

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Lake Morey
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1.0 EXECUTIVE SUMMARY

- The White River Natural Resources Conservation District (NRCD) is working with Bear Creek Environmental and other project partners to conduct lake watershed action planning within the Lake Morey watershed in Vermont. The Lake and Watershed Action Plan (LWAP) aims to address key water quality issues and to promote the long-term health and sustainability of the Lake.

- Nutrient Reduction: The LWAP outlines strategies to reduce sediment and phosphorus loading to Lake Morey by reducing nutrient runoff, promoting best management practices, implementing erosion control measures, improving stormwater management and providing vegetated buffers along inlet tributaries.

- Shoreline Protection and Restoration: The establishment and maintenance of native vegetation along the lake shoreline is important for filtering of contaminants and habitat. The LWAP also provides recommendations for protection of critical wetland habitat and improved shoreland habitat.

- Project Identification and Prioritization: Seventeen projects have been identified and prioritized in the LWAP to improve lake water quality. These projects were identified through the assessment of three sectors: Lakeshore, Streams, and Roads. The projects were prioritized based on 1) Improvement in water quality, 2) Landowner support, 3) Improvement and protection of riparian and aquatic habitat, 4) Cost effectiveness, and 5) Socioeconomic benefits.

- Conceptual designs and cost estimates were completed for eleven projects with written landowner interest. The projects include: Three culvert replacements, seven stormwater improvement, and one stream buffer enhancement project.

- Public Outreach: A meeting will be held in spring 2024 to present the LWAP and to garner interest in project development and implementation.

- Funding and Implementation: The next step is to seek grant/funding opportunities and collaborate with local organizations to leverage local, state and federal resources.

2.0 INTRODUCTION

Lake Morey is a naturally-formed lake situated in Fairlee, Vermont. The Lake has many uses ranging from recreation to aesthetics and is very important to the surrounding communities. Over the past several decades, the health of the lake has been declining as issues such as water quality impairment and invasive species have become present in the watershed. Lake Morey has shown increasing concentrations of nutrients over the past several years and cyanobacteria blooms have become an issue affecting the recreational use of the lake. Local initiatives exist within the watershed to improve water quality, wildlife habitat, and ecosystem health of the lake. Lake and Watershed Action Plans (LWAP) can be used to help guide the efforts of community lake associations and town planning.

2.1 LWAP Goals and Components

According to the document *Technical Guidelines to Conducting a LWAP* (VT DEC 2022a) authored by the Vermont Department of Environmental Conservation's Watershed Management Division, "a Lake and Watershed Action Plan (LWAP) is designed to identify and communicate the problems and fixes within a lake watershed to best protect water quality, wildlife habitat, and the lake's ecosystem health." LWAPs integrate water quality, ecological, economic, recreational, and other types of data to identify and address problems affecting a lake and its watershed.

There are three main focus areas for LWAP studies: shoreland, tributaries, and roads. The shoreland refers to lands immediately adjacent to the lake. In Vermont, the *shoreland is typically defined as lands within 250 feet from the mean water level*. This area immediately adjacent to the lake is a sensitive area and land uses changes in this area can have direct impacts on lake ecosystem health.

Tributaries refer to the streams that flow into the lake. Historic and current management of streams can greatly impact their physical stability, biological health, and water quality. Streambank erosion has been documented as an important source of sediment and nutrients that can impact downstream water quality. Adjacent land uses also contribute to the health of tributaries and ultimately the lake downstream.

Roads are the third focus area for LWAP development. Many sections of roads in Vermont are *hydrologically connected, meaning that runoff from them has the potential to make it into nearby surface waters*. Roads that do not adhere to best management practices for stormwater management or that may have erosion issues can present significant sources of sediment and nutrients to surface waters.

2.2 Lake Morey Project Goals

The primary goal of the Lake Morey LWAP is to identify sources of sediment and phosphorus that are entering the Lake and to work with project partners to develop and implement projects that reduce those sources (Figure 1). LWAP project partners include the Lake Morey Protective Association (LMPA), the Lake Morey Foundation (LMF), Vermont Department of Environmental Conservation Watershed Management Division, Two Rivers-Ottauquechee Regional Commission, the town of Fairlee including the Lake Morey Commission (LMC), private landowners, and the White River Conservation District. A project kick-off meeting was held on July 13, 2022 to discuss the goals of the Lake Morey LWAP project with these partners.

Numerous local initiatives exist within the watershed led by the lake watershed associations and lakefront landowners. The lake watershed plan is being developed in partnership with the three lake associations. The LMPA has offered to take the lead in coordinating the watershed action plan development with the lake community.

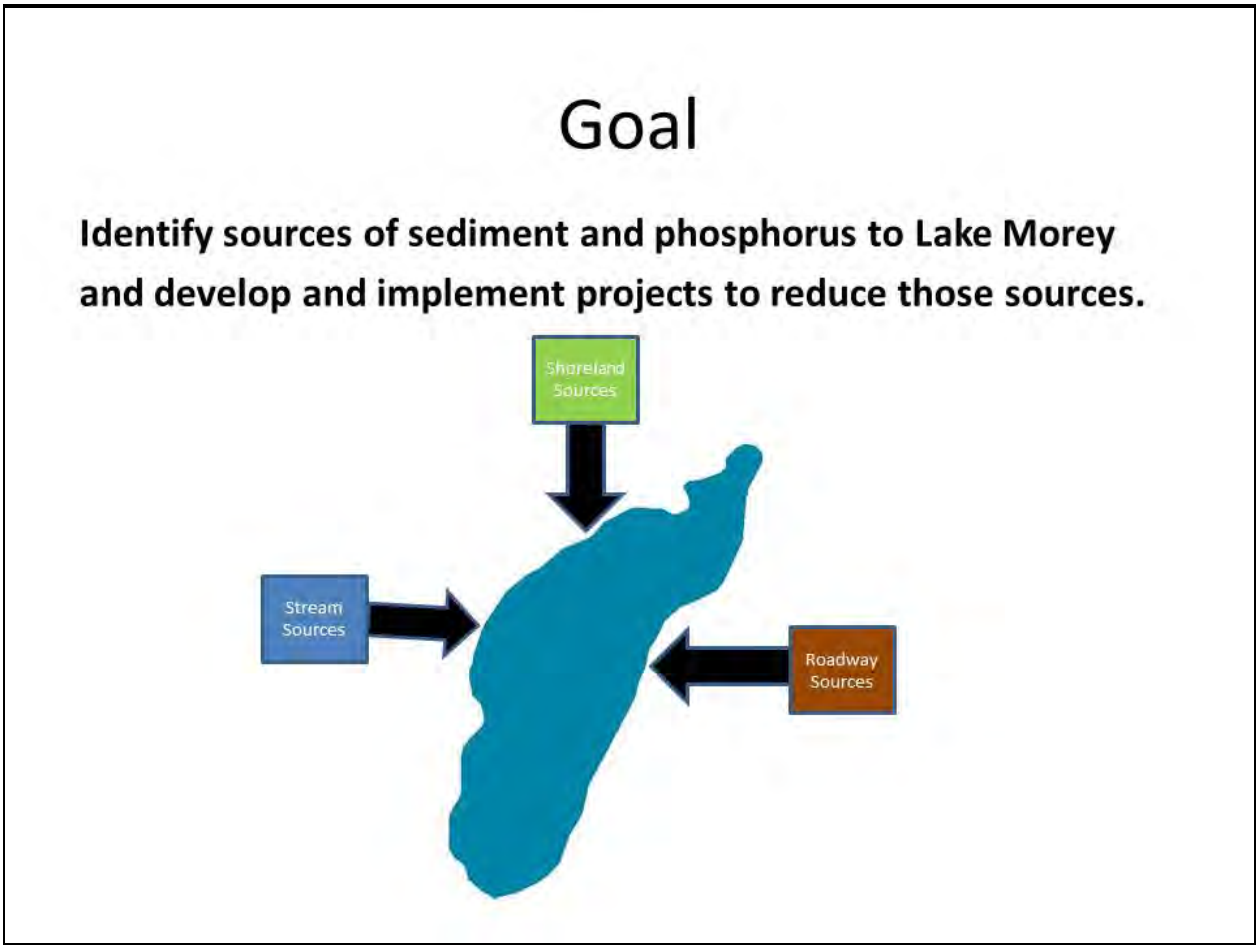


Figure 1. The primary goal of the Lake Watershed Action Plan

Lake Morey Protective Association

The purpose of the LMPA is "preserving the natural environment of Lake Morey and its immediate surroundings and promoting lake related interests" (https://lakemorey.org/). According to the LMPA website, the Lake Morey Protective Association was founded in 1907, and is the oldest lake association in the State of Vermont.

Lake Morey Foundation

The mission of the LMF is "to raise, steward and provide funds for initiatives that enhance the well-being of Lake Morey, its natural environment and its community" (https://lakemoreyfoundation.org/). The foundation provides grant funding for three main areas:

- Water quality
- Land Conservation
- Community Initiatives

Lake Morey Commission

The commission was established in the late 1970s to address phosphorus loading (https://fairleevt.gov/?SEC=496EAE22-58B8-40D6-BC5F-181F50387551). Members of the commission are appointed by the Fairlee Selectboard to advise on lake related issues.

3.0 WATERSHED INFORMATION

Lake Morey is a 550-acre lake situated in the Town of Fairlee in Orange County Vermont (Figure 2). According to the LMPA, the lake averages 28 feet in depth and has a maximum depth of 43 feet (https://lakemorey.org/about/history/). The lake drains to the Connecticut River. The lake's watershed is approximately 7.3 square miles in size. There are ten inlet streams in the watershed (Figure 3). Lake Morey is naturally formed, but lake levels are regulated by a 5-foot-high dam at the outlet. The dam was constructed in 1897 and reconstructed in 1949 (https://dec.vermont.gov/water-investment/dam-safety/dec-owned-dams#Lake%20Morey%20Dam). The dam is considered low hazard.

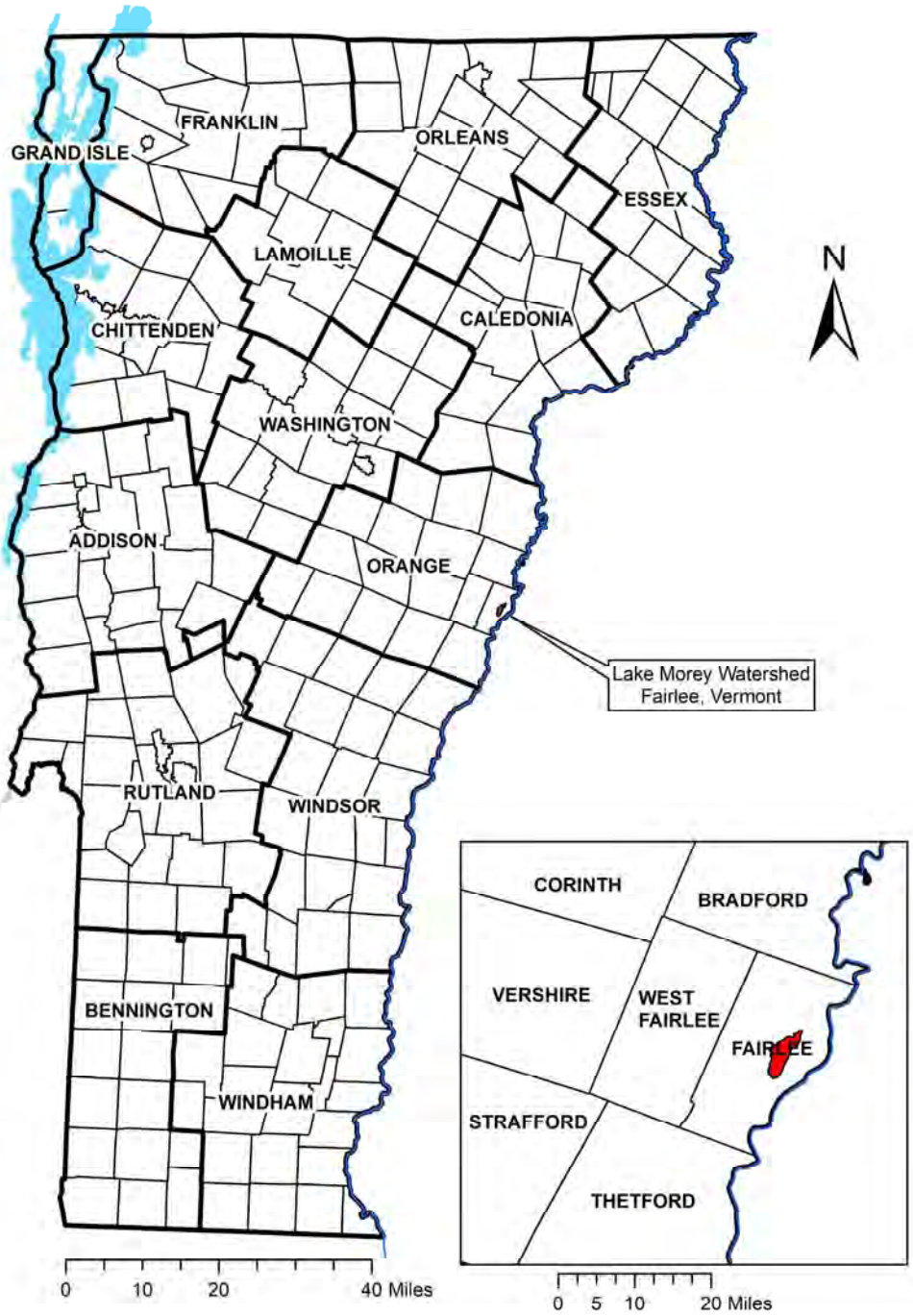


Figure 2. State of Vermont Locator Map of Lake Morey Watershed

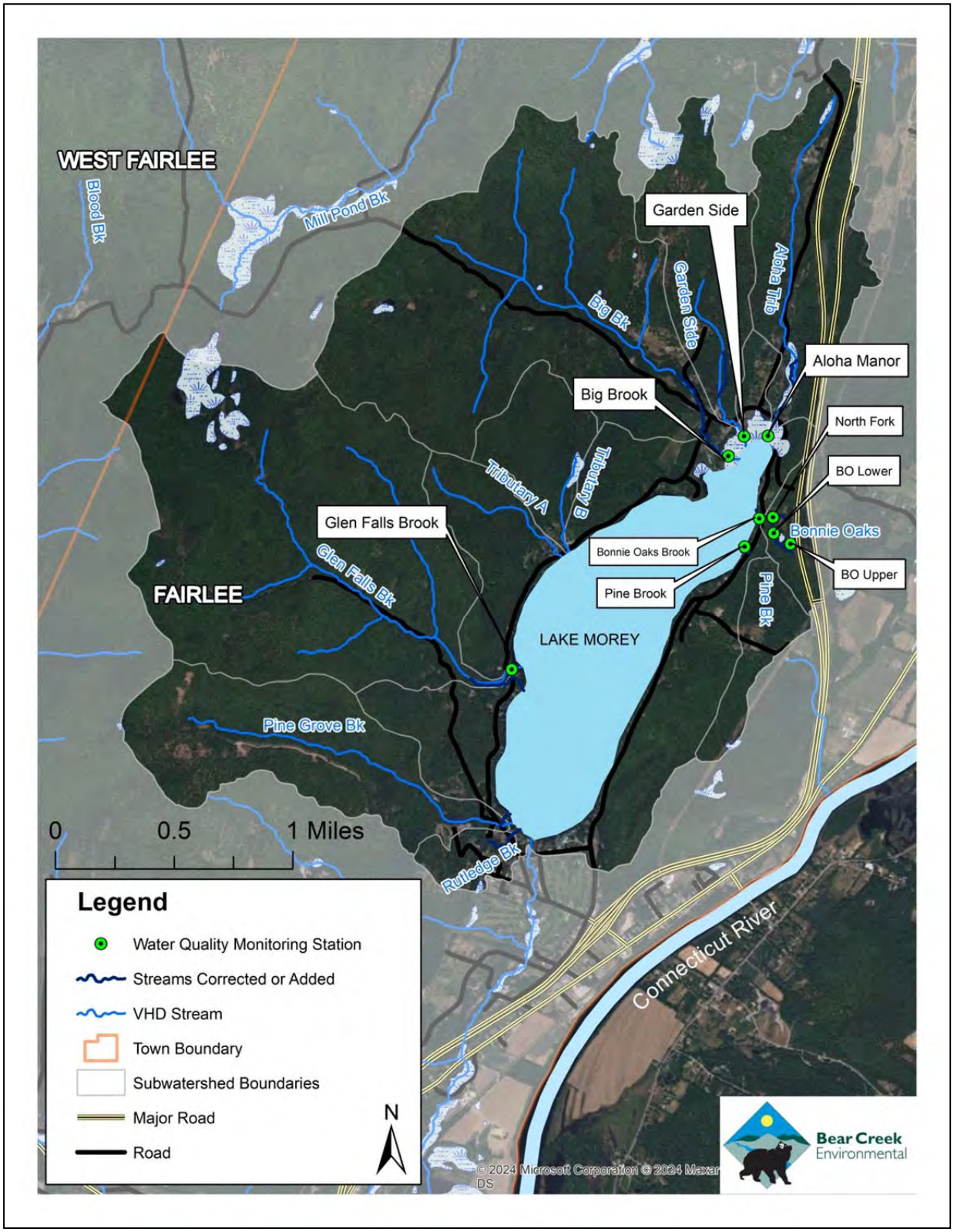


Figure 3. Lake Morey Inlet Streams and Water Quality Stations

Inlet Streams

Big Brook and Glen Falls Brook, the largest of the inlet streams, account for approximately twenty percent and twenty-two percent of the watershed area, respectively. Pine Brook and Aloha Manor Brook each drain between eight and nine percent of the watershed area. A summary of percent watershed contribution by inlet stream is provided in Appendix B and is included graphically below in Figure 4. Water chemistry data from the Lake Morey inlet streams are discussed in Section 5.3.

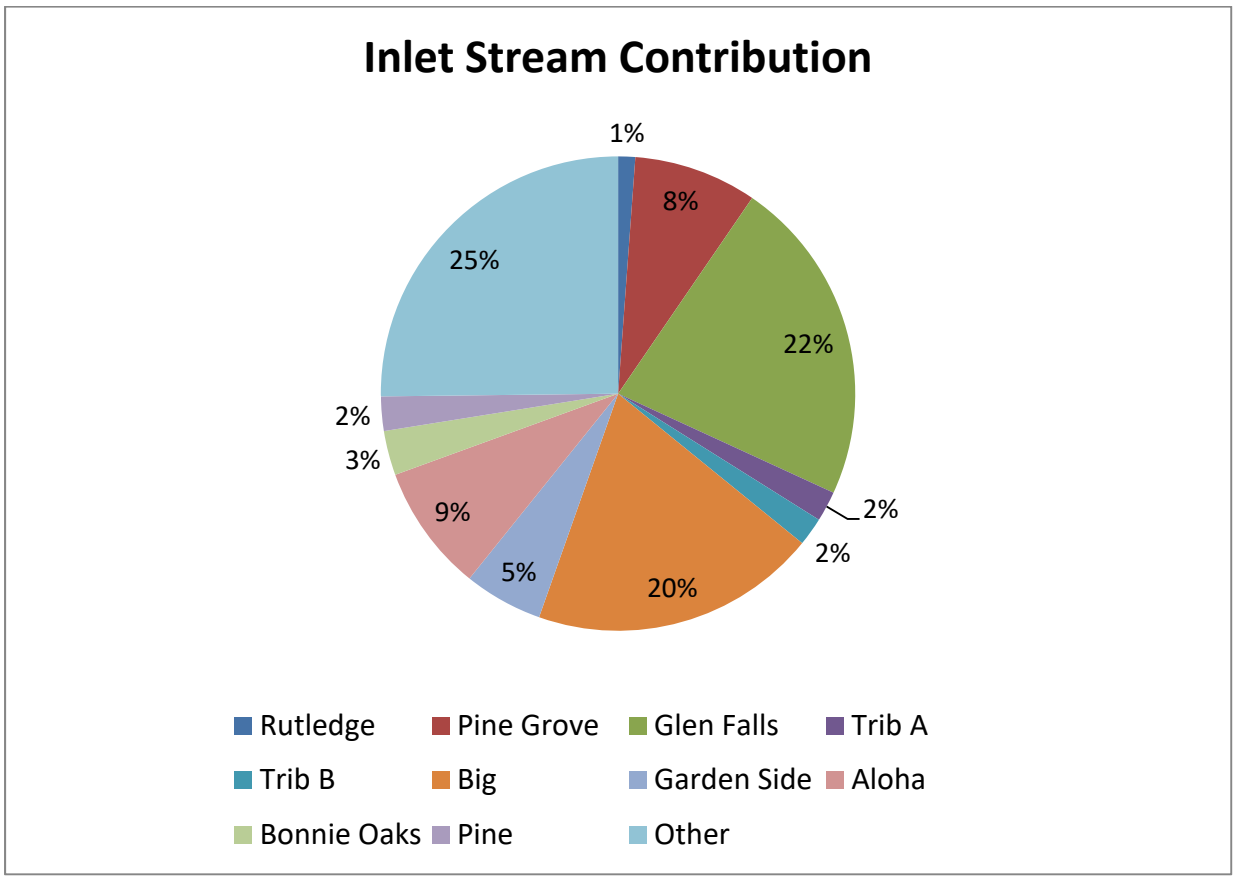


Figure 4. Inlet Stream Drainage Area Contribution by Subwatershed Size

Watershed History

The recent history of the Lake Morey watershed appears to be strongly tied to its water quality. A summary of historical events is provided in An Historical Guide to Fairlee, Vermont (Fairlee Historical Society, 2022) and the Lake Morey Diagnostic and Feasibility Study (VTDEC, 1984). The 1984 DEC study used sediment core information and a history of human activities to draw conclusions about lake water quality as summarized in Table 1.

Sediment and chlorophyll accumulation was low prior to 1880, suggesting nutrient loading and chlorophyll accumulation was low. Chlorophyll is a measure of primary productivity, and low chlorophyll numbers often are a reflection of low nutrients. Between 1880 and 1920 there was rapid development within the Lake Morey watershed. Sediment accumulation increased substantially, likely due to a disturbed shoreline. The nutrient input to the lake increased from soil erosion and sewage and the amount of chlorophyll increased. The sediment that entered the lake brought with it phosphorus. There was some reduction in sediment accumulation and chlorophyll accumulation between 1920 and 1970; however, levels did not return to baseline levels prior to the 1900s. Interstate Highway 91 was constructed between 1970 and 1972, once again, resulting in increased sediment and chlorophyll accumulation. The authors of the Lake Morey Diagnostic-Feasibility study suggest sulfur loading occurred from the highway construction.

The high sulfate levels reported in Lake Morey is significant for internal phosphorus loading Sulfide (the reduced form of sulfate) can bind with iron and precipitate as ferrous sulfide. When this happens, it reduces the availability of iron to form insoluble ferric phosphate when the *hypolimnion (lower layer of water in a stratified lake)* is oxygenated during fall turnover. This results in phosphorus being released from the sediments into the surface water and becoming available for algal growth (increase in chlorophyll). The 1984 DEC study concludes that the intensive development between 1890 and 1920 “has had a long-lasting adverse impact on water quality”.

Table 1. Relationship between Lake Health and Land Use (summarized from DEC, 1984)			
Timeframe	**Land Use**	**Sediment Accumulation**	**Chlorophyll Accumulation**
Prior to 1880	Human disturbance limited to minor farming and logging activities	**Low and stable** – farming activity confined to small portion of watershed	**Low** - water quality impact likely minor
1880 – 1920	Rapid and intensive residential and commercial development	**Increased sharply** - Likely due to erosion of disturbed shoreline sediment	**Increased greatly**– increased nutrients from soil erosion and untreated sewage
1920 - 1970	Gravel pits developed (1930-1940), wetland area at north end of lake filled (1940 – 1960); revegetation of disturbed soils, improved sewage disposal	**Decreased** – but did not return to baseline levels prior early 1900s	**Decreased** – but did not return to baseline levels prior early 1900s
1970 - 1972	Interstate Highway 91 through Lake Morey watershed was constructed	**Increased** – Disturbance from construction of interstate	**Increased –** Likely influenced by loading of sulfur to the lake (resulting in increased internal loading)

Building Density

Development within the Lake Morey watershed is concentrated along the lake, as shown on the map on page 1 of Appendix A. Many homes and businesses line the lakeshore, including the Aloha Camp, the Lake Morey Resort, and the Hulbert Outdoor Center. According to data from the Emergency-911 program, there are 241 buildings within the Lake Morey watershed. The highest building densities are at the south end of the lake.

Road Density

High road densities can lead to negative ecological impacts on lakes, including runoff and pollution, habitat fragmentation, alteration of hydrological processes, introduction of invasive species, and noise and disturbance that can stress wildlife in the vicinity of the lake.

Approximately 15 miles of road are present within the watershed, according to road centerline data from the Vermont Center for Geographic Information. Total road lengths by road class are included in Table 1 below.

The road density is approximately 2.0 miles per square mile within the Lake Morey Watershed. This is similar to the Lake Fairlee Watershed, which has a road density of 2.2 miles per square mile. The road network is denser around the lake and is 2.6 miles per square mile within a 1-mile radius of the Lake and 3.4 miles per square mile within 250 feet of the Lake. For purposes of this Action Plan, *lakeshore is defined as the land surrounding a lake that is within 250 feet of the lake's mean water level*. Jones and Grant (1996) cited in Forman and Alexander (1998) suggest increased peak flows in streams may be apparent at road densities of 3 to 5 miles per square mile. This greater density of roads (3.4 miles per square mile) within the Lake Morey lakeshore points to the importance of implementing best management practices (BMP) to reduce sediment and phosphorus loading to road surfaces in close proximity to the Lake.

Table 1. Road Class and Length within Lake Morey Watershed

Road Class	Road Class Description	Length (mi)
2	Town Highway, Class 2	4.8
3	Town Highway, Class 3	2.9
4	Town Highway, Class 4	2.7
8	Private Road, but not for display on maps	1.4
51, 52, 56	Interstate	3.1
TOTAL		14.9

Watershed Land Cover

Land cover within the watershed was examined with a high-resolution land cover dataset from 2016 using a traditional land cover mapping approach. This high-resolution Base Land Cover dataset was created by the University of Vermont Spatial Analysis Laboratory. As shown on the map on page 2 of Appendix A, the Lake Morey watershed is primarily forested (81% total watershed area). Slightly more than one percent of the watershed area is developed (Table 2).

Table 2. Vermont 2016 Base Land Cover Dataset for Lake Morey Watershed		
Classification	**Area (acres)**	**Percent of watershed area**
Tree Canopy	3712.4	80.8%
Grass/Shrub	276.3	6.0%
Bare Soil	1.4	<0.1%
Water	550.7	12.0
Building	9.2	0.2%
Road	25.6	0.6%
Other Paved Surfaces	20.0	0.4%

Based on an analysis performed by the Vermont Department of Environmental Conservation of supplemental land cover information[1] provided by the UVM Spatial Analysis Laboratory, (https://anrmaps.vermont.gov/websites/Documents/DEC_LakesLandcover/Morey_HighResLandCoverSummary.pdf), the Lake Morey watershed has the following land cover characteristics:

- 1.7 % impervious surfaces
- 0.6 % agriculture
- 3.3 % wetlands
- 92.2 % tree canopy

Lakeshore Land Cover

The lakeshore was evaluated using the Vermont Base Land Cover dataset from 2016. A 250-foot buffer was created around the Lake and the percentage of land with tree canopy, grass/shrub, and impervious surface was summarized. Lake buffer land cover information for Lake Morey (Table 3) is compared with landcover data for other lakes that is provided in the Lake Elmore Watershed Action Plan (Fitzgerald Environmental Associates, LLC, 2020) and Lake Fairlee (Bear Creek Environmental, 2023). A map showing the land cover within the 250-foot buffer is provided in Figure 5.

[1] The supplemental landcover data uses a "bottom-up" landcover mapping approach, which results in improved mapping of features overlapped/obscured by other features.

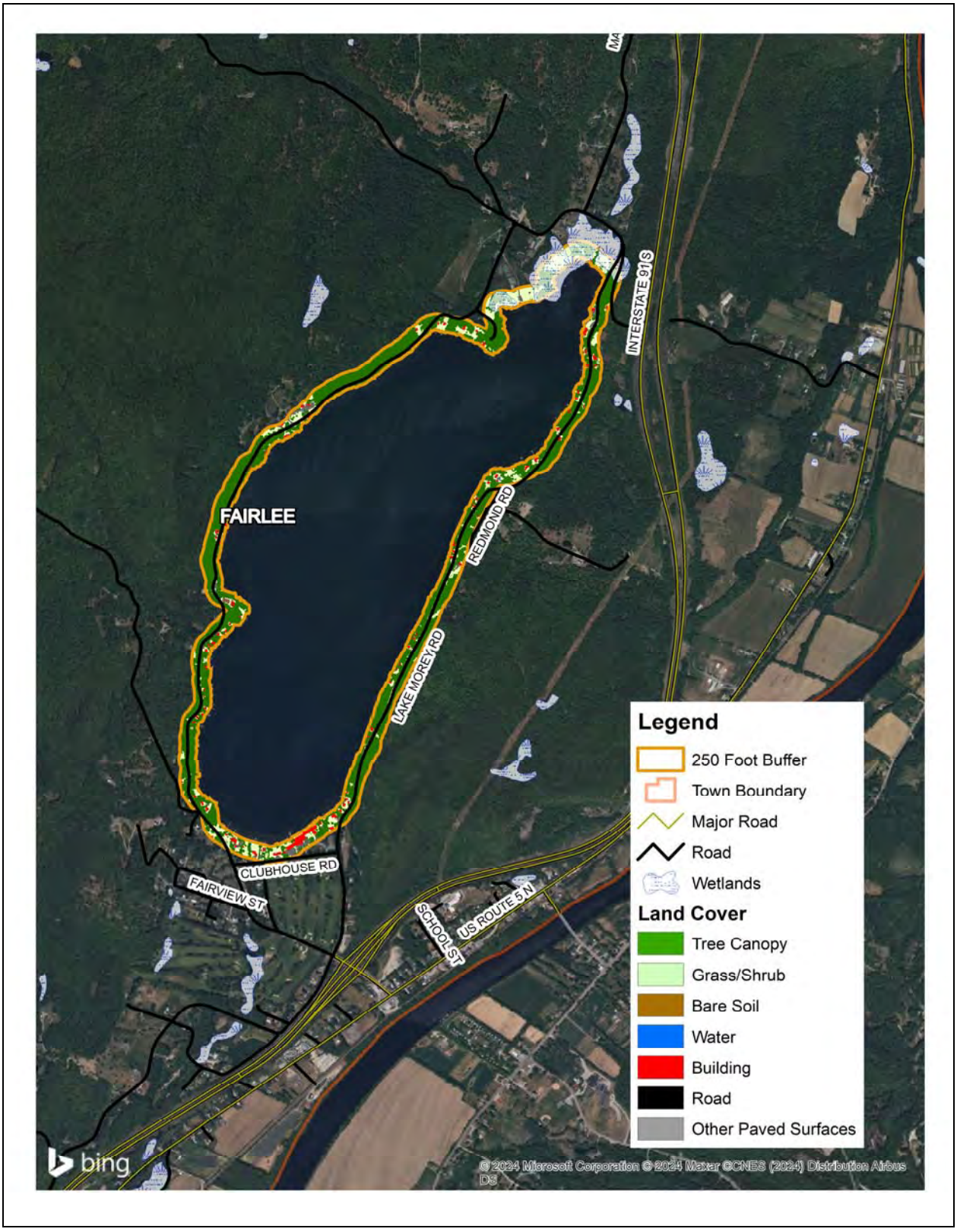


Figure 5. VT 2016 Base Land Cover Data within 250-Buffer Around Lake Morey

Table 3. Vermont 2016 Base Land Cover Dataset 250-Foot Buffer Around Vermont Lakes						
Lake	**Watershed (Sq. Mi.)**	**Lake Area (Acres)**	**Lake Perimeter (Miles)**	**Tree Canopy**	**Grass/ Shrub**	**Impervious**
Fern	0.8	67	2.3	84%	8%	8%
Morey	**7.3**	**545**	**5.2**	**74%**	**17%**	**9%**
Dunmore	20.8	1040	11.5	74%	14%	12%
Fairlee	20.3	457	8.3	67%	22%	11%
Eden	7.2	198	6.1	65%	22%	13%
Bomoseen	37.5	2415	22.9	61%	26%	13%
Little/St. Catherine	14	1085	16	58%	30%	12%
Elmore	8.4	222	3.3	50%	34%	16%
Lake Fairlee and Lake Morey information provided by Bear Creek Environmental, LLC Other lake information from Fitzgerald Environmental Associates (2020) 2016 Land cover data from University of Vermont						

The supplemental land cover information, provided by the UVM Spatial Analysis Laboratory and summarized by Vermont DEC, suggests the impervious cover within the 250-foot buffer around Lake Morey may be closer to 13% of the total area. (https://anrmaps.vermont.gov/websites/Documents/DEC_LakesLandcover/Morey_HighResLandCoverSummary.pdf). The DEC presents the following land use cover information within the 250-foot lake buffer based on the supplemental data:

- 12.7 % impervious surfaces
- 0.6 % agriculture
- 7.5 % wetlands
- 75.9 % tree canopy

Wetlands

Wetlands adjacent to inlet streams and within the Lakeshore provide many natural functions including filtration of runoff, habitat for aquatic and terrestrial species, flood protection, shoreline erosion control, recreation, and aesthetics. Wetlands are prevalent along the major

inlet streams (Big Brook, Garden Side Brook and Aloha Manor) at the northern end of Lake Morey (Appendix A, page 3). The protection of these wetlands is vital for protecting lake health.

Municipal Road Inventories

During 2018, Two Rivers-Ottauquechee Regional Commission conducted road erosion inventories for the town of Fairlee. (https://vtanr.maps.arcgis.com/apps/instant/interactivelegend/index.html?appid=0c5ebf5a1fbb4d959cd2e6274bd50278; https://anrweb.vt.gov/DEC/IWIS/MRGPReportViewer.aspx?ViewParms=True&Report=Portal.) These inventories followed the protocols set forth by the Vermont Department of Environmental Conservation Watershed Management Division titled "Municipal Roads General Permit (MRGP)-Road Erosion Inventory (REI)". Roads inventoried included the town road systems. Road segments were assigned scores of "Fully Meets", "Partially Meets", or "Does Not Meet" the MRGP.

None of the road segment within the Lake Morey watershed received a score of "Does Not Meet". All of the assessed roads received a score of either "Fully Meets" or were not considered to be hydrologically connected (Appendix A, page 4).

Geology

The bedrock geology of the Lake Morey watershed is included on a map on page 5 of Appendix A. According to Jon Kim, State Geologist with the Vermont Department of Environmental Conservation (Email dated January 11, 2023 to Mark Mitchell), the bedrock geology within the Lake Morey watershed could influence water quality of the lake.

> "The sulfate in the lake could come naturally from bedrock formations surrounding the lake, in particular the Partridge (Op) and Sawyer Mountain (Ssm) formations, which are known for having lots of pyrite ("fools gold" that dissociates into iron and sulfur during weathering). The I-91 fill does not have to be the dominant source of sulfate."

High levels of sulfate have been reported by the Vermont DEC in water quality samples collected from Bonnie Oaks Brook, Aloha Manor Brook, and the lake itself. These inlet streams are located on the eastern side of the watershed that is underlain with the Partridge formation and the Sawyer Mountain Formation. Therefore, these bedrock formations could be the dominant source of sulfate.

Another theory that has been considered for sources of sulfate and phosphorus to the lake and tributaries is the rock fill that was used for the construction of I-91. The Lake Morey Diagnostic Feasibility Study (DEC 1984) attributes elevated sulfate concentration in Lake Morey to blasting and filling operations associated with highway construction. As stated in the report, the bedrock in the vicinity of the highway is a dark gray or black slate that contains iron sulfate. As mentioned by Kim in his January 11, 2023 email, in order to understand the influence of the fill on water chemistry, the rock composition of the I-91 fill and the chemistry of the seepage would need to be known.

The high sulfate levels reported in Lake Morey is significant for internal phosphorus loading, according to the Lake Morey Diagnostic Feasibility Study (DEC, 1984). As discussed in Section 3.0, sulfide (the reduced form of sulfate) can bind with iron and precipitate as ferrous sulfide. When this binding occurs, it reduces the availability of iron to form insoluble ferric phosphate when the *hypolimnion, or lower layer of water*, is oxygenated during fall turnover. Subsequently, phosphorus is being released from the sediments into the water column.

For additional information about the geology of Fairlee, Vermont, including glacial history, bedrock history, and bedrock types; the reader is encouraged to access the Forests & Trails of Fairlee, Vermont website prepared by Friends of the Fairlee Forest https://www.fairleeforest.org/geology#:~:text=After%20most%20of%20the%20last,of%20the%20present%20Lake%20Morey.

Town Regulations

There has been a concern about cyanobacteria blooms by members of the Lake Morey community. This has led to the adoption of a couple of town regulations and outreach activities.

1. Conditional Use Moratorium

The town of Fairlee adopted a one-year building (conditional use) moratorium around Lake Morey during September 2021 to allow time to better understand nutrient sources that may be contributing to cyanobacteria blooms in the lake. This moratorium restricted the building of new subdivisions, new principal buildings or projects that require a conditional use permit. This moratorium was extended in September 2022 by the Fairlee Selectboard and was repealed in April 2023.

Two juniors at the University of Vermont worked with the town of Fairlee in 2022 to assess the moratorium on building around Lake Morey, and prepared a report (Valko, C. and E. Frankenthaler, 2022) describing their assessment.

2. Upgrades to Fairlee Unified Development Bylaw

According to Chris Brimmer, Zoning Administrator for the Town of Fairlee, Interim Amendments were made to the Fairlee Unified Development Bylaw (UDB) in April 2023 that replaced the moratorium. These amendments were adopted by voters on July 11, 2023.

4.0 WATERSHED DATA LIBRARY

An important part of the LWAP planning process is the compilation and review of existing data for a lake and its watershed. Bear Creek Environmental reviewed existing water quality, biological, road inventory, stream geomorphic assessment, geospatial data, and more as part of the digital library creation. The library is contained in a Microsoft Excel workbook titled “Lake Morey_LWAP_DigitalLibruary_082422.xlsx”. Many of the maps in the Excel file have been

reproduced in pdf format and are contained in Appendix A. A summary of the library is included below.

- Municipal Roads General Permit Road Erosion Inventory data
- Geospatial (GIS) data – surface waters, roads, land cover, development, wetlands, geology, and water quality monitoring sites
- Water chemistry monitoring of inlet streams
- Biomonitoring
- Lake Scorecard
- Lake Studies

5.0 WATER QUALITY DATA

The water quality section of the Lake Morey LWAP report is split into three sections: A) Previous Studies, B) Lake Water Quality, and C) Inlet Stream Water Quality.

5.1. Previous Studies

1. Lake Morey Diagnostic – Feasibility Study 1980 – 1984

A large study was completed by the Vermont Department of Environmental Conservation between 1980 and 1984 to understand the cause of water quality problems in Lake Morey and to determine appropriate strategies for restoration. The methods, results and recommendations of the study are provided in the Lake Morey, Diagnostic –Feasibility Study, Final Report, prepared by the Vermont Department of Environmental (1984). Prior to the commencement of the Diagnostic – Feasibility Study, a recommendation had been made for the planning and construction of a 3-million-dollar sewer line and wastewater treatment plant to serve the Lake Morey community. According to the Diagnostic – Feasibility study report, the lake has had a long-term problem with excessive algae and plant growth, resulting in nuisance conditions that have impeded recreational use. The goal of the study was to create a

phosphorus budget to use in developing water quality models, which could be used to predict the benefit of different phosphorus controls.

The following conclusions are presented in the DEC's 1984 Report:

- Internal phosphorus recycling, rather than loading from the watershed, is the primary cause of elevated phosphorus in Lake Morey.
- Low oxygen and low iron are important parameters causing phosphorus release from the sediments. Low iron levels may be related to excessive sulfur loading, thereby producing iron sulfide.
- Alum treatment is a good restoration option to control internal loading.
- Algae problems in the lake are related to historical land use activities and paleolimnological findings.
- In general phosphorus concentrations in the inlet stream were low and typical of forested, undeveloped watersheds.
- Four streams had elevated phosphorus concentrations (Gardenside Brook, Bonnie Oaks, Pine Brook, and Aloha Camp).
- Garden Side and Pine Brook would be difficult to achieve significant phosphorus reductions due to phosphorus being in a particulate form, suggesting erosional processes were the cause.
- High phosphorus concentrations at Aloha Camp culvert were attributed to faulty septic system (high dissolved phosphorus and fecal coliform).
- Bonnie Oaks may have been affected by seepage from nearby sewage lagoons operated by an inn. Repairs were made to the inn's treatment system in 1983 to reduce the direct surface discharge. However, improvements to reduce subsurface seepage were not feasible.
- Phosphorus inputs from shoreline septic system by groundwater input were determined to be very minor, accounting for less than one percent of the total phosphorus input. Although shoreline septic systems did not appear to significantly impact growth of

algae, the authors caution that shoreline septic systems should be properly maintained to reduce localized areas with problematic plant growth.

- A mechanical weed harvesting program was recommended for controlling nuisance aquatic plant growth.

2. Alum Treatment of Lake Morey

Lake Morey was treated with liquid alum and liquid sodium aluminate during the thermal stratification season of May 23 to June18, 1986 (Smeltzer 1990). Prior to the treatment, summer phosphorus concentrations in the *upper layer of the lake (epilimnion)* were typically 10-30 ug/L and spring and fall turnover values were within the range of 30-40 ug/L. Following the treatment, summer epilimnetic values and spring and fall turnover values were generally below 10 ug/L. Significant phosphorus reductions were also noticed in the hypolimnion.

According to Smeltzer (1990), summer chlorophyll-a concentrations were reduced significantly within the first few years following the alum treatment and the water clarity increased.

3. Lake Morey Sediment Study (Alum Feasibility Study)

SOLitude Lake Management (SLM) was retained by the Town of Fairlee to conduct a Lake Morey sediment analysis. The purpose of the study was to quantify the phosphorus in the lake sediments and to determine the amount of alum required to reduce internal P loading (SOLitude Lake Management, 2023). SLM's methods, results, and recommendations are contained in the report "Enhancing Water Quality through Nutrient Inactivation (Lake Morey Sediment Study & Management Recommendations)" and summarized below.

- There are two sources of phosphorus in the Lake Morey sediments that are available to contribute phosphorus to the water column. The first source is redox-sensitive phosphorus (primarily in the form of iron bound phosphorus), and the second source if biogenic- phosphorus or organic phosphorus that is most readily available to dissolve into the water column.

- SLM determined that an alum treatment with an average of 33.5 g Al/m2 is required to inactivate the phosphorus in the sediment and reduce internal loading.

5.2. Lake Water Quality

1. Lake Score Card

The Vermont Department of Environmental Conservation has a scoring system for lakes in Vermont. The scorecard is used to assess the health of lakes in Vermont and to answer the question "how is the lake doing". Vermont Lake Score Card indicates Lake Morey is *Moderately Disturbed* and is *Stressed* when evaluated with the Vermont water quality standards (https://anrweb.vt.gov/PubDocs/DEC/WSMD/Lakes/Lake_Score_Cards/MOREY.HTML). Of the four categories evaluated, Water Quality Trend and Mercury scored in the *Fair* category, while Shoreland Condition and Invasive species scored *Poor* (Figure 6). Summer Phosphorus in the Lake had a trend of *Significantly Increasing*.

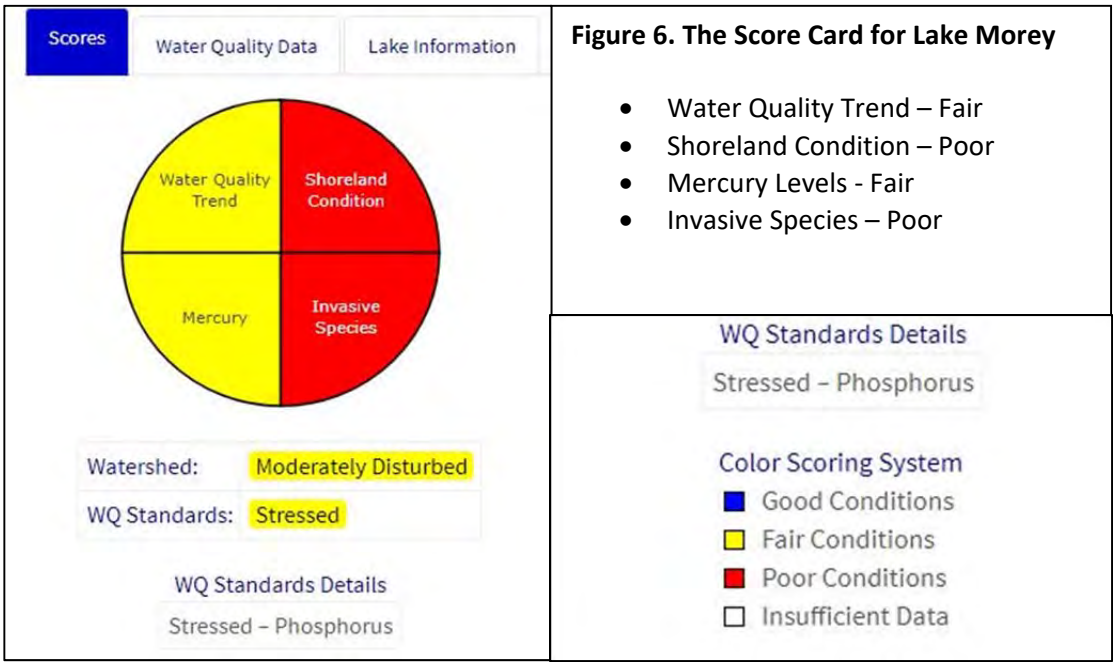


Figure 6. The Score Card for Lake Morey

- Water Quality Trend – Fair
- Shoreland Condition – Poor
- Mercury Levels - Fair
- Invasive Species – Poor

2. Cyanobacteria Blooms

Based on information provided by the Vermont Department of Environmental Conservation, significant cyanobacteria blooms have impacted the recreational use of Lake Morey. (https://dec.vermont.gov/watershed/restoring/morey).

- During August – October 2022 – "intense, prolonged cyanobacteria blooms" curtailed the summer recreational season

- During the 1970s and early 1980s cyanobacteria blooms "severely interfered with recreational use of the lake"

Lake association and community members have been looking for a solution to management these blooms. An alum feasibility study was completed in 2023 to address this issue.

3. Caffeine Monitoring

Caffeine can be used as an anthropogenic marker to estimate the contribution of septic systems to lake water quality (Onjiko et al. 2011). The Vermont DEC incorporated caffeine sampling of Lake Morey into the 2023 lay monitoring program. On five occasions during the summer, samples from the surface of the lake (epilimnion at 0.5 m) were analyzed for caffeine. Four times during summer 2023, samples were also collected from the deep part of the lake (hypolimnion at 10 m) and were analyzed for caffeine.

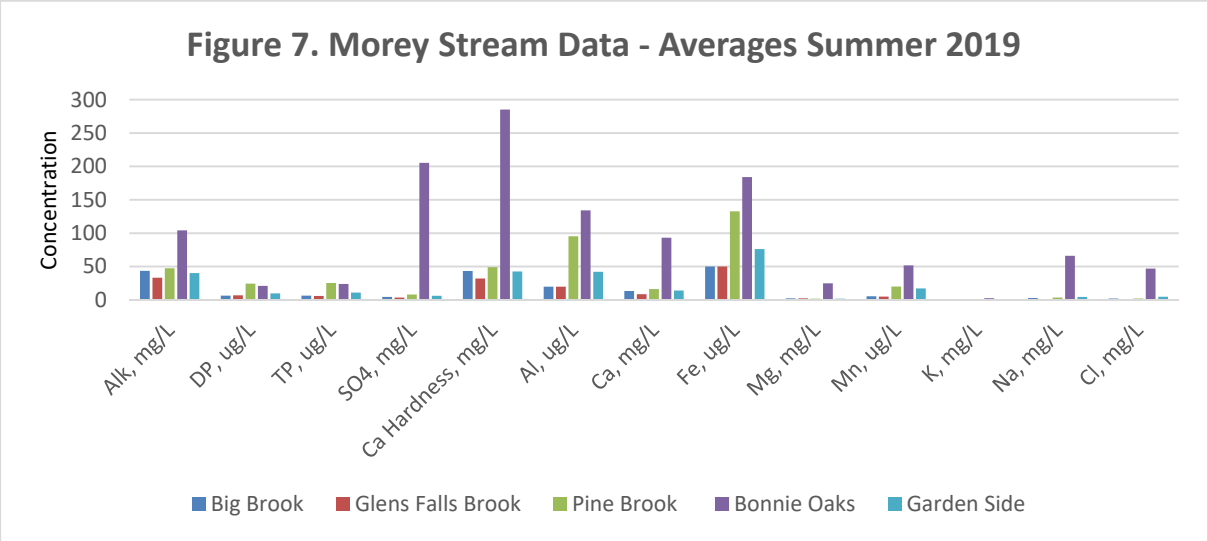
According to Mark Mitchell, Limnologist with the VTDEC, all caffeine samples collected from Lake Morey in 2023 were below the pilot detection limit of 0.50 µg/L. The VTDEC plans to sample caffeine in Lake Morey during the 2024 monitoring period and have it analyzed at a lower detection limit of 0.05 µg/L

5.3. Inlet Stream Water Quality

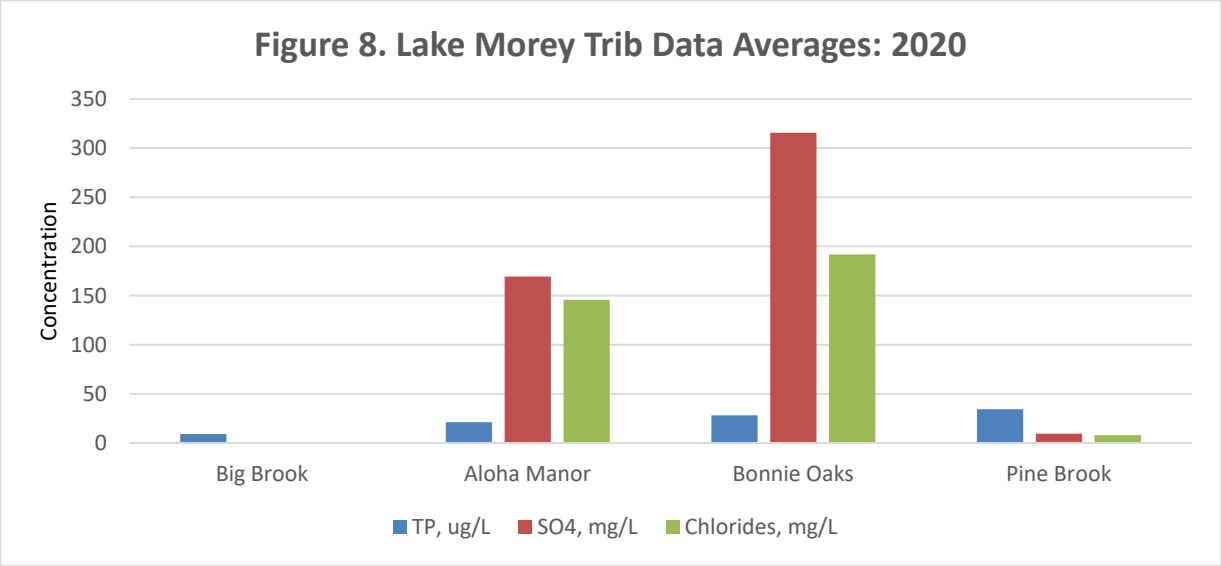
Water chemistry data from the Lake Morey inlet streams are available from Vermont DEC Lakes and Ponds Program and through stream monitoring carried out by the Lake Morey Commission through a lay monitoring program, which is supported by the VTDEC.

Lay Monitoring: Sampling for the lay monitoring program began in 2019 and has occurred annually since then during the summer. During the past five years, samples have been collected from six inlet streams: Glenn Falls Brook, Big Brook, Gardenside, Bonnie Oaks, Pine Brook, and Aloha Manor. Sampling was discontinued on Glenn Falls Brook and Gardenside Brook following the first year of monitoring. According to Greg Allen of the Lake Morey Commission, total phosphorus concentrations were low at these two streams and streamflow was low or dry on the summer sampling dates in 2019.

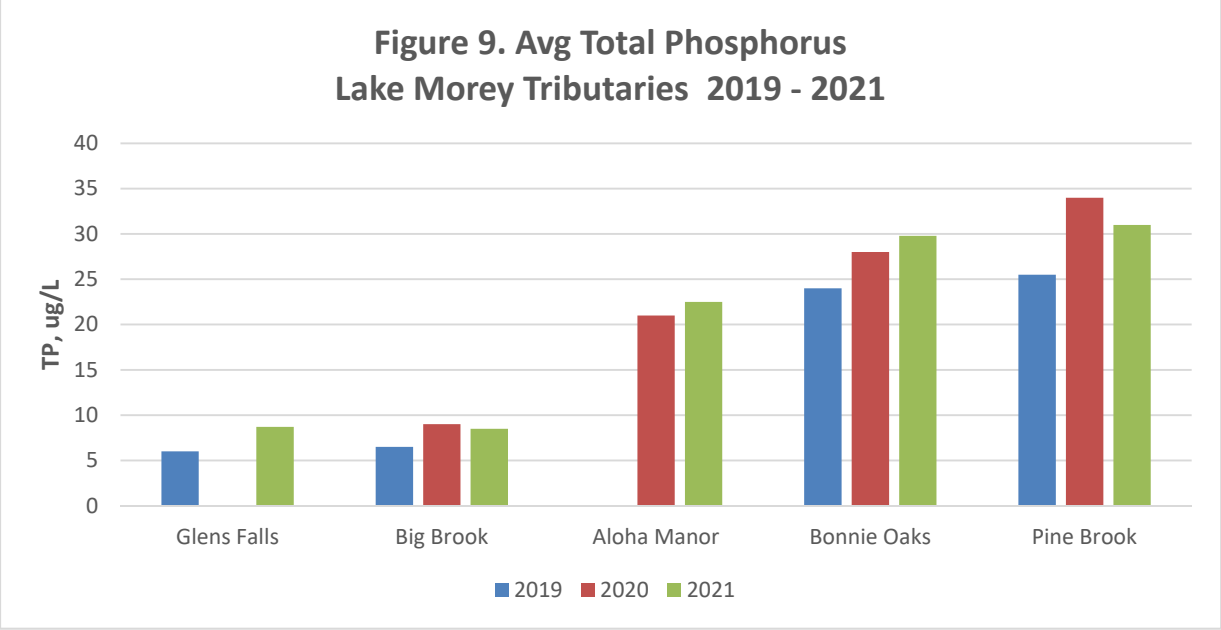
2019: During the first year of monitoring in 2019, water quality samples were collected on Glenn Falls Brook, Big Brook, Gardenside, Bonnie Oaks, and Pine Brook. Sampling during 2019 consisted of four samples taken monthly between May and August. Only two samples were taken of Glenn Falls Brook due to lack of flow at the sampling station in July and August 2019. Samples were analyzed for alkalinity, dissolved phosphorus, total phosphorus, sulfate, hardness, aluminum, calcium, iron, magnesium, manganese, potassium, sodium, and chloride. As shown in the Figure 7 below, Bonnie Oaks Brook had the highest average values for alkalinity, sulfate, hardness, aluminum, calcium, iron, manganese, sodium and chloride of the five monitoring stations sampled in 2019.



2020: The lay monitoring program was cut back to four water quality stations (Big Brook, Aloha Manor, Bonnie Oaks, and Pine Brook) and three monitoring parameters (total phosphorus, sulfate and chloride) in 2020. Aloha Manor and Bonnie Oaks, had elevated concentrations of sulfate and chlorides (Figure 8). Scientists at the Vermont Department of Environmental have suggested there is a possible link between these high sulfate and chloride concentrations and Interstate 91. Pine Brook and Bonnie Oaks Brook had the highest average total phosphorus concentrations.



2021: Lay monitoring sampling continued in 2021 with the monitoring of five inlet streams (Glens Falls Brook, Big Brook, Aloha Manor, Bonnie Oaks, and Pine Brook). Once again, elevated total phosphorus concentrations were reported for Aloha Manor, Bonnie Oaks and Pine Brook (Figure 9). Consistent with past observations, chloride was elevated on Aloha Manor and Bonnie Oaks, which are both located downstream of Interstate 91.



2021 Bonnie Oaks Special Study: A special study was conducted in October 2021 within the vicinity of Bonnie Oaks Brook watershed to better understand the source of the elevated phosphorus, chloride, and sulfate near the inlet. A focus of the study is two wastewater lagoons that are located below Interstate 91 on the main stem of the brook (Figure 10). Sampling was conducted at the following stations by Rob McGrath and analyzed at the LaRosa Laboratory.

- Upstream of the lagoons on Bonnie Oaks mainstem
- Upper lagoon
- Lower lagoon
- Downstream of the lagoons on Bonnie Oaks mainstem
- North Fork of Bonnie Oaks Brook
- Bonnie Oaks Brook at the inlet

Additional sampling of the Bonnie Oaks watershed took place during 2022 (McGrath, 2022). Based on the sampling in 2021 and 2022, Mr. McGrath concluded the following:

- There is a source of total phosphorus upstream of the lagoons
- The total phosphorus concentration does not change “dramatically” downstream of the lagoons.

2022-2023: Water quality monitoring of Big Brook, Aloha Manor, Bonnie Oaks at inlet, Bonnie Oaks Upper (above lagoons) and Bonnie Oaks Lower (below lagoons) was conducted by the Lake Morey Commission as part of the DEC lay monitoring program during 2022 and 2023. Samples were analyzed for total phosphorus and chloride, and the results provided by Greg Allen are presented graphically below in Figures 11 and 12. Bonnie Oaks and Pine Brook had the highest average TP concentrations, while Big Brook had the lowest. Chloride concentrations were elevated on Aloha Manor and Bonnie Oaks, but not on Pine Brook or Big Brook.

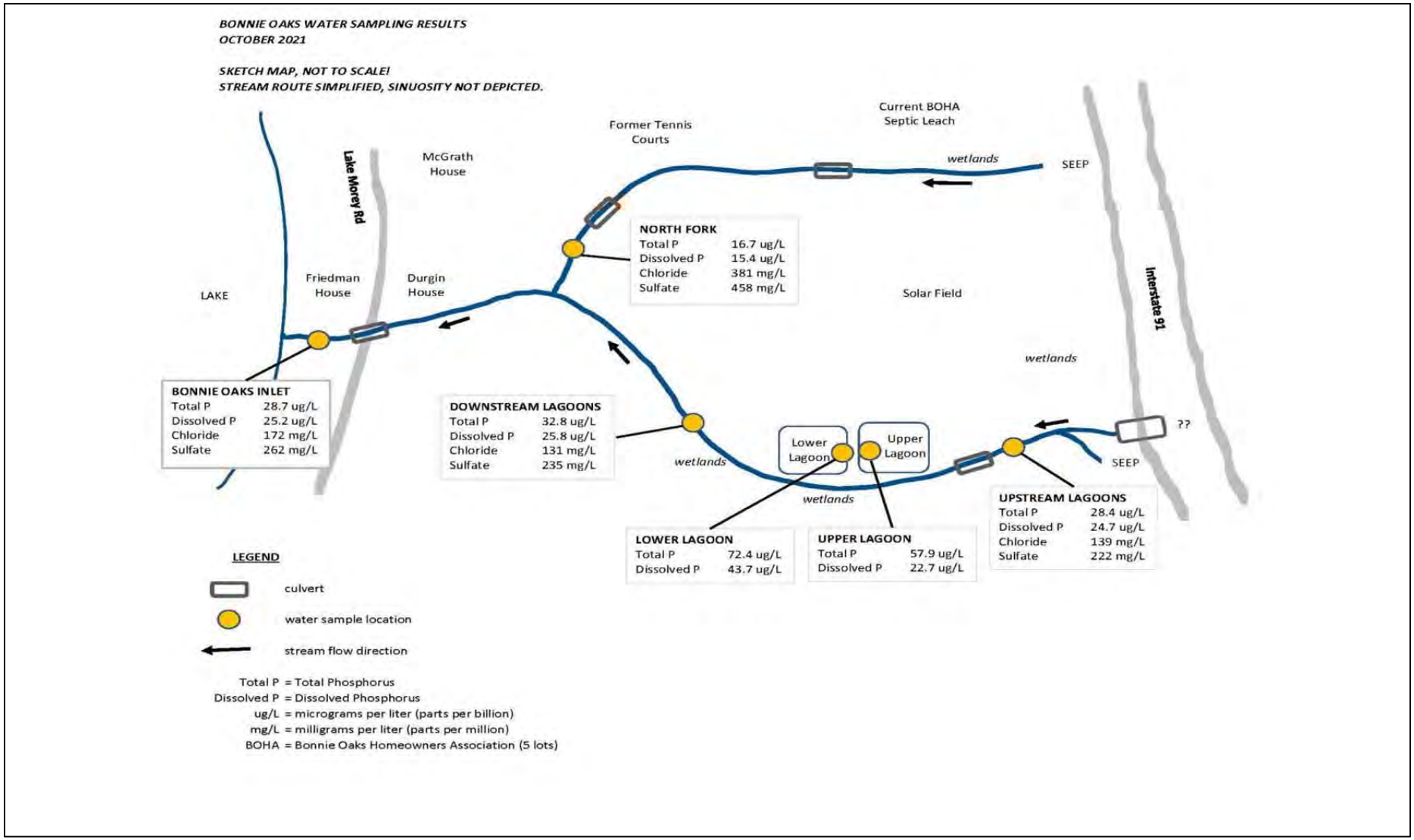


Figure 10. Sketch Map of Bonnie Oaks October 2021 Results (Prepared by Rob McGrath, 2021)

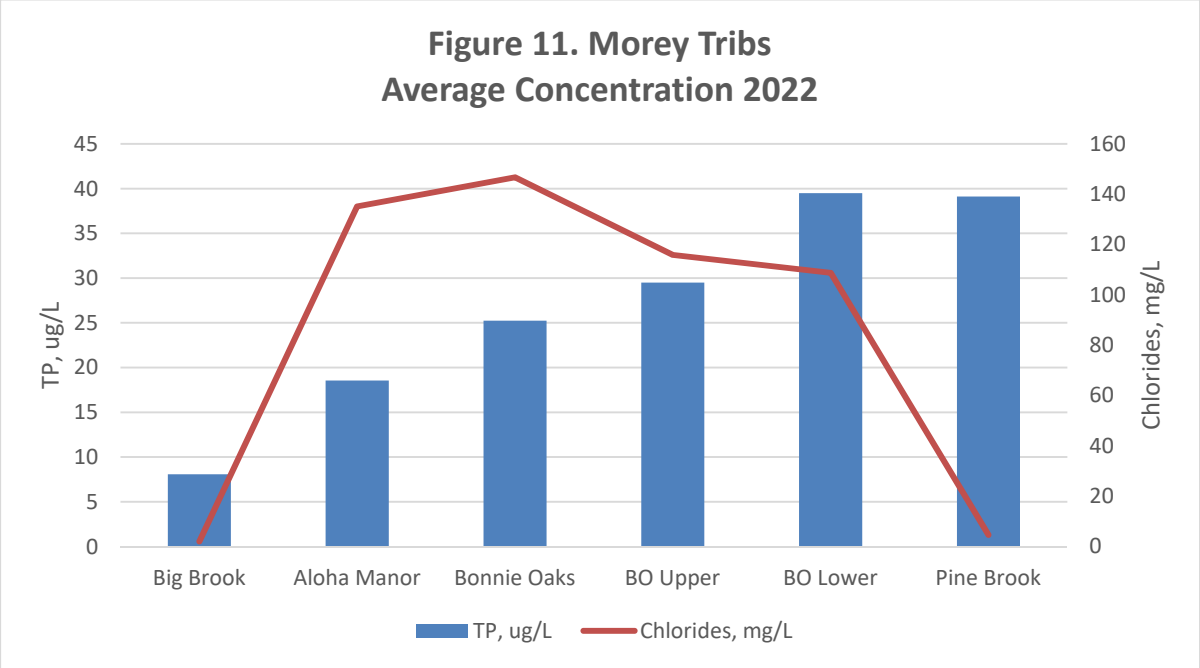


Figure 11. Morey Tribs
Average Concentration 2022
TP, ug/L
Chlorides, mg/L
45
40
35
30
25
20
15
10
5
0
160
140
120
100
80
60
40
20
0
Big Brook
Aloha Manor
Bonnie Oaks
BO Upper
BO Lower
Pine Brook
TP, ug/L
Chlorides, mg/L

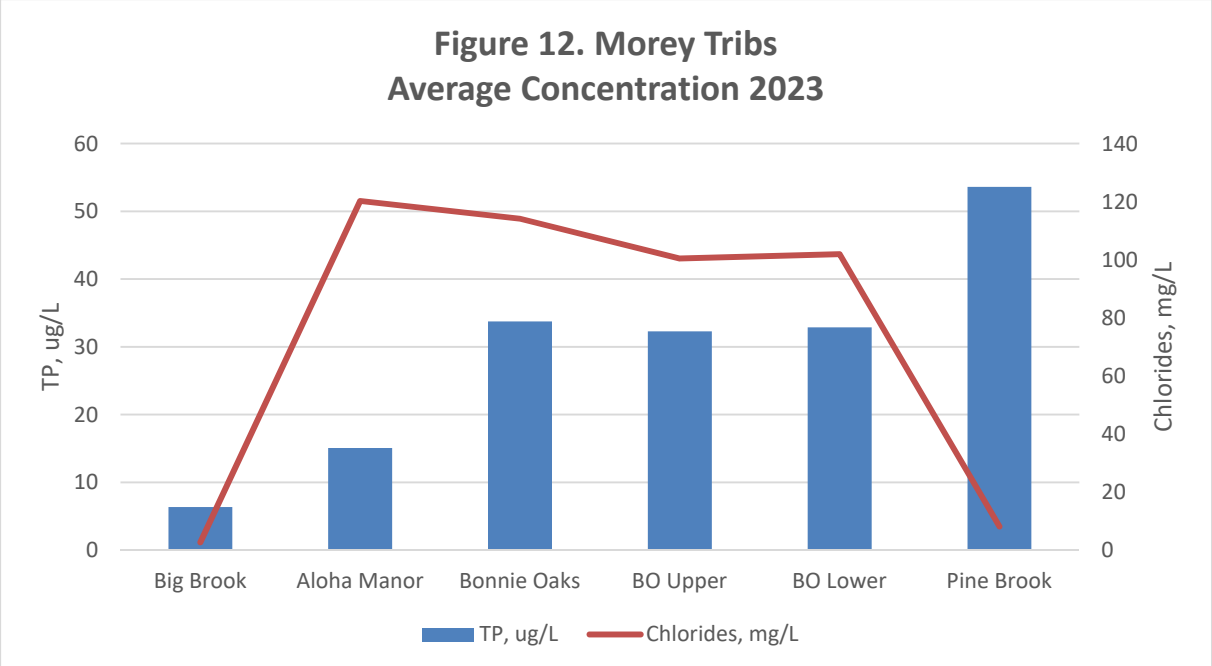


Figure 12. Morey Tribs
Average Concentration 2023
TP, ug/L
Chlorides, mg/L
60
50
40
30
20
10
0
140
120
100
80
60
40
20
0
Big Brook
Aloha Manor
Bonnie Oaks
BO Upper
BO Lower
Pine Brook
TP, ug/L
Chlorides, mg/L

Water quality graphs (Figures 13 and 14) provided by Mark Mitchell (VTDEC) for the 2023 monitoring year provide information about total phosphorus and chloride concentrations for select inlet streams to Lake Morey. Figure 13 shows elevated concentrations of total phosphorus on Pine Brook, on Bonnie Oaks near the mouth, on Bonnie Oaks downstream of the lagoons and Bonnie Oaks upstream of the lagoons in early May 2023, when streamflows were elevated. TP was also elevated during a freshet event in mid-July at all three Bonnie Oaks stations in 2023.

As shown in Figure 14, chloride concentrations for Big Brook and Pine Brook were at background levels, while chloride was elevated at the three Bonnie Oaks stations and Aloha Manor, which are located downgradient of Interstate 91. Chloride concentrations appear to be lowest during the spring and in mid-July 2023, when flows were elevated due to higher precipitation. Deicing agents applied to road surfaces are the most likely reason for the elevated chloride concentrations. High concentrations of chloride can harm aquatic life. All of the chloride concentrations in the inlet stream were below the chronic limit of 230 mg/L specified in the Vermont Water Quality Standards (VWQS); however, the DEC is considering lowering the standards when the VWQS are revised (personal communication with Mark Mitchell).

Figure 13. 2023 Lake Morey Tributary Total Phosphorus Monitoring

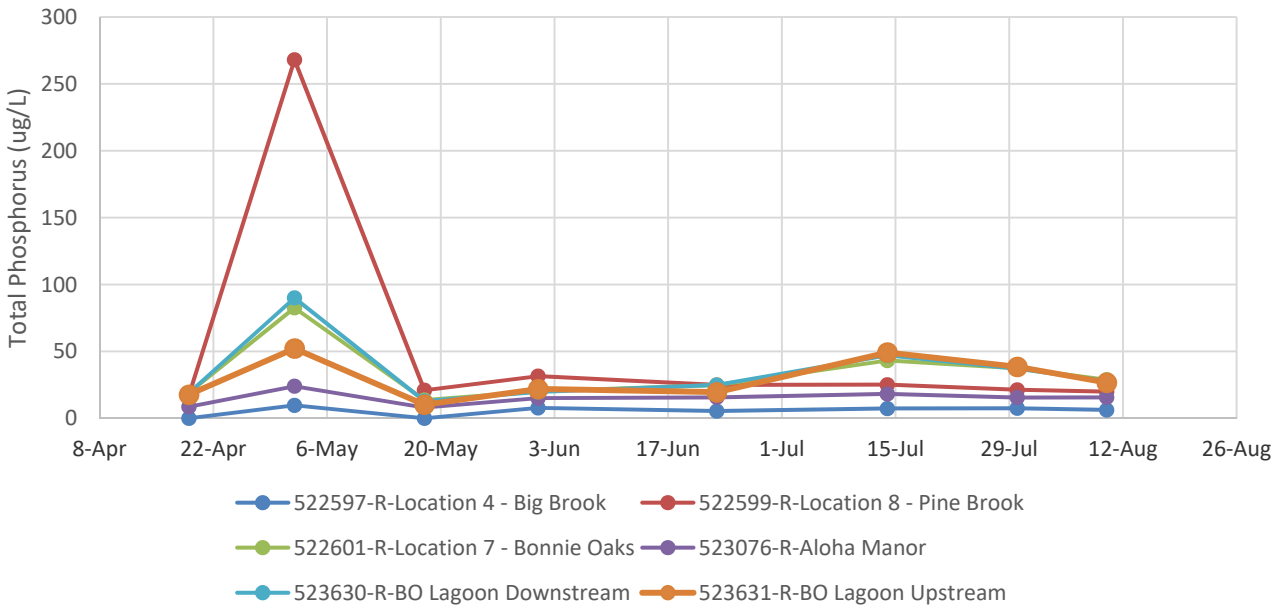
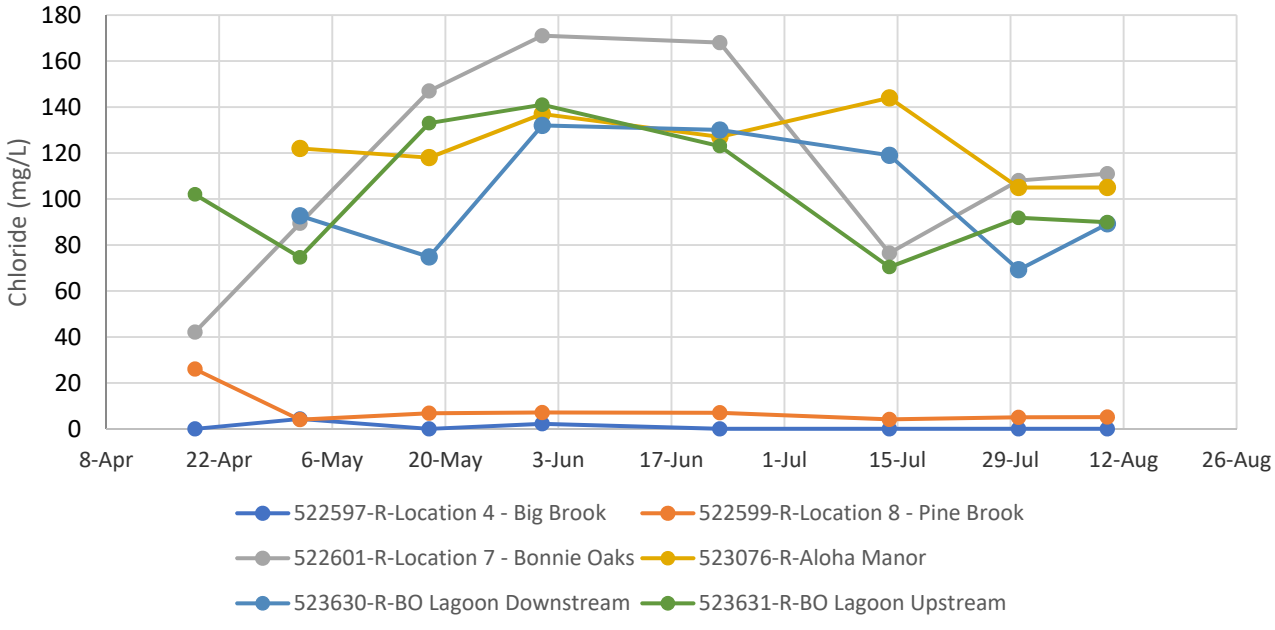


Figure 14. 2023 Lake Morey Tributary Chloride Monitoring



6.0 ASSESSMENTS

Three sectors (lakeshore, streams, and roads) were assessed to identify water quality problem areas. Problem summary sheets were developed to compile the information from the three sectors. The summary sheets include the following:

- Project Name
- Level of Landowner Commitment
- Site Location and Locator Map
- Site Description and Design Considerations
- Permitting Needs
- Cost Estimate Range
- Restoration/Water Quality Improvement Objectives

6.1 Stream Assessments

Target Streams

The lower reaches of Pine Grove Brook, Glen Falls Brook, Big Brook, Gardenside Brook, Aloha Manor Brook, Bonnie Oaks Brook, and Pine Brook were targeted for stream assessment reaches. These reaches were selected based on a review of the water quality data and conversations with Greg Allen (Lake Morey Foundation) and Danielle Owczarski (Vermont Department of Environmental Conservation). In addition to reviewing water quality data and speaking with key stakeholders, land use, slope, and watershed contribution to Lake Morey were considered as part of the reach prioritization process. All the inlet streams, with the exception of Rutledge Brook and Unnamed Tributaries A and B, were included in the stream assessment of the Lake Morey watershed, as shown in Figure 15. Tributaries A and B have primarily forested land use within their subwatersheds and small drainage areas and Rutledge Brook is small in size.

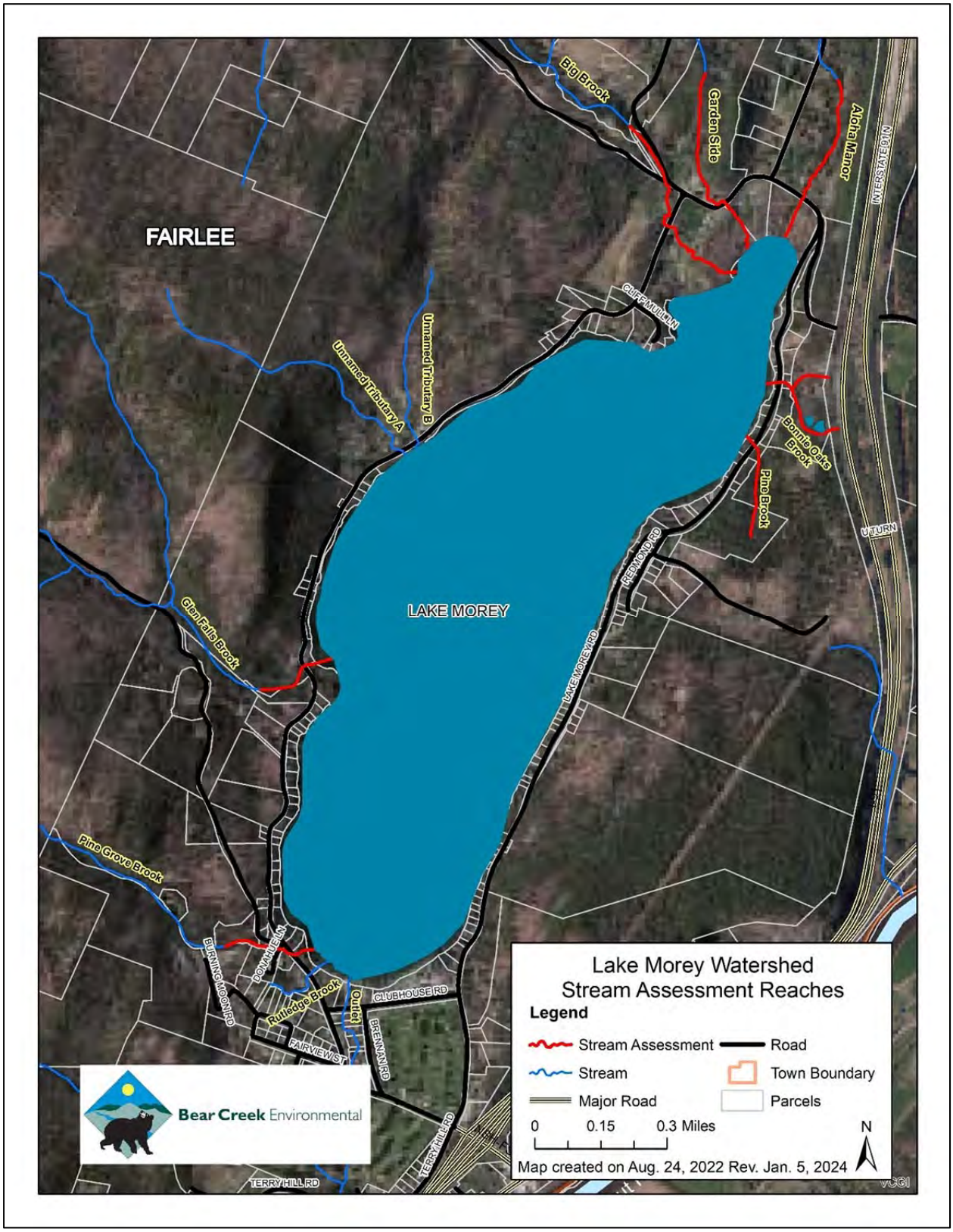


Figure 15. LWAP Stream Assessment Reaches and Major Tributaries

The inlet streams are listed in order from northeast of the lake Morey outlet going in a clockwise direction around the Lake. StreamStats[2], a tool provided by the United States Geological Survey (USGS), was used to calculate drainage areas of each of the inlet streams and outlet of Lake Morey. The drainage area at the Lake Morey outlet is approximately 7.3 square miles. The watershed area of the nine inlet streams sum to 5.4 square miles. This leaves about 1.9 square miles of watershed area that in not accounted for by the inlet streams.

Table 4. Watershed Area Contribution of Inlet Streams to Lake Morey

Stream Name	Watershed Area (Sq. Mi.)	Percent Watershed Contribution
1. Rutledge Brook[1]	0.085	1.2%
2. Pine Grove Brook	0.61	8.4%
3. Glen Falls Brook	1.62	22.3%
Unnamed Tributary A	0.15	2.1%
Unnamed Tributary B	0.14	1.9%
4. Big Brook	1.42	19.6%
5. Gardenside Brook	0.39	5.4%
6. Aloha Manor Brook	0.63	8.7%
7. Bonnie Oaks Brook[1]	0.22	3.0%
8. Pine Brook[1]	0.17	2.3%
[1]Not included in the Vermont Hydrography Dataset (VHD)		

The lack of landowner access limited the assessment of Pine Brook to the vicinity of Lake Morey Road. The assessment reaches of Glen Falls Brook and Pine Grove Brook were extended upstream from the initial reach selection, based on interest from local landowners, who met us in the field.

Landowner Outreach

During late August 2022, the White River Natural Resources Conservation District and Bear Creek Environmental, LLC mailed out post cards and letters to riparian landowners with property on the assessment reaches to provide information about the upcoming stream walks.

[2] https://streamstats.usgs.gov/ss/

Twenty-five landowners were contacted as part of this process. Two of the landowners reached out to Bear Creek Environmental with interest in meeting with them in the field, two of the landowners denied access to their property, and three landowners sent post cards back with interest in learning more about potential stream restoration projects on their property.

Stream Walks

During the stream walks, which took place in mid-October 2022, data were collected with a handheld global positioning system (gps) unit to assist with project identification (Figure 14). Features such as, bank erosion, areas with buffers less than 25 feet, culverts, ledge grade controls, and bridges and culvert were mapped in the field. The stream centerline was also mapped in locations where it was considerably different than the Vermont Hydrography dataset (VHD).

Figure 16. Stream Assessment of Big Brook by Bear Creek Environmental – October 2023

6.2 Road Erosion Surveys

Hydrologically connected road segments were assessed in 2018 by Two Rivers Ottauquechee Regional Commission (TRORC) using the Municipal Roads General Permit (MRGP) protocol. The MRGP data set was reviewed as a starting point to identify road problem areas within the Lake Morey watershed. All of the MRGP road segments within the watershed were either given a score of "fully meets" the standard or were not considered hydrologically connected.

Bear Creek Environmental visited each of the publicly accessible roads within the Lake Morey watershed in June 2023, and revisited the locations identified as being potential sources of sediment and phosphorus to Lake Morey in August 2023 with Water Resources Engineer, Matt Murawski of Ripple Natural Resources, Figure 17. The AOT Class 2, 3, and 4 roads were assessed by Bear Creek Environmental and Ripple Natural Resources, regardless of whether they were considered hydrologically connected by the MRGP database. A map showing the road assessment study area for the Lake Watershed Action Plan is provided in Figure 18.

Figure 17. Road Assessments were conducted during summer 2023 by Bear Creek Environmental and Ripple Natural Resources

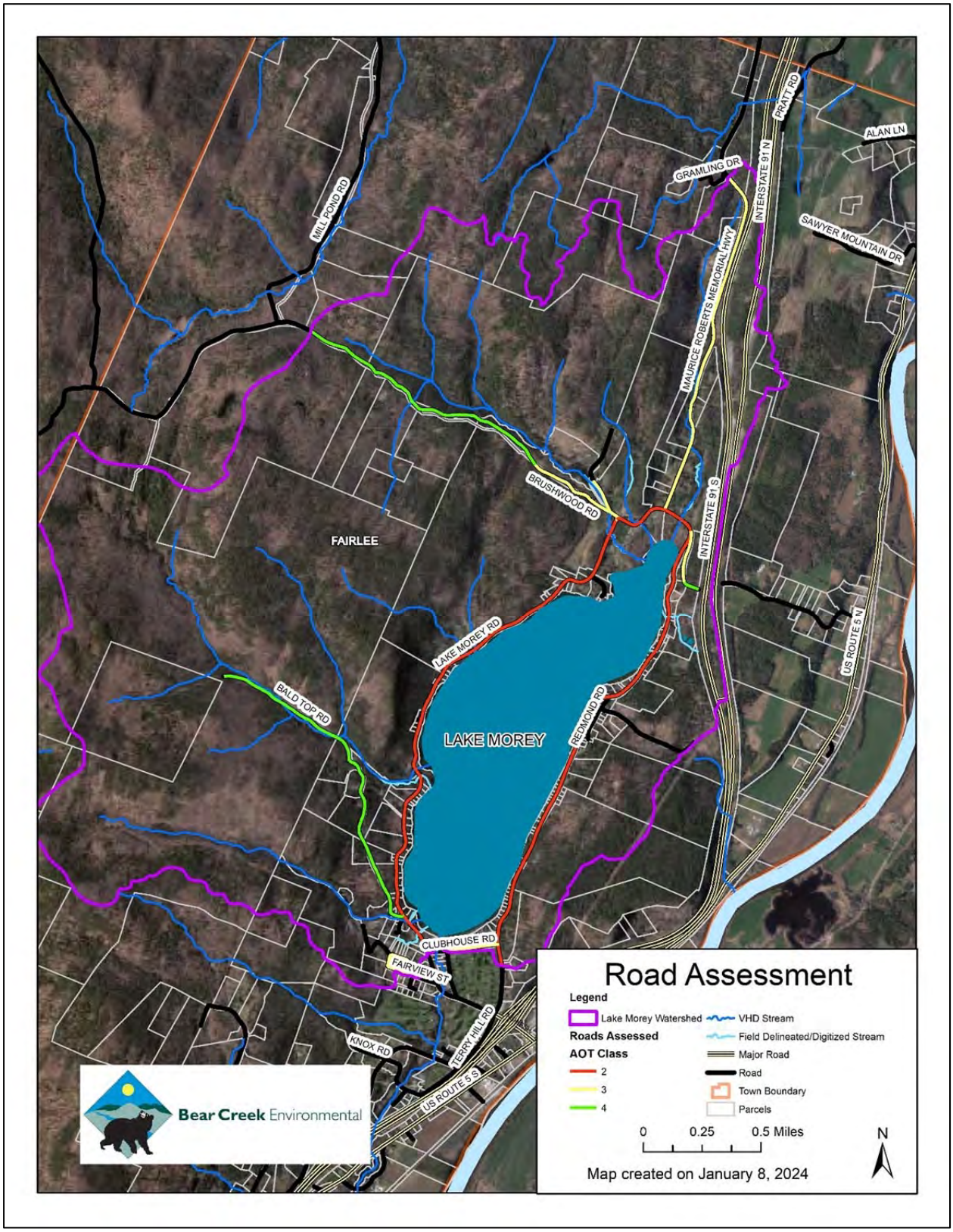


Figure 18. LWAP Road Assessment Study Area – Class 2, 3 and 4 Roads

6.3 Lakeshore Assessments

The shoreland of Lake Morey was assessed through a boat reconnaissance and LakeWise visits. On June 19, 2023, Bear Creek Environmental (BCE), White River Conservation District (WRNRCD), members of the Lake Morey Protective Association (LMPA), and a representative from the Vermont Department of Environmental Conservation (VTDEC) toured the lake (Figure 19). During the boat tour, members of the LMPA shared their knowledge of the lake community.

Figure 19. Boat Reconnaissance with LMPA on June 19, 2023

WRNRCD visited with interested lakeshore property owners and conducted LakeWise assessments. A total of 29 LakeWise assessments of the shoreline of Lake Morey have been completed (Figure 20). The assessments took place from 2017 through 2023, with nearly 80 percent of the assessments taking place in 2023. Greater than 15% of the shorefront property owners earned the LakeWise Award, resulting in the Lake Morey community hitting the Gold Standard. On August 9, 2023, BCE, WRNRCD, and Ripple Natural Resources (RNR) visited several areas of concern that were identified during LakeWise assessments.

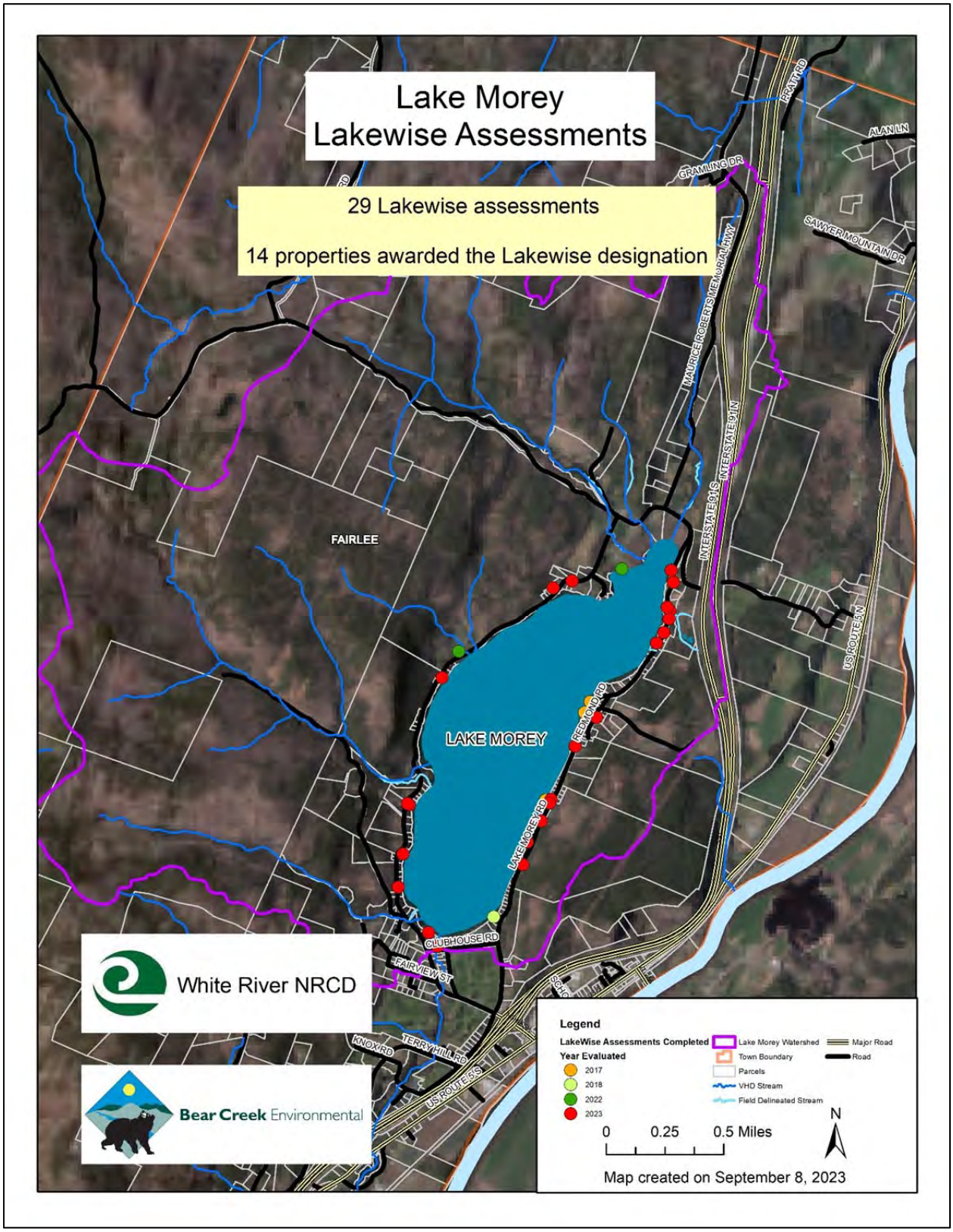


Figure 20. LakeWise Assessment Completed in Lake Morey Watershed (2017-2023)

7.0 PROJECT IDENTIFICATION

Information from the lakeshore, stream and road assessments was used to identify potential projects.

7.1 Stream Project Identification

Six stream problem areas were identified using information from stream walks that took place during October 2022 (Appendix B and Figure 21). Three of the projects (Projects 1-3, 1-5 and 1-6) are culvert replacements on Big Brook and Gardenside. One of the projects is a passive restoration project involving stream buffer enhancement on Big Brook, while another project is an active restoration project at the mouth of Glen Falls Brook. The other project (1-1), is a stormwater improvement project on Pine Grove Brook. Notes about each of the inlet streams that were assessed are provided below.

Pine Grove Brook: This brook has a steep slope in the upper watershed and starts to drop in slope near a house that is off of Burning Moon Road. Off of Bald Top Road, stormwater enters Pine Grove Brook, just below the access drive to the water tanks. Sediment entering Pine Grove Brook from upper and lower Bald Mountain Road is a concern and has been identified for remediation in the roads section (Section 7.2) of the report. Downstream of intersection of Reservoir Road and Bald Top Road, Pine Grove Brook is channelized with hard bank armoring and lacks a wooded buffer as it runs in close proximity to a house and yard. The path of the brook downstream of Lake Morey Road is to the north of that shown on the Vermont Hydrography Dataset (VHD)

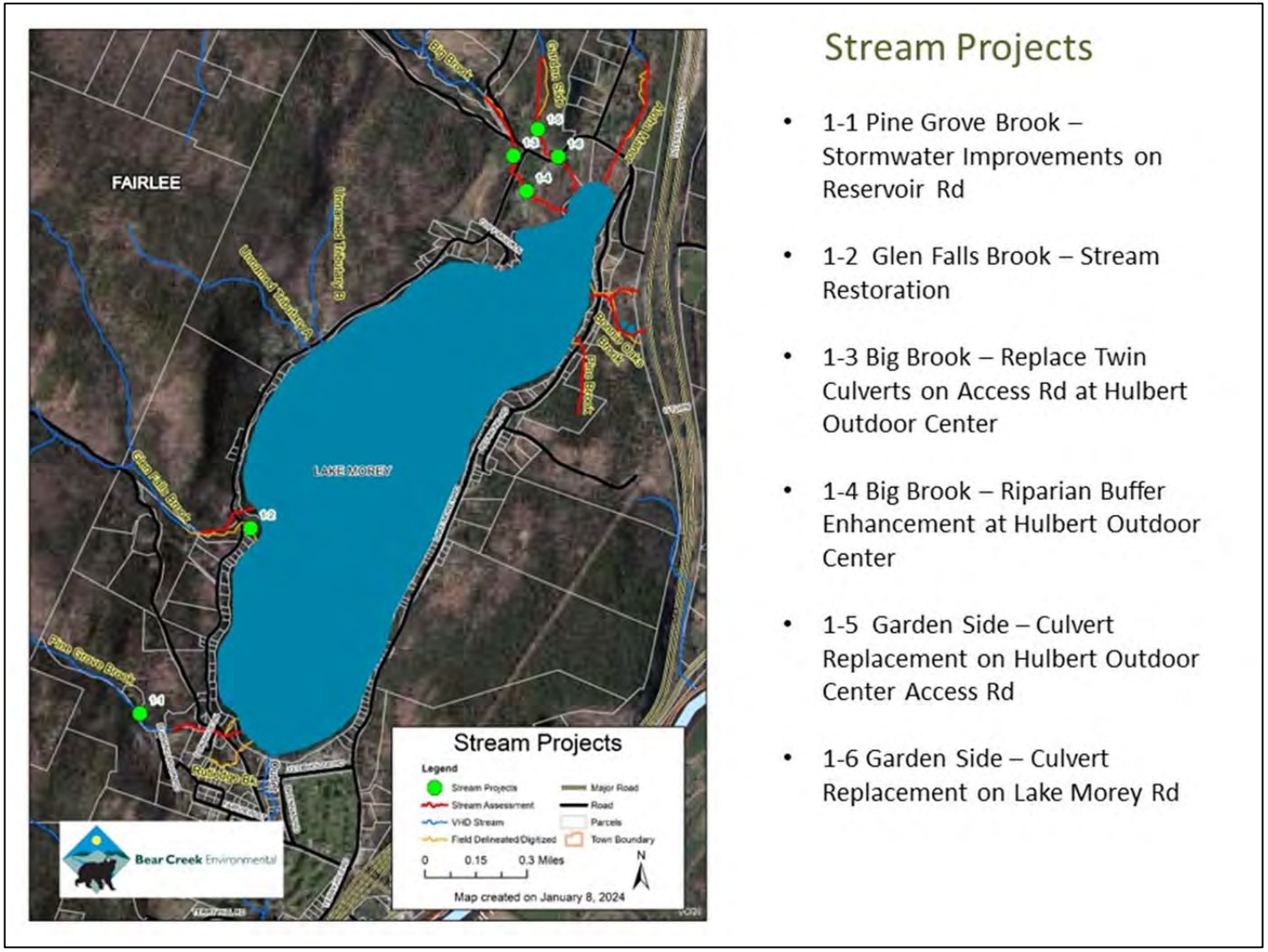


Figure 21. Proposed Stream Projects within Lake Morey Watershed

Glenn Falls Brook: Above approximately 500 feet in elevation, the channel of Glen Falls Brook is quite steep and contains ledge and waterfalls. The watershed is forested upstream of lake Morey Road. A parshall flume, likely used to measure stream flow as part of DEC's studies in the mid-1980s, was noted to still be in the channel at elevation 475 feet, where the slope of the channel starts to drop (Figure 22). The centerline of stream channel was mapped in the field using a submeter GPS unit, as it differs significantly from the channel location shown on the VHD. The section of channel downstream of Lake Morey Road appears to be an alluvial fan, where the slope flattens, gravel is deposited, and the stream channel would be naturally braided. This section of stream has been heavily managed in the past in different single thread channels. Just upstream of the inlet to Lake Morey, the channel is a losing stream as it decreases in flow as it travels through the gravel deposits below Lake Morey Road. A beaver dam break in the upper watershed took place in May 2016, resulting in a significant release of woody debris and water in the lower reach of the brook and the west side of Lake Morey (Valley News, 5/27/2016).

Figure 22. Remnants of Parshall Flume Stream Gauging Structure

Big Brook: The Big Brook watershed above 500 feet is steep and forested. The Hulbert Outdoor Center is located in the lower part of the watershed as the slope flattens near the mouth of the Brook. Twin culverts, located at an access road, are undersized and are potentially impeding fish passage and have been recommended for replacement. The lower gradient section of channel through the Hulbert Outdoor Center, below Lake Morey Road, lacks a vegetated buffer. The section of channel between the Lake Morey Road and the pedestrian bridge, with the interest and support of the Aloha Foundation, has been targeted for a stream buffer improvement project. Below the pedestrian bridge, Big Brook flows through a shrub-scrub wetland, into Lake Morey.

Garden Side Brook: The land use within the Garden Side Brook watershed is also primarily forested. Two culverts, one on an access road at the Hulbert Outdoor Center and one at the Lake Morey Road crossing were noted to be undersized and have been recommended for replacement. Below Lake Morey Road, the Garden Side Brook channel is incised and has active erosion. This channel also travels through wetland habitat before reaching Lake Morey.

Aloha Manor: The section of Aloha Manor Brook below Maurice Roberts Memorial Highway has extensive areas of wetlands adjacent to the channel, especially near the mouth of the brook. The stream centerline, which did not always match the VHD, was mapped in the field by Bear Creek Environmental.

Bonnie Oaks Brook: The riparian corridor of the main stem of Bonnie Oaks Brook from downstream of Interstate 91 S to Lake Morey was noted to be generally well vegetated. For the most part, the channel and banks looked stable, and there is good floodplain access with the presence of riparian wetlands. Burning bush and Japanese barberry were prevalent invasive species noted adjacent to Bonnie Oaks Brook. There are two large lagoons in the watershed, which were formerly used for wastewater disposal.

7.2 Road Project Identification

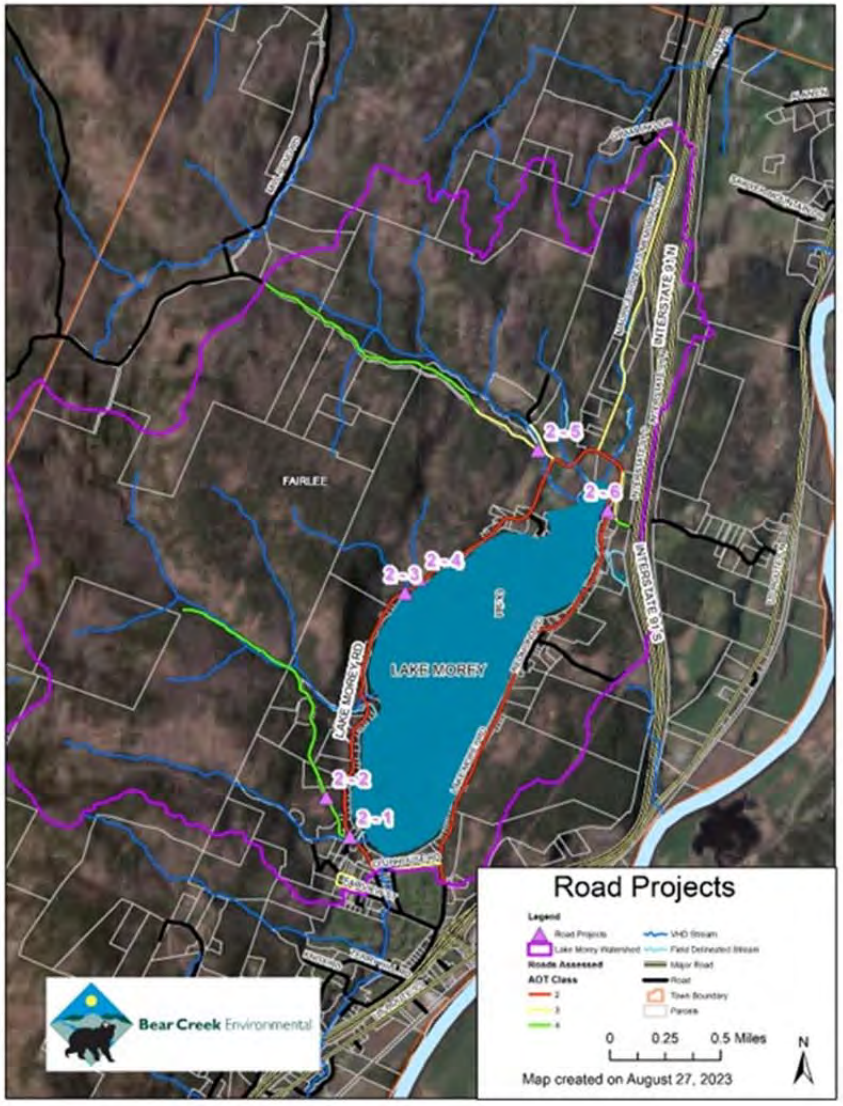
Stormwater improvement projects were identified on Bald Top Road, on access drives at the Aloha Camp, Brushwood Road, and Lake Morey Road (Appendix C and Figure 23).

Bald Top Road is a Class 4 Road that begins high up in the Town Forest in the Glen Falls Brook watershed and then continues to the south into the Pine Grove Brook watershed, ending at Lake Morey Road. The road steepness makes it problematic in terms of erosion and dispersion of water off the road.

Upper Bald Top Road: Currently, water is channelized in steep road side ditches on upper Bald Top Road for 1500 feet +/- until the runoff eventually discharges into Pine Grove Brook. The goal of the stormwater improvement project of upper Bald Top Road is to use cross culverts to break up the water volume and reduce velocities and erosion of the roadside ditches. The addition of stone check dams in the ditches is intended to slow water and accumulate sediment, prior to reaching surface waters.

Lower Bald Top Road: Erosion of the road and roadside ditch were noted upstream of the existing drop inlet that is near the intersection of Bald Top Road and Lake Morey Road. Raising and grading the road to drain to the north and installing a stone-lined ditch would help address this issue.

Aloha Camp Access Drives are located close to Lake Morey. Their steepness makes them a challenge for stormwater treatment. The Aloha Camp is conscientious about this problem and frequently makes repairs and improvements to these drives.



Road Projects

Stormwater Improvements

2-1: Lower Bald Top Road

2-2: Upper Bald Top Road

2-3: Aloha Camp South Access Drive

2-4: Aloha Camp Northwestern Drive

2-5: Brushwood Road near Hulbert Outdoor Center's Shop Parking Lot

2-6: Lake Morey Road

Figure 23. Proposed Road Project within Lake Morey Watershed

South Access Drive: Stormwater runoff is causing erosion of the steep south access road at the Aloha Camp. The erosion could be reduced by extending the water bar down slope and creating a small sediment basin at the outlet. Relocating the head of the driveway could create a more robust water bar and improve safety. A sump at the outlet of the water bar would help retain sediment and promote infiltration.

Northwestern Access Drive: Stormwater runoff is causing erosion of the northeastern access drive of the Aloha Camp. This drive is located on the north side of Lake Morey Road. The addition of a cross culvert at the upper end of the drive would reduce concentration of stormwater runoff. Regrading the drive to eliminate rills and drain to improved roadside ditches would help to reduce erosion.

Brushwood Road transitions to a trail upslope of the shop parking lot at the Hulbert Outdoor Center. It is a third-class road in the vicinity of the shop building. Stormwater runoff is causing erosion of the shop parking lot and Brushwood Road, leading to sediment accumulation in close proximity to Big Brook. The Aloha Foundation had already taken steps to reduce the concentration of stormwater by installing a water bar at the base of the trails. Additional stormwater improvements, such as stone lining the ditches along Brushwood Road and constructing a small sediment basin, could reduce sediment reaching Big Brook.

Lake Morey Road is a second-class road that circles the lake. A stormwater issue was noted about 0.35 miles south of the intersection of Maurice Roberts Memorial Highway and Lake Morey Road. Sediment from roadside erosion is accumulating in the roadside ditches and on an adjacent lawn, which is located in close proximity to Lake Morey. Currently, the sediment is being trapped and does not appear to be reaching Lake Morey. Roadside improvements, particularly to the shoulder at the edge of the road, should reduce the volume of sediment being generated.

7.3 Lakeshore Project Identification

Five lakeshore problem areas (Appendix D and Figure 24) were identified using information from the LakeWise Assessments. Lakeshore projects fall under two main categories: Stormwater Improvement and Buffer Enhancement.

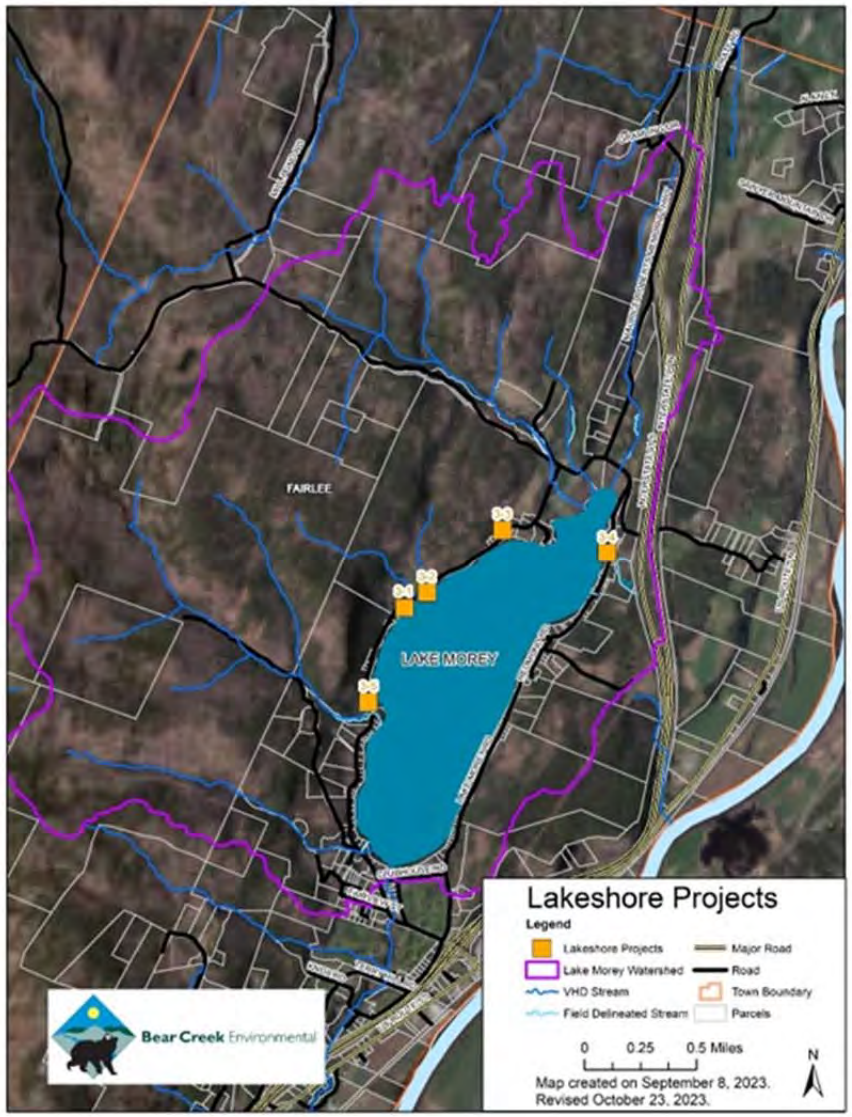
Stormwater improvement projects within the lakeshore help by improving infiltration of runoff, which reduces erosion and decreases phosphorus and sediment loading to the lake. Lakeshore buffer planting projects stabilize the soil and provide for vegetation that takes up phosphorus and reduces nutrients loading. The identified lakeshore projects are provided below by category.

Buffer Improvements:

- **Project 3-1 – Aloha Camp Buffer Improvement along Lakeshore** – An area adjacent to Lake Morey at the Aloha Camp is lacking a vegetated buffer. Some blueberry bushes have already been planted in this location. The buffer could be improved by expanding the area of plantings or by creating a no mow zone.

Stormwater Improvements:

- ***Project 3-2 – Aloha Camp Beach Area*** - The sandy beach in front of the Aloha Camp's boathouse is eroding. Groundwater from the hillside and a small stream are contributing to the erosion. A French drain to intercept the groundwater and improvements to the channel to reduce surface flow onto the beach are recommended.
- **Project 3-3 and 3-4 – Driveway Improvements for Private Landowners** – Private driveways off of Lake Morey Road are eroding. Installing and improving existing water bars along with some additional recommendations will reduce the concentration of stormwater runoff.
- **Project 3-5 – Stormwater Improvements at VT Fish and Wildlife (VDFW) Boat Launch** – There are minor erosion issues at the VDFW boat launch. The access road and the lower launch area need to be repaved to prevent erosion.



Lakeshore Projects

- 3-1 Buffer Enhancement along Lakeshore at Aloha Camp
- 3-2 Stormwater Improvement at Aloha Camp Beach
- 3-3 Stormwater Improvements on Private Driveway #1
- 3-4 Stormwater Improvements on Private Driveway #2
- 3-5 Stormwater Improvements at VT Fish and Wildlife Boat Launch

Figure 24. Proposed Stream Project within Lake Morey Watershed

8.0 PROJECT PRIORITIZATION

Criteria were developed to prioritize the 17 projects that were identified within the Lake Morey watershed. A point system ranging from a score of zero to three was assigned to each of five categories. Two of the categories (Improves Water Quality and Cost effectiveness) rely on the use of the VTDEC's phosphorus reduction tool. The project prioritization criteria are defined on page 1 of Appendix E and are summarized below. Each category was assessed a weighting that totals 100 percent for the five categories.

Five Categories (Score of 0 to 3)

1. **Improves Water Quality** (25%) – based on the amount estimated total phosphorus reduction in kilograms per year (kg/yr).
2. **Landowner Support** (25%) – ranges from lack of interest to having a landowner agreement
3. **Improves or Protects Riparian or Aquatic Habitat** (20%) - ranges from does not improve habitat to significantly improves habitat
4. **Cost Effectiveness** (20%) – based on the total cost, estimated phosphorus reduction and the estimated life span of the project (measured in $/kg/yr).
5. **Other Benefit** (10%) – 1 point per benefit for up to 3 points maximum
    - Improves or protects infrastructure
    - Demonstration project
    - Provides opportunity for education
    - Reduces peak flows and erosion
    - Reduces flooding

A map showing the location of the lake, stream and road projects is provided on page 2 of Appendix E. Information about each of these projects is listed by project number on pages 3 and 4 of Appendix E. First, a score was calculated using the criteria from the five categories listed above. A maximum score of 3 is possible.

Next, the projects were sorted by score from the highest score to the lowest score (pages 5 and 6 of Appendix E). Stormwater improvements project on access roads at the Aloha Camp and Upper Bald Top Road, culvert replacement projects (Big Brook and Garden Side Brook), and a shoreland improvement project at the Aloha Camp resulted in the highest scores.

9.0 CONCEPTUAL DESIGNS

Eleven of the projects were selected for 30% concept designs. Selection was based on the priority rating and written landowner interest.

The conceptual designs were prepared by Ripple Natural Resources, LLC and Bear Creek Environmental, LLC. These designs are provided in Appendix F and include:

- A site plan with existing site features;
- Proposed design elements;
- Typical details for proposed practice;
- A preliminary cost estimate; and
- Expected permits.

The following projects were selected for the 30% conceptual designs:

1. Project 1-3: Twin Culvert Replacement on Big Brook at Hulbert Outdoor Center
2. Project 1-4: Buffer Enhancement of Big Brook at Hulbert Outdoor Center
3. Project 1-5: Culvert Replacement on Garden Side Brook at Hulbert Outdoor Center
4. Project 1-6: Culvert Replacement on Garden Side Brook at Lake Morey Road
5. Project 2-1: Lower Bald Top Road Stormwater Improvements
6. Project 2-2: Upper Bald Top Road Stormwater Improvements
7. Project 2-3: South Access Drive Stormwater Improvements at Aloha Camp
8. Project 2-4: Northwestern Access Drive Stormwater Improvements at Aloha Camp
9. Project 3-2: Beach at Aloha Camp Stormwater Improvements
10. Project 3-3: Private Driveway North of Lake Morey Road Stormwater Improvements
11. Project 3-4: Private Driveway West of Lake Morey Road Stormwater Improvements

10.0 NEXT STEPS

The Lake Morey LWAP has many stakeholders, and a number of actions are required to implement the Plan. The LFA, WNRCD, and local conservations commissions, the VTDEC, and private landowners are all important partners in continuing outreach and project development within the Lake Morey watershed. The next step is to seek grants or other funding opportunities to move preliminary designs toward implementation. This will require collaboration between local organizations and the leveraging of local, state, and federal resources.

Funding for lake shoreland projects is available from the DEC Clean Water Initiative Program. https://dec.vermont.gov/watershed/lakes-ponds/lakeshores-lake-wise/LWAP. Available grant programs include:

- Project Development Block Grant – Funds to develop clean water projects;
- Design/Implementation Block Grant – Pass-through funds for preliminary design, final design, and implementation; and
- Woody Buffer Block Grant – Pass-through funds for design (planting plan) and implementation of native riparian buffers.

Funding for agricultural projects is available from the Vermont Agency of Agriculture. https://agriculture.vermont.gov/grants. Available programs include:

- Agricultural Clean Water Initiative Project – to support the improvement of water quality;
- Technical and financial assistance for improving best management practices on farms;
- Capital Equipment Assistance Program – financial assistance for new or innovative equipment; and
- Conservation Reserve Enhancement Program (CREP) – to improve water quality by removing land from agricultural production and establishing riparian buffers.

There are a number of programs available for riparian buffer plantings along streams including:

- Trees for Streams – a state-wide program that is funded through the Vermont Agency of Natural Resources and is implemented by the Vermont Natural Resources Conservations Districts.

- Conservation Reserve Enhancement Program (CREP) - CREP is a voluntary program through the Vermont Agency of Agriculture, Food and Markets, which involves removing land from agricultural production and establishing riparian buffers.

It is also recommended that additional funding be secured through Vermont Multi-sector Assessment grant program for further assessment work to identify and prioritize lake stressors and projects to improve lake and stream water quality.

Landowners interested in pursuing projects to improve the water quality of Lake Morey or who would like to participate in the LakeWise program are encouraged to contact the White River Conservation District.

Lisa Niccolai
Conservation Specialist
White River Conservation District
28 Farmvu Drive
White River Junction, VT 05001
802-222-1293
Lisa.wrnrcd@gmail.com

White River Natural Resources Conservation District

11.0 REFERENCES

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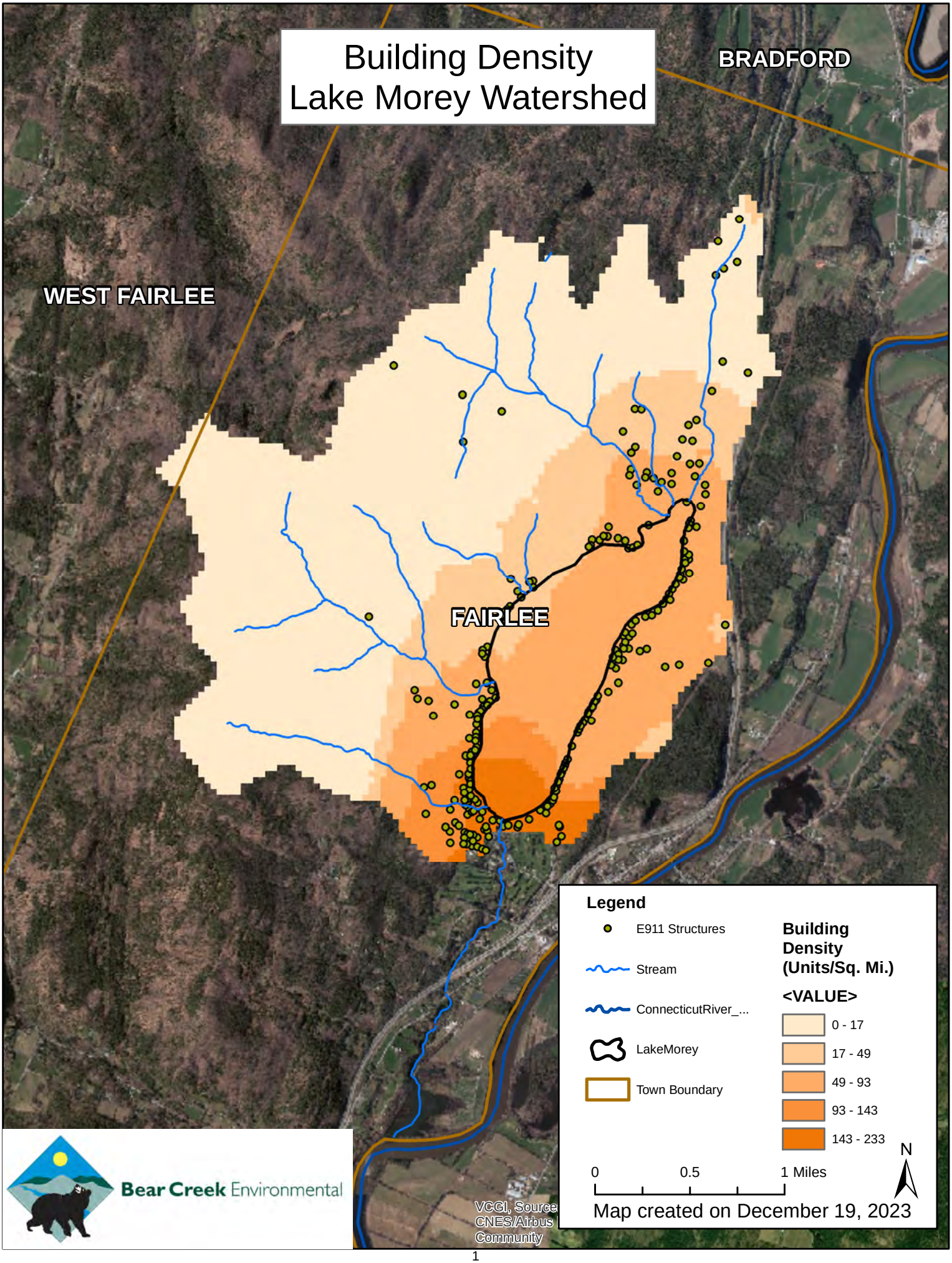
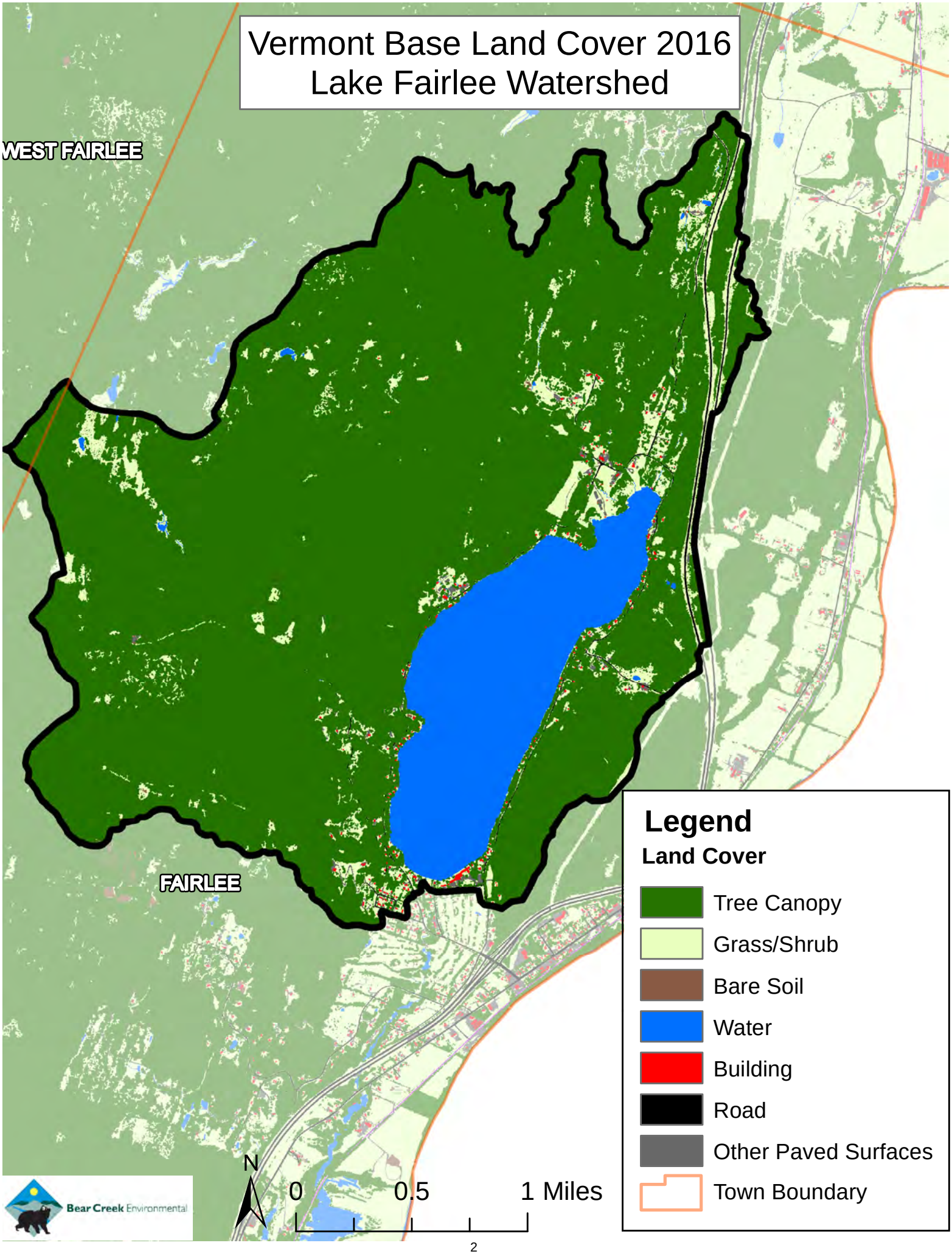
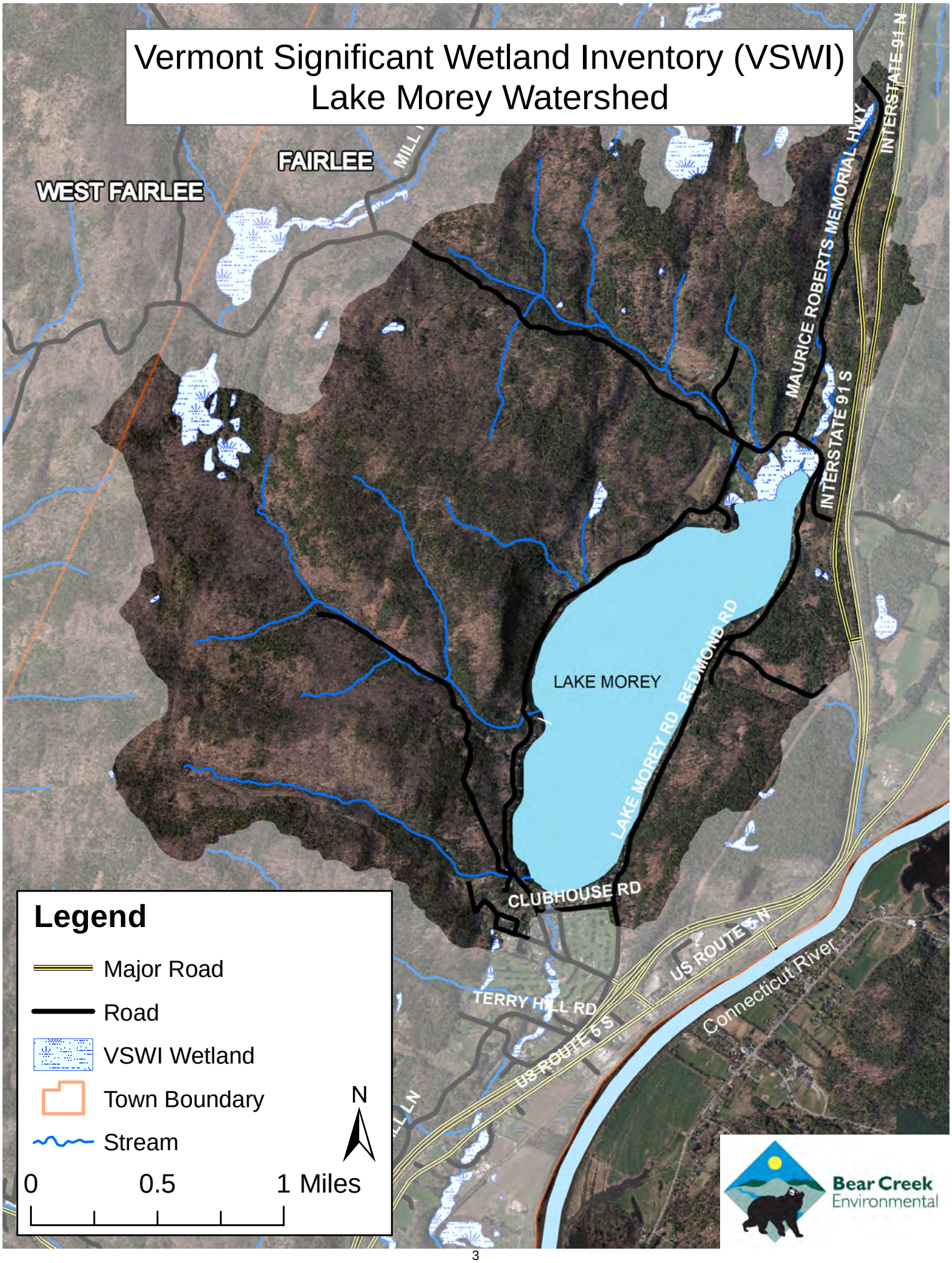
APPENDIX A

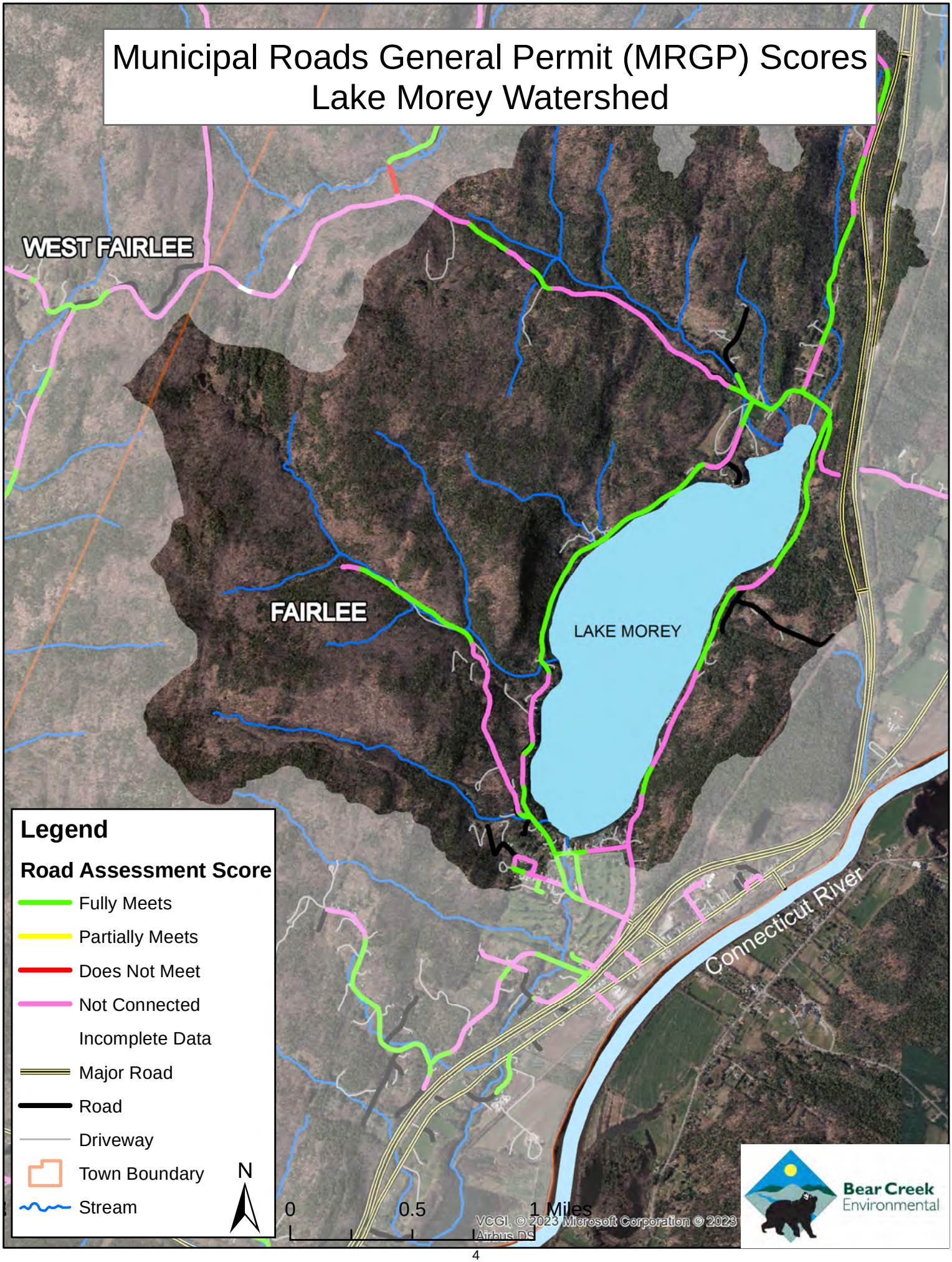
MAPS

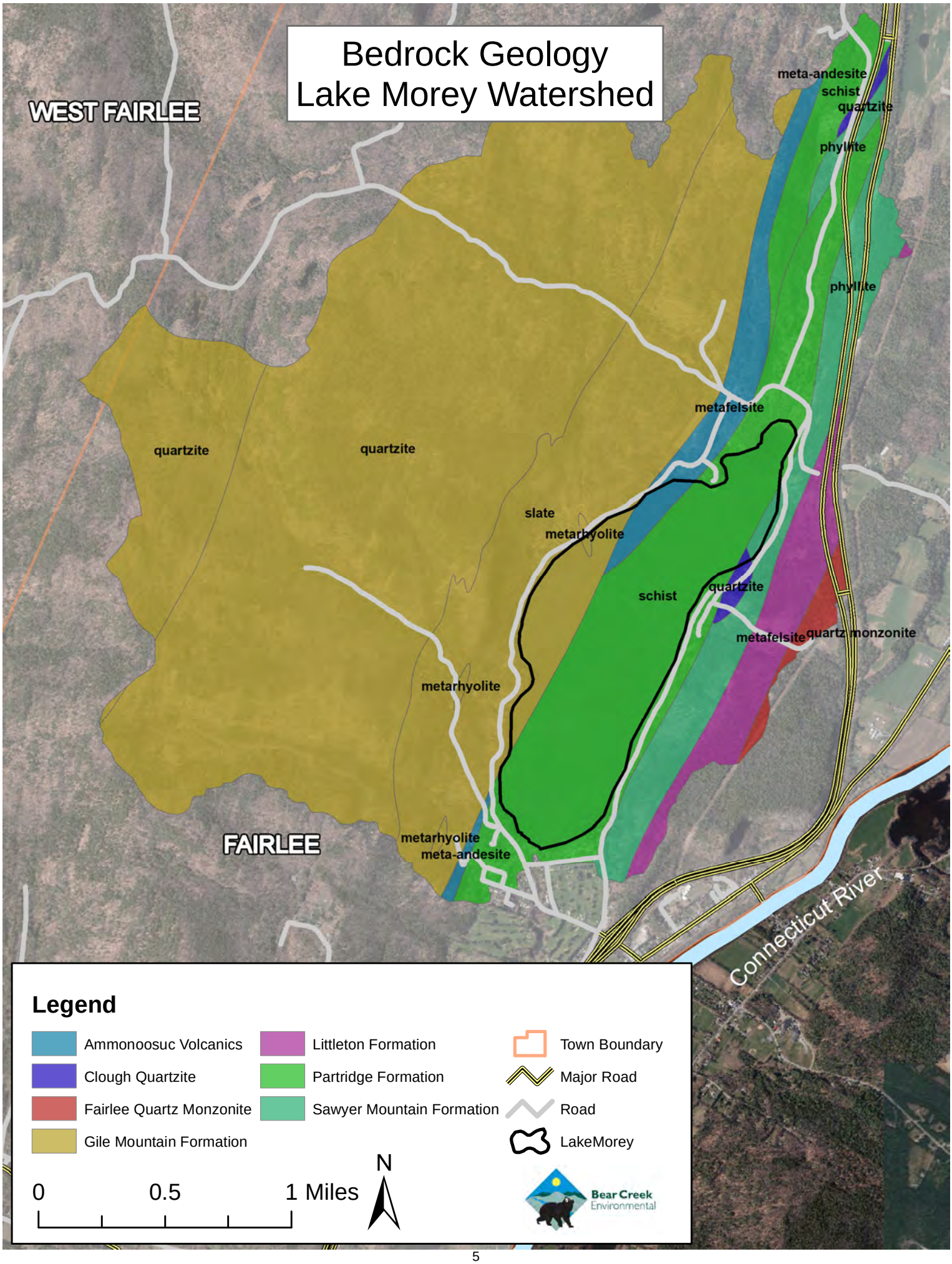

Building Density
Lake Morey Watershed
BRADFORD
WEST FAIRLEE
FAIRLEE
Legend
E911 Structures
Stream
ConnecticutRiver_...
LakeMorey
Town Boundary
Building Density (Units/Sq. Mi.)
<VALUE>
0 - 17
17 - 49
49 - 93
93 - 143
143 - 233
0
0.5
1 Miles
N
Map created on December 19, 2023
Bear Creek Environmental
VCGI, Source CNES/Airbus Community


Vermont Base Land Cover 2016
Lake Fairlee Watershed
WEST FAIRLEE
FAIRLEE
Legend
Land Cover
Tree Canopy
Grass/Shrub
Bare Soil
Water
Building
Road
Other Paved Surfaces
Town Boundary
N
0
0.5
1 Miles
Bear Creek Environmental

Vermont Significant Wetland Inventory (VSWI)
Lake Morey Watershed




Municipal Roads General Permit (MRGP) Scores
Lake Morey Watershed
WEST FAIRLEE
FAIRLEE
LAKE MOREY
Connecticut River
Legend
Road Assessment Score
Fully Meets
Partially Meets
Does Not Meet
Not Connected
Incomplete Data
Major Road
Road
Driveway
Town Boundary
Stream
N
0
0.5
1 Miles
VCGI, © 2023 Microsoft Corporation © 2023 Airbus DS
Bear Creek Environmental


Bedrock Geology
Lake Morey Watershed
WEST FAIRLEE
FAIRLEE
meta-andesite
schist
quartzite
phyllite
phyllite
metafelsite
quartzite
quartzite
slate
metarhyolite
schist
quartzite
metafelsite
quartz monzonite
metarhyolite
metarhyolite
meta-andesite
Connecticut River
Legend
Ammonoosuc Volcanics
Clough Quartzite
Fairlee Quartz Monzonite
Gile Mountain Formation
Littleton Formation
Partridge Formation
Sawyer Mountain Formation
Town Boundary
Major Road
Road
LakeMorey
0
0.5
1 Miles
N
Bear Creek Environmental

APPENDIX B

STREAM PROJECT SUMMARY SHEETS

Lake Morey Watershed Action Plan
Stream Assessment Summary (Revised 2/26/24)

Target Streams

The lower reaches of Pine Grove Brook, Glen Falls Brook, Big Brook, Gardenside Brook, Aloha Manor Brook, Bonnie Oaks Brook, and Pine Brook were targeted for stream assessment reaches. These reaches were selected based on a review of the water quality data and conversations with Greg Allen (Lake Morey Foundation) and Danielle Owczarski (Vermont Department of Environmental Conservation).

In addition to reviewing water quality data and speaking with key stakeholders; land use, slope, and watershed contribution to Lake Morey were considered as part of the reach prioritization process. The location of the target stream reaches was provided to the Vermont Department of Environmental Conservation as part of the deliverables for Task 2 (Digital Library).

The inlet streams are listed in order from northeast of the lake Morey outlet going in a clockwise direction around the Lake. StreamStats[1], a tool provided by the United States Geological Survey (USGS), was used to calculate drainage areas of each of the inlet streams and outlet of Lake Morey. The drainage area at the Lake Morey outlet is approximately 7.3 square miles. The watershed area of the ten inlet streams sum to 5.4 square miles. This leaves about 1.8 square miles of watershed area that in not accounted for by the inlet streams.

Table 1. Watershed Area Contribution of Inlet Streams to Lake Morey

Stream Name	Watershed Area (Sq. Mi.)	Percent Watershed Contribution
Rutledge Brook	0.085	1.2%
Pine Grove Brook	0.61	8.4%
Glen Falls Brook	1.62	22.3%
Unnamed Tributary A	0.15	2.1%
Unnamed Tributary B	0.14	1.9%
Big Brook	1.42	19.6%
Gardenside Brook	0.39	5.4%
Aloha Manor Brook	0.63	8.7%
Bonnie Oaks Brook	0.22	3.0%
Pine Brook	0.17	2.3%

[1] https://streamstats.usgs.gov/ss/

All the inlet streams, with the exception of Unnamed Tributaries A and B, were included in the stream assessment of the Lake Morey watershed. Tributaries A and B have primarily forested land use within their subwatersheds and small drainage areas.

The lack of landowner access limited the assessment of Pine Brook to the vicinity of Lake Morey Road. The assessment reaches of Glen Falls Brook and Pine Grove Brook were extended upstream from the initial reach selection, based on interest from local landowners, who met us in the field.

Landowner Outreach

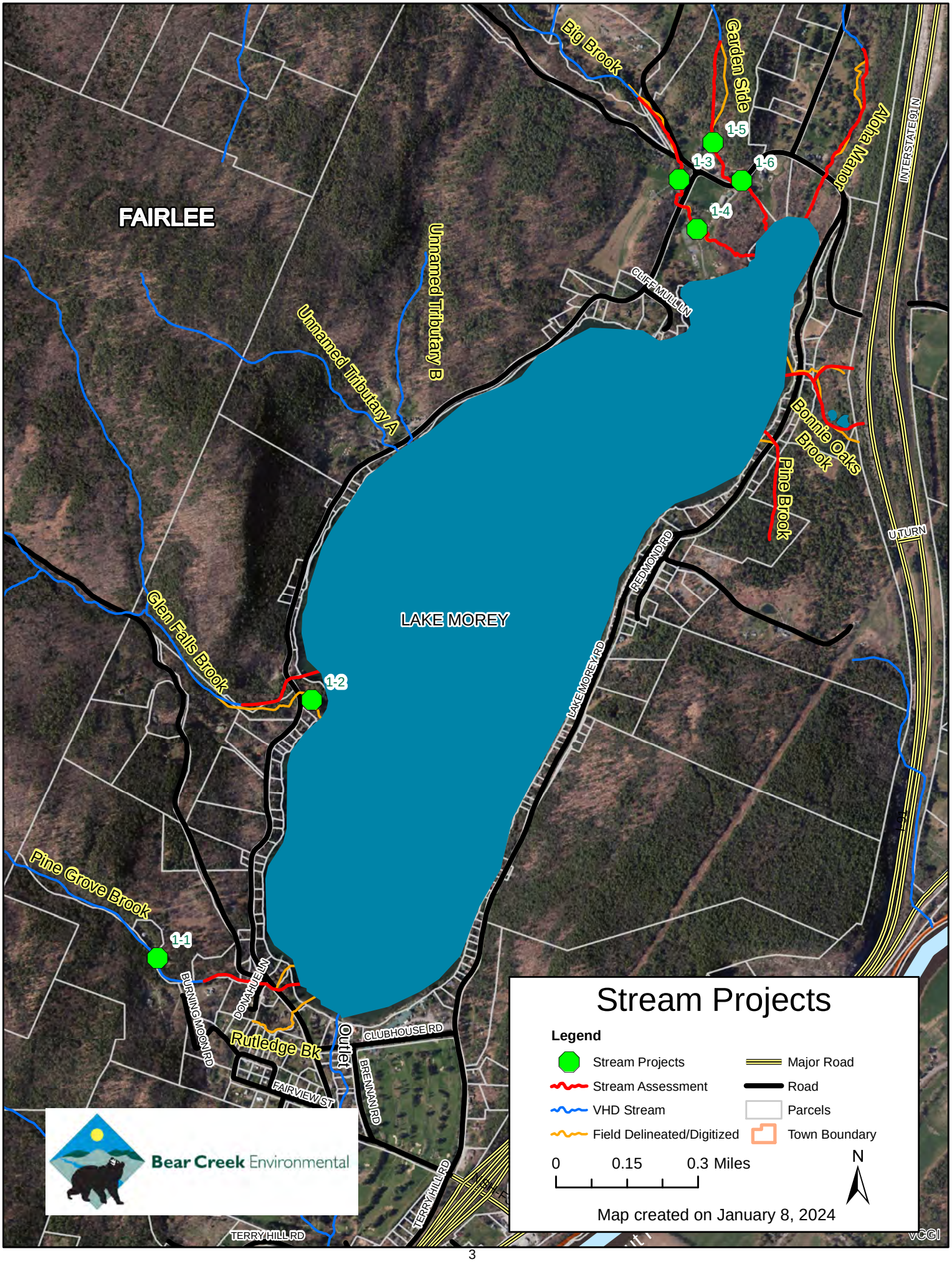
During late August 2022, the White River Natural Resources Conservation District and Bear Creek Environmental, LLC mailed out post cards and letters to riparian landowners with property on the assessment reaches to provide information about the upcoming stream walks. Twenty-five landowners were contacted as part of this process. Two of the landowners reached out to Bear Creek Environmental with interest in meeting with them in the field, two of the landowners denied access to their property, and three landowners sent post cards back with interest in learning more about potential stream restoration projects on their property.

Stream Walks

During the stream walks, which took place in October 2022, points were collected with a handheld global positioning system (gps) unit to assist with project identification. Features such as, bank erosion, areas with buffers less than 25 feet, culverts, ledge grade controls, and bridges and culvert were mapped in the field. The stream centerline was also mapped in locations where it was considerably different than the Vermont Hydrography dataset (VHD).

This Stream Assessment Summary includes the following:

1) A locator map of seven identified projects
2) A table summarizing the identified project in a format that can be effectively used for project prioritization during the next phase of the project.
3) Stream Problem Areas Summary Sheets
    - Project Name
    - Land Ownership
    - Site Location
    - Locator Map
    - Site Description
    - Site Design Considerations
    - Permitting Needs
    - Cost Estimate Range
    - Restoration/Water Quality Improvement Objectives
    - Level of Landowner Commitment


Stream Projects
Legend
Stream Projects
Stream Assessment
VHD Stream
Field Delineated/Digitized
Major Road
Road
Parcels
Town Boundary
0
0.15
0.3 Miles
N
Map created on January 8, 2024
Bear Creek Environmental
FAIRLEE
LAKE MOREY
Big Brook
Garden Side
Aloha Manor
Unnamed Tributary A
Unnamed Tributary B
Glen Falls Brook
Pine Grove Brook
Rutledge Bk
Outlet
Bonnie Oaks Brook
Pine Brook
1-1
1-2
1-3
1-4
1-5
1-6
CLIFF MULLIN
REDMOND RD
LAKE MOREY RD
DONAHUE LN
BURNING MOON RD
CLUBHOUSE RD
FAIRVIEW ST
BRENNAN RD
TERRY HILL RD
INTERSTATE 91 N
U TURN

Lake Morey Watershed Action Plan - Project Identification
Fairlee, Vermont
White River Natural Resources Conservation District
February 26, 2024

Project Number Segment	Project Category	Project Type	Project Location	Town	Ownership	Project Location	Stream Name	Project Description	Environmental Benefits	Degree of Landowner Commitment
1-1	Stream	Erosion Control and Buffer Expansion	Reservoir Rd	Fairlee	Right of Way	-72.165234, 43.912454	Pine Grove Brook	Add water bars along access drive to reduce erosion	1,2	Unknown
1-2	Stream	Stream Restoration	mouth of Glen Falls Brook	Fairlee	Private Landowner	-72.158662, 43.920328	Glen Falls Brook	Large wood addition to reduce the amount of incision and help with sediment and debris accumulation prior to discharging to Lake Morey. Open up blocked off channel to attenuate high flows and trap sediment. Note: The lower reach of Glen Falls Brook is an alluvial fan (where the slope changes from being steep and then flattens out). The channel has been historically managed in this location. Beaver dam breach in 2016 that affected this property. Infrastructure is in close proximity of channel project, making it a high risk project.	1,2	Low

[1] Enhances or protects aquatic or riparian habitat
[2] Reduces sedimentation and phosphorus levels
[3] Moves the channel toward equilibrium where the water and sediment are in balance
[4] Reduces risk of flooding and erosion hazard

Lake Morey Watershed Action Plan - Project Identification
Fairlee, Vermont
White River Natural Resources Conservation District
February 26, 2024

Project Number Segment	Project Category	Project Type	Project Location	Town	Ownership	Project Location	Stream Name	Project Description	Environmental Benefits	Degree of Landowner Commitment
1-3	Stream	Culvert Replacement	0.25 miles upstream from the mouth of the brook	Fairlee	Aloha Foundation Inc	-72.143028, 43.936201	Big Brook	Replace twin culverts on driveway near intersection with Lake Morey Rd	1,2	High
1-4	Stream	Buffer Expansion	0.15 miles upstream from the mouth of the brook	Fairlee	Aloha Foundation Inc	-72.142273, 43.934687	Big Brook	Expand stream buffer by increasing areas where no mowing occurs or where woody vegetation can be planted on Hulbert Outdoor Center campus	1,2	High
1-5	Stream	Culvert Replacement	0.25 miles upstream from the mouth of the brook on road behind Hulbert Outdoor Center	Fairlee	Aloha Foundation Inc	-72.141592, 43.937333	Garden Side	Replace culvert on road behind Hulbert Outdoor Center	1,2	High
1-6	Stream	Culvert Replacement	0.15 miles upstream from the mouth of the brook on Lake Morey Rd	Fairlee	Town of Fairlee	-72.14039 43.936151	Garden Side	Replace culvert on Lake Morey Rd	1	Low

[1] Enhances or protects aquatic or riparian habitat
[2] Reduces sedimentation and phosphorus levels
[3] Moves the channel toward equilibrium where the water and sediment are in balance
[4] Reduces risk of flooding and erosion hazard

Project Number and Name: 1-1 Right-Of-Way Erosion Control and Buffer Expansion
Land Ownership: Town of Fairlee
Site Location: Right-Of-Way to Town Water Tanks (65 Bald Top Rd, Fairlee, VT 05045) Stream Name: Pine Grove Brook

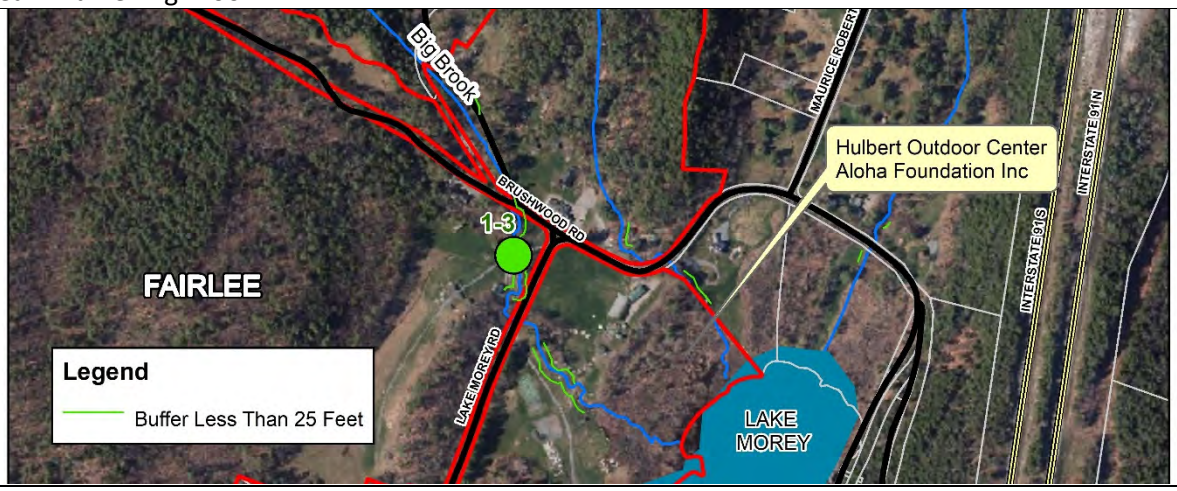
Site Description: Water bar installation to reduce erosion occurring on the Right-Of-Way.

Site Design Considerations: The Town of Fairlee needs road access to the town water tanks for large trucks. It does not appear to be feasible to narrow the road to improve the riparian buffer. Improve water quality by reducing erosion through water bar installation.
Permitting Needs: No permits are required for this project.
Cost Estimate Range: $2,500 to $7,500
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Lake Morey by installing water bars.
Level of Landowner Commitment: Unknown

Project Number and Name: 1-2 Glen Falls Brook Stream Restoration
Land Ownership: Private
Site Location: At mouth of the brook downstream of Lake Morey Road Stream Name: Glen Falls Brook

Site Description: Large wood addition to reduce the amount of incision and help with sediment and debris accumulation prior to discharging to Lake Morey. Open up blocked off channel to attenuate high flows and trap sediment.
 
Site Design Considerations: There are valuable buildings on the property that are close to the stream channel. There was a large beaver dam breach in 2016 that deposited considerable sediment and debris on this property and into the Lake Fairlee. There is the potential for this to happen again.
Permitting Needs: A stream alteration permit, ACOE permit, and potentially other permits are needed for this project.
Cost Estimate Range: $80,000 - $120,000 (cost varies depending upon design)
Restoration/Water Quality Improvement Objectives: Project will reduce sediment and phosphorus reaching Lake Morey by reducing erosion from channel widening due to incision and providing structure for sediment accumulation. Opening up the former channel would also help attenuate high flows and trap sediment.
Level of Landowner Commitment: Low

Project Number and Name: 1-3 Twin Culvert Replacement at Hulbert Outdoor Center Drive
Land Ownership: Aloha Foundation Inc.
Site Location: Driveway near intersection with Lake Morey Rd (2968 Lake Morey Rd, Fairlee, VT 05045) Stream Name: Big Brook



Site Description: Replace twin culverts that are perched 1.2 feet to increase geomorphic compatibility and improve fish passage. Drainage area of Big Brook at this location is 1.4 square miles.

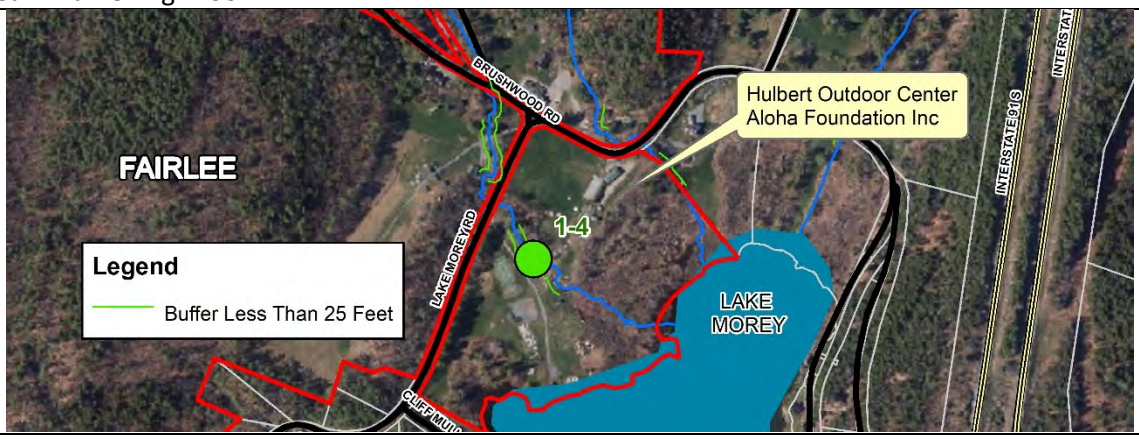
Site Design Considerations: Private drive and funding sources are unknown. Culvert is undersized causing sediment to build up upstream and create a scour pool on the downstream end.
Permitting Needs: A Vermont stream alteration permit and ACOE permit are required for this project.
Cost Estimate Range: $80,000 to $120,000 (Includes design, permitting & installation)
Restoration/Water Quality Improvement Objectives: Project will reduce sediment and phosphorus reaching Lake Morey by decreasing erosion in addition to providing aquatic organism passage.
Level of Landowner Commitment: WRNRCD reached out to Julie Butler of U.S. Fish and Wildlife Service (FWS). The Vermont Fish and Wildlife Department electrofished this section of stream and found a self-sustaining population of brook trout. The Hulbert Outdoor Center is interested in replacing this undersized road crossing.

Stream Problem Areas Summary Sheet

Project Number and Name: 1-4 No Mowing Buffer Expansion at Hulbert Outdoor Center

Land Ownership: Aloha Foundation Inc.

Site Location: 0.15 miles upstream from the mouth of the brook (2968 Lake Morey Rd, Fairlee, VT 05045)
Stream Name: Big Brook



Site Description: Implement no mow zones or plant trees/shrubs within the stream buffer to improve vegetation along the stream to filter sediment and phosphorus.

Site Design Considerations: The Hulbert Outdoor Center has a concern about safety of their campers, and would like to maintain some visibility of campers in and along the stream channel.

Permitting Needs: No permits are required for this project.

Cost Estimate Range: $500 - $7,000 (depending upon planting plan)

Restoration/Water Quality Improvement Objectives: Reduce sediment & phosphorus reaching the Lake

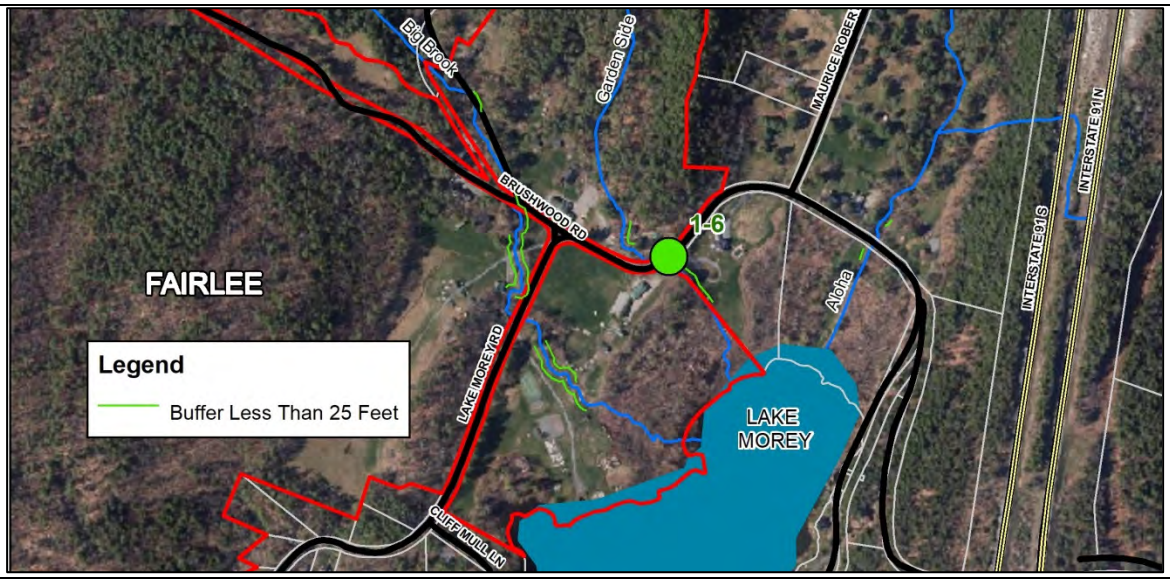
Level of Landowner Commitment: The Hulbert Outdoor Center has been approached by the WRNRCD about improving riparian buffers. The Center would like to maintain some visibility of campers in and along Big Brook. Mowing on only one side was discussed as a possible compromise.

Project Number and Name: 1-5 Culvert Replacement on drive at Hulbert Outdoor Center
Land Ownership: Aloha Foundation, Inc.
Site Location: 0.25 miles upstream from the mouth of the brook on road behind the Hulbert Outdoor Center (2968 Lake Morey Rd, Fairlee, VT 05045) Stream Name: Garden Side Brook

Site Description: Replace culvert that is perched 0.8 feet to increase geomorphic compatibility and potentially improve fish passage. Drainage area of Garden Side Brook at this area is 0.25 square miles.

Site Design Considerations: Private Road and funding sources are unknown. This stream has a small drainage area and it is unknown whether fish utilize this brook. The stream is likely intermittent given the small drainage area.
Permitting Needs: A 404 permit from the ACOE is required; a State of Vermont Stream Alteration permit is likely not required, assuming the intermittent flow status.
Cost Estimate Range: $60,000 - $70,000
Restoration/Water Quality Improvement Objectives: Project will reduce sediment and phosphorus reaching Lake Morey by decreasing erosion in addition to providing aquatic organism passage.
Level of Landowner Commitment: The Hulbert Outdoor Center has expressed an interest in replacing this undersized culvert.

Stream Problem Areas Summary Sheet

Project Number and Name: 1-6 Culvert Replacement on Lake Morey Road
Land Ownership: Town of Fairlee
Site Location: 0.15 miles upstream from the mouth of the brook on Lake Morey Road on Brushwood Rd Stream Name: Garden Side Brook

Site Description: Replace culvert that is perched 3.9 feet on the outlet side and mostly buried at the inlet. This will increase geomorphic compatibility and potentially improve fish passage. Drainage area of Garden Side Brook at this area is 0.38 square miles.
 
Site Design Considerations: This stream has a small drainage area and it is unknown whether fish utilize this brook.
Permitting Needs: A Vermont Stream Alteration Permit may be required for this project.
Cost Estimate Range: $190,000 - $200,000
Restoration/Water Quality Improvement Objectives: Project will reduce sediment and phosphorus reaching Lake Morey by decreasing erosion in addition to providing aquatic organism passage.
Level of Landowner Commitment: Low

APPENDIX C

ROAD PROJECT SUMMARY SHEETS

Lake Morey Watershed Action Plan
Road Assessment Summary (Revised 2/27/24)

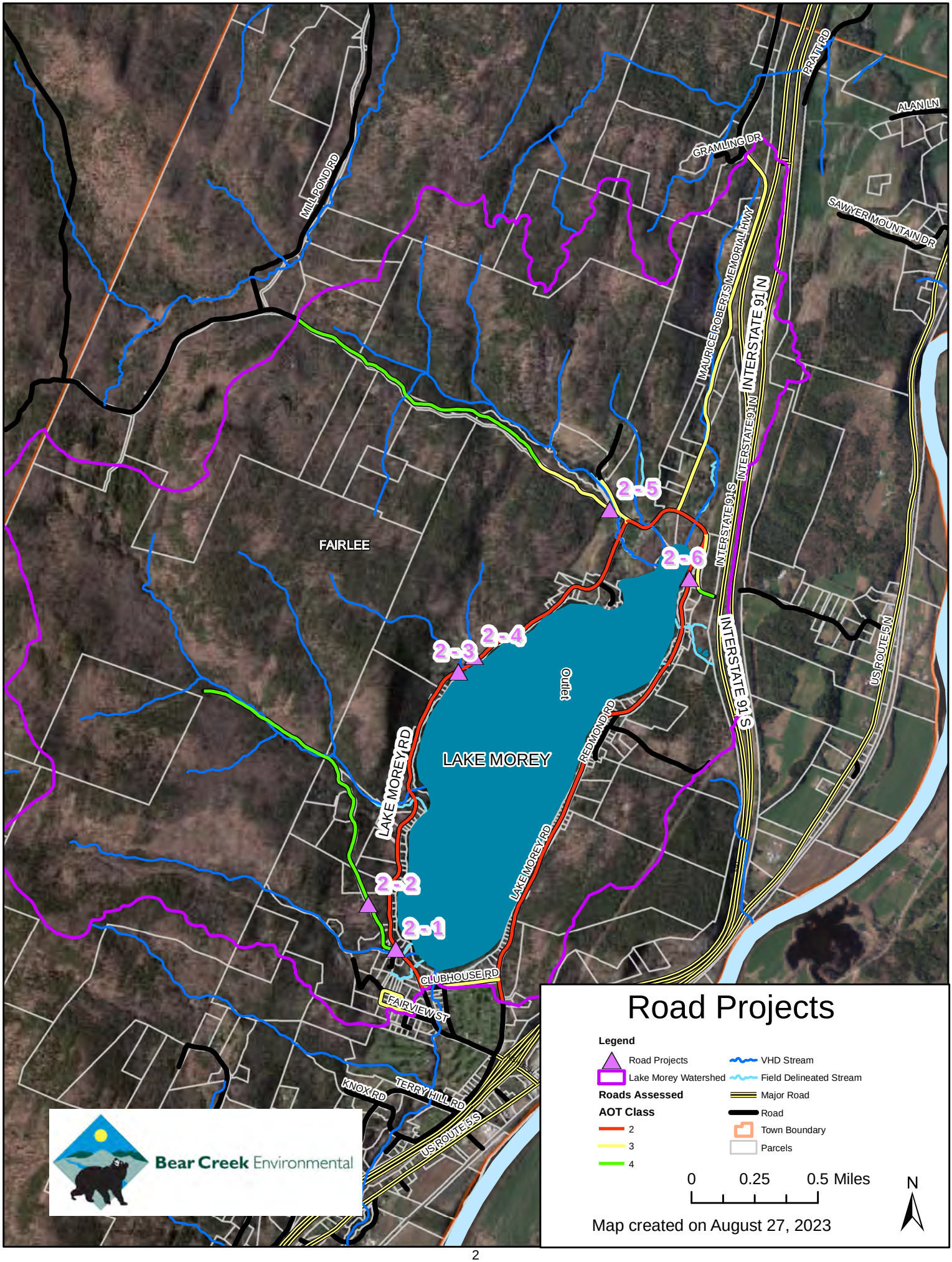
Methodology

Hydrologically connected road segments were assessed using the Municipal Roads General Permit (MRGP) protocol in 2018. The MRGP data set was reviewed as a starting point to identify road problem areas within the Lake Morey watershed. All of the MRGP road segments within the Lake Morey watershed were either given a score of "fully meets" the standard or were not considered hydrologically connected.

The AOT Class 2, 3, and 4 roads within the Lake Morey watershed, regardless of whether they were considered hydrologically connected by the MRGP database, were included in the study area for the Lake Watershed Action Plan. Bear Creek Environmental visited each of these publicly accessible roads within the watershed in June 2023, and revisited the locations identified as being potential sources of sediment phosphorus to Lake Morey in August 2023 with Water Resources Engineer, Matt Murawski of Ripple Natural Resources.

This road assessment summary includes the following:

1) A locator map of four identified projects
2) A table summarizing the identified project in a format that can be effectively used for project prioritization during the next phase of the project.
3) Road problem areas summary sheets
    - Project Name
    - Land Ownership
    - Site Location
    - Locator Map
    - Site Description
    - Site Design Considerations
    - Permitting Needs
    - Cost Estimate Range
    - Restoration/Water Quality Improvement Objectives
    - Level of Landowner Commitment


Road Projects
Legend
Road Projects
Lake Morey Watershed
Roads Assessed
AOT Class
2
3
4
VHD Stream
Field Delineated Stream
Major Road
Road
Town Boundary
Parcels
0
0.25
0.5 Miles
N
Map created on August 27, 2023
Bear Creek Environmental
2-1
2-2
2-3
2-4
2-5
2-6
LAKE MOREY
Outlet
FAIRLEE
LAKE MOREY RD
REDMOND RD
CLUBHOUSE RD
FAIRVIEW ST
KNOX RD
TERRY HILL RD
US ROUTE 5 S
INTERSTATE 91 S
INTERSTATE 91 N
MAURICE ROBERTS MEMORIAL HWY
GRAMLING DR
MILL POND RD
PRATT RD
ALAN LN
SAWYER MOUNTAIN DR
US ROUTE 5 N

Lake Morey Watershed Action Plan - Project Identification
Fairlee, Vermont
White River Natural Resources Conservation District
September 3, 2023

Project Number Segment	Project Category	Project Type	Project Location	Town	Ownership	Project Description	Environmental Benefits	Degree of Landowner Commitment
2-1	Road	Stormwater Improvement	Lower Bald Top Road	Fairlee	Town of Fairlee	Lower Bald Top Road is steep and is eroding. Raise the road and grade toward the rock lined ditch to reduce rilling.	1, 2	Unknown
2-2	Road	Stormwater Improvement	At the intersection of Bald Top Rd and Reservoir Rd	Fairlee	Town of Fairlee	Bald Top Road near the water storage tanks is steep and is eroding. Sediment is reaching Pine Grove Brook upslope of Lake Morey. Crown the road and add several new cross culverts. Clean out existing cross culvert and add sump at outlet. Add check dams to reduce velocities in steep ditches.	1, 2	Unknown
2-3	Road	Stormwater Improvement	South Access Drive at Aloha Camp	Fairlee	Aloha Foundation	Stormwater runoff is causing erosion of steep access road, which is in close proximity to Lake Fairlee. Reduce erosion by extending the water bar down slope and creating a small sedimentation basin at the outlet. Move top of access road slightly to east.	1, 2	High
2-4	Road	Stormwater Improvement	Northeastern Access Drive at Aloha Camp	Fairlee	Aloha Foundation	Stormwater runoff is causing erosion of northeastern access drive of the Aloha Camp. Add a cross culvert at the upper end of drive to reduce concentration of stormwater runoff. Rock line the ditch along the drive and regrade the parking lot.	1, 2	High

[1] Enhances or protects aquatic or riparian habitat
[2]Reduces sedimentation and phosphorus levels
[3]Moves the channel toward equilibrium where the water and sediment are in balance
[4]Reduces risk of flooding and erosion hazard

Lake Morey Watershed Action Plan - Project Identification
Fairlee, Vermont
White River Natural Resources Conservation District
September 3, 2023

Project Number Segment	Project Category	Project Type	Project Location	Town	Ownership	Project Description	Environmental Benefits	Degree of Landowner Commitment
2-5	Road	Stormwater Improvement	Brushwood Road and Hulbert Outdoor Center Shop Parking Lot	Fairlee	Aloha Foundation	Stormwater runoff is causing erosion of shop parking lot at the Holbrook Outdoor Center and the edges of Brushwood Road. Stone line ditches and construct a small sediment basin to reduce sediment reaching Big Brook.	1, 2	High
2-6	Road	Stormwater Improvement	Lake Morey Road at Northeast End of Lake Morey	Fairlee	Town of Fairlee	Stormwater runoff is causing erosion of the roadside on Lake Morey Road. Sediment is depositing in roadside ditches and on adjacent lawn. Roadside improvements, particularly to the shoulder at the edge of the road, will reduce the volume of sediment generated.	1, 2	Unknown

[1] Enhances or protects aquatic or riparian habitat
[2]Reduces sedimentation and phosphorus levels
[3]Moves the channel toward equilibrium where the water and sediment are in balance
[4]Reduces risk of flooding and erosion hazard

Project Number and Name: 2-1 Road Erosion along Lower Bald Top Rd (near Intersection with Lake Morey Road)
Land Ownership: Town of Fairlee
Site Location: Bald Top Road – Lower end of Bald Top Road above intersection with Lake Morey Road

Site Description: Roadside ditches are steep. The rock lined ditch leads to a drop inlet at intersection of Bald Top Road and Lake Morey Road.
 
Site Design Considerations: The roadway is steep. Raise the road and grade toward the rock lined ditch. Grading of the road will help reduce sediment input by reducing riling.
Permitting Needs: No permits are required for this project.
Cost Estimate Range: $40,000 to $50,000
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Lake Morey by reducing road erosion.
Level of Landowner Commitment: Unknown

Project Number and Name: 2-2 Road Erosion along Bald Top Road (near Intersection with Reservoir Road)
Land Ownership: Town of Fairlee
Site Location: Bald Top Road – near intersection with Reservoir Road

Site Description: Roadside ditches are steep and sediment is draining to Pine Grove Brook
 
Site Design Considerations: Crown the road and add several new cross culverts. Clean out existing cross culvert and add sump at outlet. Add check dams to reduce velocities in steep ditch and allow sediment to settle out.
Permitting Needs: No permits are required for this project.
Cost Estimate Range: $60,000 - $70,000
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Pine Grove Brook and Lake Morey by reducing road erosion and improving the trapping of sediment.
Level of Landowner Commitment: Unknown

Project Number and Name: 2-3 South Access Drive of Aloha Camp
Land Ownership: Aloha Foundation Inc. – Aloha Camp
Site Location: South of Lake Morey Road at the northern end of Lake Morey (about 0.7 miles southwest of intersection of Lake Morey Road and Cliff Mull Lane)

Site Description: Stormwater runoff is causing erosion of steep, south access drive of the Aloha Camp.
 
Site Design Considerations: The south access drive is steep and is in close proximity to Lake Fairlee. In an effort to reduce erosion and sedimentation, extend the water bar down slope and create a small sedimentation basin. It is also recommended that the top of the access road be moved slightly to the east.
Permitting Needs: No permits are required for this project.
Cost Estimate Range: $10,000 to $15,000
Restoration/Water Quality Improvement Objectives: Project will reduce sediment and phosphorus reaching Lake Morey.
Level of Landowner Commitment: The Aloha Foundation Inc. has expressed an interest in completing this project.

Project Number and Name: 2-4 Aloha Camp Northeastern Access Drive (Below Horse Barn)
Land Ownership: Aloha Foundation Inc.
Site Location: North of Lake Morey Road (approximately 0.65 miles southwest of intersection of Lake Morey Road and Cliff Mull Lane

Site Description: Stormwater runoff is causing erosion of the northeastern access drive of the Aloha Camp.
 
Site Design Considerations: The northeastern access drive is steep and is in close proximity to Lake Morey. The access drive could be improved by adding a cross culvert at the upper end to reduce concentration of stormwater runoff. Rock lining the ditch along the drive and regrading the parking lot should also result in reduced erosion and sedimentation.
Permitting Needs: No permits are required for this project.
Cost Estimate Range: $15,000 - $25,000
Restoration/Water Quality Improvement Objectives: Reduce sediment & phosphorus reaching the Lake
Level of Landowner Commitment: The Aloha Foundation Inc. has expressed an interest in completing this project.

Project Number and Name: 2-5 Brushwood Road near Holbrook Outdoor Center Shop Parking Lot

Land Ownership: Aloha Foundation Inc.

Site Location: On Brushwood Road about 0.1 miles northwest of intersection of Brushwood Road and Lake Morey Road in vicinity of parking log for the shop at Holbrook Outdoor Center

Site Description: Stormwater runoff is causing erosion of the shop parking lot at the Holbrook Outdoor Center and Brushwood Road leading to sediment accumulation in close proximity to Big Brook

Site Design Considerations: Brushwood Road is steep and transitions to a trail upslope of the shop parking lot. The Aloha foundation has already taken steps to reduce concentration of stormwater by installing a water bar at the base of the trail. Additional stormwater improvements, such as stone lining the ditches along Brushwood Road and or constructing a small sediment basin, could reduce sediment reaching Big Brook.

Permitting Needs: No permits are required for this project.

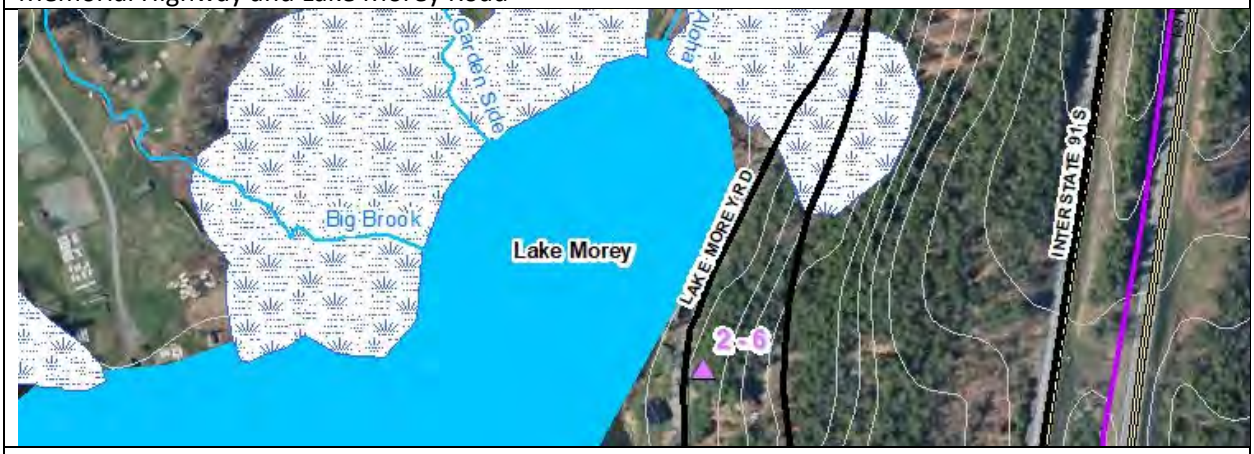
Cost Estimate Range: $5,000 - $10,000

Restoration/Water Quality Improvement Objectives: Reduce sediment & phosphorus reaching Big Brook, which flows into Lake Morey

Project Number and Name: 2-6 Lake Morey Road at Northeast End of Lake Morey

Land Ownership: Town of Fairlee

Site Location: On Lake Morey Road about 0.35 miles south of intersection of Maurice Roberts Memorial Highway and Lake Morey Road



Site Description: Stormwater runoff is causing erosion of the roadside on Lake Morey Road and sediment deposition in roadside ditches and a downslope lawn

Site Design Considerations: The sediment from the roadside erosion is accumulating in the roadside ditches and on an adjacent lawn, which is located in close proximity to Lake Morey. Currently, the sediment is being trapped and does not appear to be reaching Lake Morey. Roadside improvements may be warranted to prevent sediment from traveling towards Lake Morey at some point in the future.

Permitting Needs: No permits are required for this project.

Cost Estimate Range: $5,000 - $10,000

Restoration/Water Quality Improvement Objectives: Reduce possibility of sediment & phosphorus reaching Lake Morey

APPENDIX D

LAKE SHORELAND PROJECT SUMMARY SHEETS

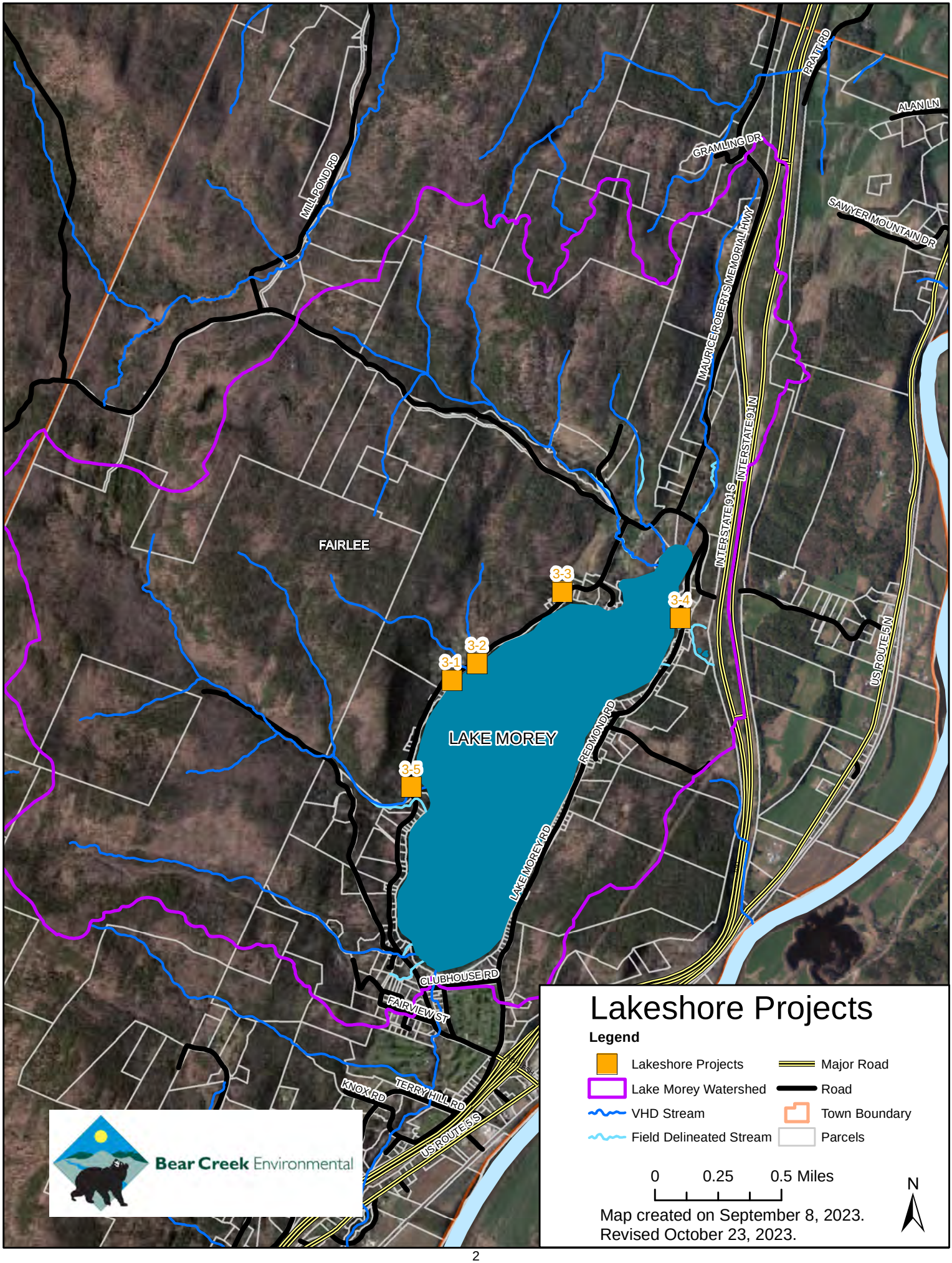
Lake Shoreland Assessment Summary

The shoreland of Lake Morey was assessed through a boat reconnaissance and LakeWise visits. On June 19, 2023, Bear Creek Environmental (BCE), White River Conservation District (WRNRCD), members of the Lake Morey Protective Association (LMPA), and a representative from the Vermont Department of Environmental Conservation (VTDEC) toured the lake. During the boat trip, members of the LMPA shared their knowledge of the lake community. WRNRCD visited with interested lakeshore property owners and conducted LakeWise assessments. On August 9, 2023, BCE, WRNRCD, and Ripple Natural Resources (RNR) visited several areas of concern that were identified during LakeWise assessments.

The WRNRCD has completed 29 LakeWise assessments of the shoreline of Lake Morey (page 2). The assessments took place from 2017 through 2023, with nearly 80 percent of the assessments taking place in 2023. Review of the assessment reports identified several projects with a high level of landowner interest. The summer camps receive very high use during the summer months and are often the largest waterfront properties. For these reasons these projects received high ranking.

This Lake Shoreland Assessment Summary includes the following:

1) A locator map of four identified projects (page 3)
2) A table summarizing the identified project in a format that can be effectively used for project prioritization during the next phase of the project (page 4)
3) Lakeshore Problem Areas Summary Sheets
    - Project Name
    - Land Ownership
    - Site Location
    - Locator Map
    - Site Description
    - Site Design Considerations
    - Permitting Needs
    - Cost Estimate Range
    - Restoration/Water Quality Improvement Objectives
    - Level of Landowner Commitment


FAIRLEE
LAKE MOREY
3-1
3-2
3-3
3-4
3-5
MILL POND RD
GRAMLING DR
PRATT RD
ALAN LN
SAWYER MOUNTAIN DR
MAURICE ROBERTS MEMORIAL HWY
INTERSTATE 91 S
INTERSTATE 91 N
US ROUTE 5 N
REDMOND RD
LAKE MOREY RD
CLUBHOUSE RD
FAIRVIEW ST
KNOX RD
TERRY HILL RD
US ROUTE 5 S
Bear Creek Environmental
Lakeshore Projects
Legend
Lakeshore Projects
Lake Morey Watershed
VHD Stream
Field Delineated Stream
Major Road
Road
Town Boundary
Parcels
0
0.25
0.5 Miles
N
Map created on September 8, 2023.
Revised October 23, 2023.

Lake Morey Watershed Action Plan - Project Identification
Fairlee, Vermont
White River Natural Resources Conservation District
September 12, 2023 (Revised 2/27/24)

Project Number Segment	Project Category	Project Type	Project Location	Town	Ownership	Project Description	Environmental Benefits	Degree of Landowner Commitment
3-1	Shoreland	Buffer Improvement	Aloha Camp	Fairlee	Aloha Foundation	Create no mow zone or plant along Lake Morey shoreline and small tributary	1, 2	High
3-2	Shoreland	Stormwater Improvement	Aloha Camp	Fairlee	Aloha Foundation	The beach near the boathouse at the Aloha Camp is eroding. Groundwater from the hillside and surface water flow are contributing to the problem. Create a French drain to intercept groundwater and consider improvements to reduce surface water flow onto the beach.	1, 2	High
3-3	Shoreland	Stormwater Improvement	Off of Lake Morey Road	Fairlee	Private Parcel #1	A private driveway on the north side of Lake Morey Road is eroding. Groundwater seeps are contributing to problem during non-storm events. Reduce the concentration of stormwater by installing additional water bars and rebuilding existing water bars.	1, 2	High
3-4	Shoreland	Stormwater Improvement	Off of Lake Morey Road	Fairlee	Private Parcel #2	A steep, private driveway on the west side of Lake Morey Road is eroding. Install two water bars to break up the concentration of stormwater runoff.	1, 2	High

[1] Enhances or protects aquatic or riparian habitat
[2]Reduces sedimentation and phosphorus levels
[3]Moves the channel toward equilibrium where the water and sediment are in balance
[4]Reduces risk of flooding and erosion hazard

Lake Morey Watershed Action Plan - Project Identification
Fairlee, Vermont
White River Natural Resources Conservation District
September 12, 2023 (Revised 2/27/24)

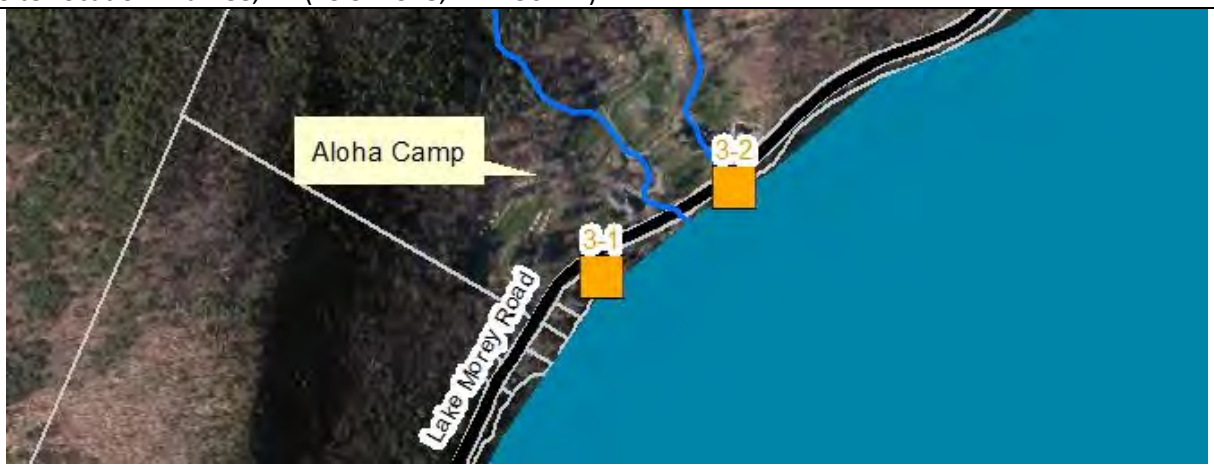
Project Number Segment	Project Category	Project Type	Project Location	Town	Ownership	Project Description	Environmental Benefits	Degree of Landowner Commitment
3-5	Shoreland	Stormwater Improvement	VT Fish and Wildlife Boat Launch	Fairlee	State of VT	There are minor erosion issues at the VDFW boat launch. The access road and lower launch area needs to be repaved to prevent erosion. The steep access path has eroded and could be fenced off.	1, 2	Low

[1] Enhances or protects aquatic or riparian habitat
[2]Reduces sedimentation and phosphorus levels
[3]Moves the channel toward equilibrium where the water and sediment are in balance
[4]Reduces risk of flooding and erosion hazard

Lake Morey Watershed Action Plan

Lakeshore Problem Areas summary Sheet

Page 1 of 5

Project Number and Name: 3-1 Aloha Camp Buffer Improvement along Lakeshore
Land Ownership: Aloha Foundation
Site Location: Fairlee, VT (43.927328, -72.156242)

Site Description: The area adjacent to Lake Morey is lacking a vegetated buffer. Some blueberry bushes have already been planted at the eastern edge of this area along the shoreline. The buffer could be improved by expanding the area of plantings or by creating a no mow zone.
 
Site Design Considerations: This area to the south (photo right) of culvert outlet channel is not being actively used by campers and could be converted to buffer. The area is very wet due to outflow from a culvert and natural seepage from the adjacent slope. Plants that are adapted to wet soils would do best in this location.
Permitting Needs: No permits are required for planting or allowing this area to grow in naturally.
Cost Estimate Range: $500 - $1,000
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Lake Morey by creating a vegetative buffer along the small stream and Lake Morey
Level of Landowner Commitment: A representative of the Aloha Foundation has expressed an interest in enhancing the buffer in this location.

Project Number and Name: 3-2 Aloha Camp Beach Area Improvement

Land Ownership: Aloha Foundation

Site Location: Fairlee, VT (43.928295, -72.154236)

Site Description: The sandy beach in the vicinity of the Aloha Camp's boathouse is eroding. Groundwater from the hillside and a small stream are contributing to the erosion. Install a French drain to intercept the groundwater and enlarge and naturalize the channel to reduce surface water flow onto the beach.

Site Design Considerations: This area is heavily used by campers.

Permitting Needs: A Section 404 permit would be required for any instream work below ordinary high water. A shoreland permit may be required for channel work.

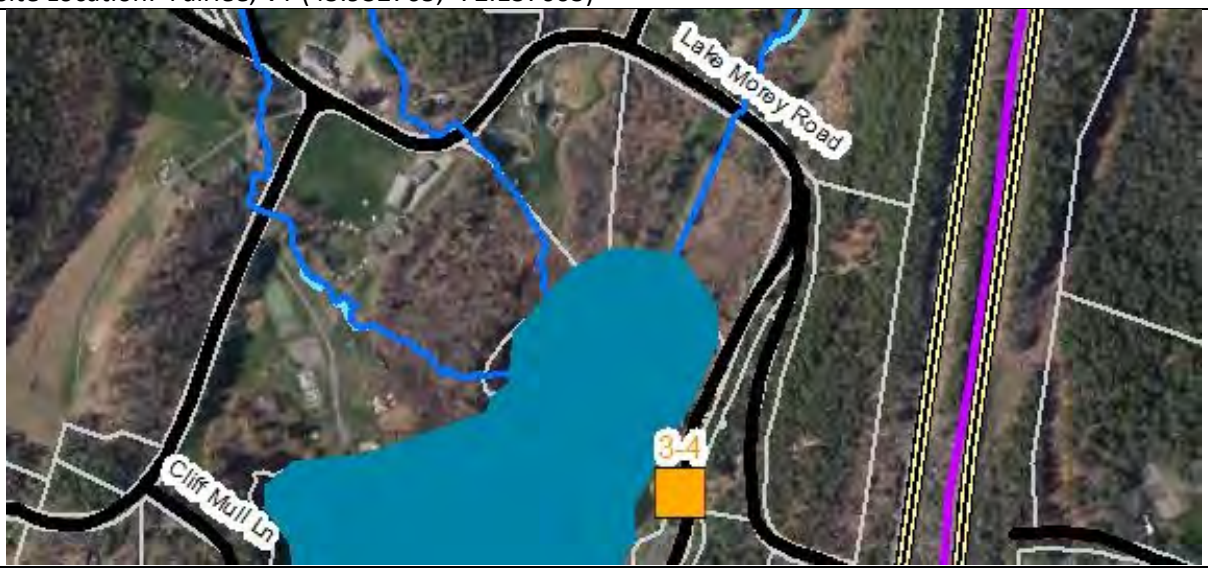
Cost Estimate Range: $20,000 to $40,000

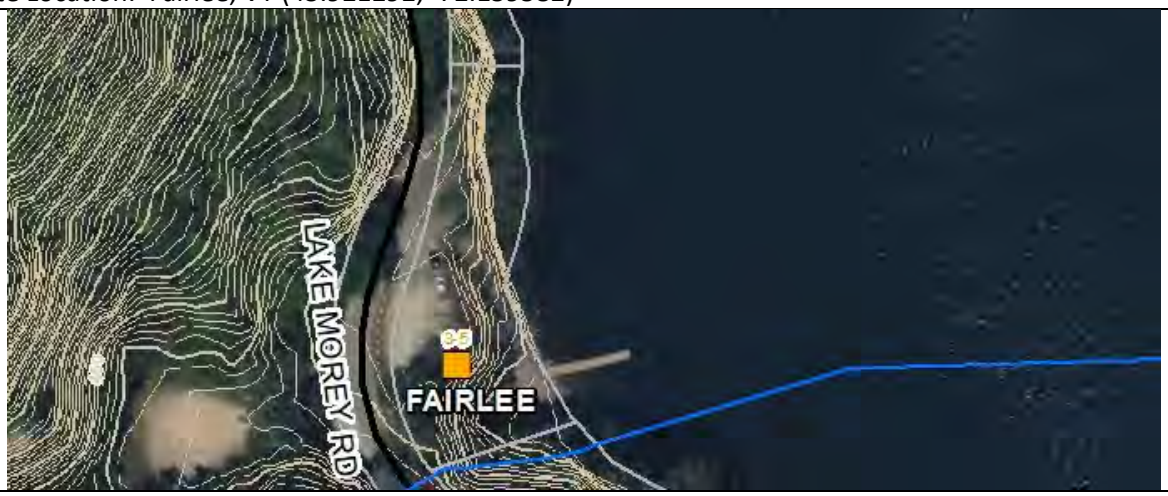
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Lake Morey by increasing filtration and reducing erosion.

Level of Landowner Commitment: A representative of the Aloha Camp visited the site with the project team and was interested in making improvements to the beach.

Project Number and Name: 3-3 Driveway Improvements to Reduce Runoff and Erosion
Land Ownership: Private landowner #1
Site Location: Fairlee, VT (43.932354, -72.147455)

Site Description: A private driveway is eroding and potentially contributing sediment and phosphorus to Lake Morey. There are some existing wooden water bars. Reduce the concentration of stormwater runoff by installing three water bars at locations 25' (new), 55' (replacement), and 90' (new) above Lake Morey Road. Cut and ditch east side of driveway within 25' of road to route seepage to driveway culvert. Grade outlet of lowest water bar to drain to roadside ditch.
 
Site Design Considerations: Groundwater seeps on the upslope side of the driveway are contributing water during non-storm events.
Permitting Needs: No permits are required
Cost Estimate Range: $5,000 -$10,000
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Lake Morey by reducing concentration of stormwater runoff.
Level of Landowner Commitment: A LakeWise assessment was conducted at this location and the landowner is interested in making improvements to the driveway.

Project Number and Name: 3-4 Driveway Improvements to Reduce Erosion
Land Ownership: Private landowner #2
Site Location: Fairlee, VT (43.932765, -72.137603)

Site Description: This private driveway is eroding and has the potential to contribute sediment and phosphorus to Lake Morey. Install two water bars to break up the concentration of stormwater runoff: one near the top of the driveway and a second about 60 feet from top.
 
Site Design Considerations: The driveway is steep and there is no room to excavate a ditch on the north side. Slope water bars to drain to south. Driveway cannot safely be pitched to south to shed water because of unsafe winter conditions.
Permitting Needs: No permits are required
Cost Estimate Range: $5,000 - $10,000
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Lake Morey by reducing concentration of stormwater runoff.
Level of Landowner Commitment: WRNRCD conducted a LakeWise assessment of this property, and landowners have expressed an interest in making driveway improvements.

Project Number and Name: 3-5 VDFW Boat Launch
Land Ownership: State of VT
Site Location: Fairlee, VT (43.921292, -72.159582)

Site Description: The access road and lower launch area need to be repaved to prevent erosion. The steep access path is eroding and could be fenced off.
  
Site Design Considerations: There is no room for stormwater treatment. The site is steep.
Permitting Needs: No permits are required
Cost Estimate Range: $20,000 - $30,000
Restoration/Water Quality Improvement Objectives: Reduce sediment and phosphorus reaching Lake Morey by reducing concentration of stormwater runoff.
Level of Landowner Commitment: Mike Wichrowski of VFWD was contacted in November 2023. According to Mr. Wichrowski, the VFWD is supportive of water quality project, but thought it was difficult to find a contractor to for a small pavement patching project. VFWD may apply for Clean Water Funding at some point in the future.

APPENDIX E

PROJECT PRIORITIZATION

Lake Morey LWAP
Prioritization of Problem Areas
Bear Creek Environmental, LLC

Improves Water Quality (weight -25%) – Uses P reduction Calculation (kg/yr)

- 0 points – P reduction is 0 kg/yr to <0.2 kg/year
- 1 point - P reduction is 0.2 kg/yr to <1.0 kg/year
- 2 points – P reduction is 1 kg/yr to <2.0 kg/year
- 3 points – P reduction is ≥ 2 kg/yr

Landowner Support (weight – 25%)

- 0 points – Strong evidence of lack of interest
- 1 point - Uncertain, some evidence of lack of interest
- 2 points - Uncertain, some evidence of support
- 3 points - Written support – landowner agreement

Improves or Protects Riparian or Aquatic Habitat (weight 20%)

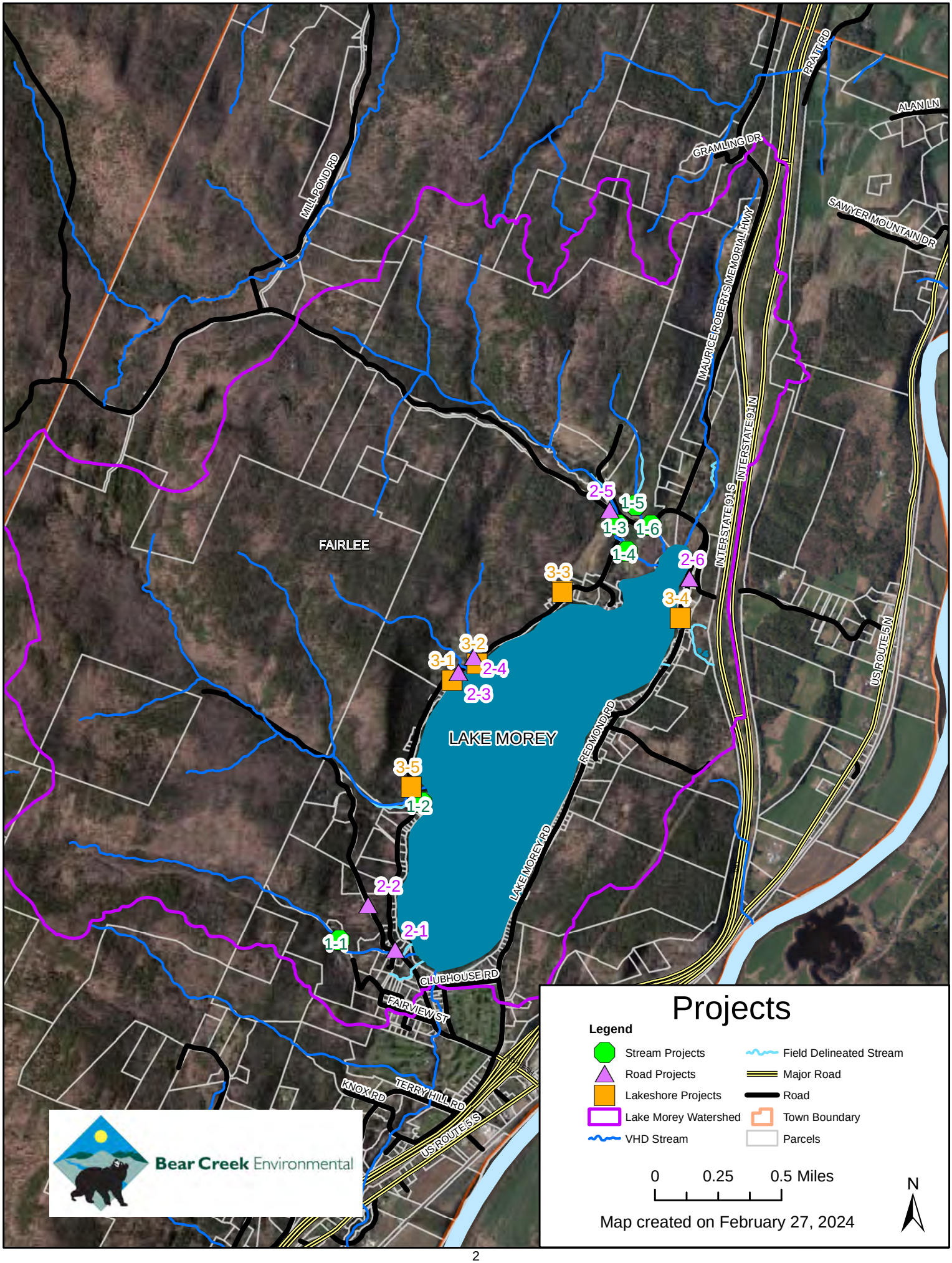
- 0 points – Does not improve habitat
- 1 points – offers Minor habitat enhancement
- 2 points – offers Moderate habitat enhancement
- 3 points - offers Significant habitat enhancement

Cost Effectiveness (weight 20%) **–** Uses P tool (total cost, P reduction, and estimated project life span)

- 0 points - >50,000 $/kg/yr
- 1 point - >25,000 to 50,000 $/kg/yr
- 2 points – >10,000 to 25,000 $/kg/yr
- 3 points – ≤10,000 $/kg/yr

Other Benefits (weight 10%) - 1 point per item up to 3 total points

- Improves or protects infrastructure
- Demonstration project
- Provides opportunity for education
- Reduces peak flows or erosion
- Reduces flooding


FAIRLEE
LAKE MOREY
MILL POND RD
GRAMLING DR
PRATT RD
ALAN LN
SAWYER MOUNTAIN DR
MAURICE ROBERTS MEMORIAL HWY
INTERSTATE 91 S
INTERSTATE 91 N
US ROUTE 5 N
REDMOND RD
LAKE MOREY RD
CLUBHOUSE RD
FAIRVIEW ST
KNOX RD
TERRY HILL RD
US ROUTE 5 S
1-1
1-2
1-3
1-4
1-5
1-6
2-1
2-2
2-3
2-4
2-5
2-6
3-1
3-2
3-3
3-4
3-5
Bear Creek Environmental
Projects
Legend
Stream Projects
Road Projects
Lakeshore Projects
Lake Morey Watershed
VHD Stream
Field Delineated Stream
Major Road
Road
Town Boundary
Parcels
0
0.25
0.5 Miles
N
Map created on February 27, 2024

Lake Morey LWAP - Projects Listed by Project type
Fairlee, Vermont
White River Natural Resources Conservation District
March 19, 2023

Project Number Segment	Project Order	Project Category	Project Type	Project Description	Project Location	Improve Water Quality (P reduction Calculator)	Cost Effectiveness ($/kg/yr)	Landowner Support	Improves or Protects Habitat	Additional Benefits	Average Score (out of possible score of 3)	Priority	Comments
						25.0%	20.0%	25.0%	20.0%	10.0%			
1-1	1	Stream	Stormwater Improvements	Create turn outs and install Water Bar	Pine Grove Brook - Right-of-way to Water Tanks	0	0	3	1	2	1.15	Low	Create two turnouts and install one water bar along the access road to the water tanks.
1-2	2	Stream	Stream Restoration	Large Wood Addition to Reduce Incision	Glen Falls Brook - Mouth	2	0	1	1	1	1.05	Low	The lower reach of the brook is an alluvial fan. The channel has been historically managed. Beaver dam breach in 2016 that affected this property.
1-3	3	Stream	Culvert Replacement	Replace Twin Culverts on Access Drive	Big Brook - Access Drive at Hulbert Outdoor Center	3	0	3	3	3	2.40	**High**	The twin culverts on the Hulbert Outdoor Center's access drive are undersized. This has resulted in geomorphic incompatibility and fish passage issues.
1-4	4	Stream	Buffer Enhancement	Widen and Enhance Buffers Along Stream	Big Brook - Hulbert Outdoor Center	0	1	3	3	3	1.85	**Moderate**	Expand stream buffer by increasing area where no mowing occurs or trees can be planted on Hulbert Outdoor Center campus.
1-5	5	Stream	Culvert Replacement	Replace Culvert on Access Drive	Garden Side - Hulbert Outdoor Center	3	1	3	2	1	2.20	**High**	Replace small culvert at Hulbert Outdoor Center; possible it is fish passage barrier (only 0.25 sq. mile drainage area)
1-6	6	Stream	Culvert Replacement	Replace Culvert on Lake Morey Road	Garden Side - Lake Morey Road	3	0	1	2	1	1.50	**Moderate**	Replace culvert on Lake Morey Road.
2-1	8	Road	Stormwater Improvement	Raise and Grade Road	Lower Bald Top Road	1	0	3	1	2	1.40	Low	Lower Bald Top Road is steep and is eroding. Raise the road and grade toward the existing rock lined ditch to reduce rilling.
2-2	9	Road	Stormwater Improvement	Install Water Bars, Check Dams, and Cross Culverts	Upper Bald Top Road	3	1	3	3	3	2.60	**High**	Bald Top Road near the Reservoir access drive is steep and is eroding. Sediment is reaching Pine Grove Brook upslope of Lake Morey. Crown the road and add several new cross culverts. Clean out existing cross culvert and add sump at outlet. Add check dams to reduce velocities in steep ditches.
2-3	10	Road	Stormwater Improvement	Extend Water Bars and Create Small Sedimentation Basin	South Access Drive at Aloha Camp	1	1	3	3	3	2.10	**High**	Stormwater runoff is causing erosion of steep access road, which is in close proximity to Lake Morey. Reduce erosion by extending the water bar down slope and creating a small sedimentation basin at the outlet. Move top of access road slightly to east.
2-4	11	Road	Stormwater Improvement	Install Cross Culvert, Regrade Parking Lot, and Rock Lined Drainage Ditch	Northwestern Access Drive at Aloha Camp	3	2	3	3	3	2.80	**High**	Stormwater runoff is causing erosion of northeastern access drive of the Aloha Camp. Add a cross culvert at the upper end of drive to reduce concentration of stormwater runoff. Rock line the ditch along the drive and regrade the parking lot.
2-5	12	Road	Stormwater Improvement	Stone Line Drainage Ditches and Install Sedimentation Basin	Brushwood Road at Hulbert Outdoor Center Shop Parking Lot	0	0	2	2	1	1.00	Low	Stormwater runoff is creating erosion of shop parking lot at the Hulbert Outdoor Center and the edges of Brushwood Road. Stone line ditches and construct a small sediment basin to reduce sediment reaching Big Brook

Lake Morey LWAP - Projects Listed by Project type
Fairlee, Vermont
White River Natural Resources Conservation District
March 19, 2023

Project Number Segment	Project Order	Project Category	Project Type	Project Description	Project Location	Improve Water Quality (P reduction Calculator)	Cost Effectiveness ($/kg/yr)	Landowner Support	Improves or Protects Habitat	Additional Benefits	Average Score (out of possible score of 3)	Priority	Comments
						25.0%	20.0%	25.0%	20.0%	10.0%			
2-6	13	Road	Stormwater Improvement	Improve Roadside to reduce Sediment	Lake Morey Road at Northeast End of Lake Morey	0	0	3	1	2	1.15	Low	Stormwater runoff is causing erosion of the roadside on Lake Morey Road. Sediment is depositing in roadside ditches and on an adjacent lawn. Roadside improvements, particularly to the shoulder, will reduce volume of sediment generated.
3-1	14	Shoreland	Buffer Enhancement	Create No Mow Zone or Plant Adjacent to Lake	Aloha Camp	0	1	3	3	3	1.85	**Moderate**	Create no mow zone or plant along Lake Morey shoreline and small tributary, where land use allows.
3-2	15	Shoreland	Stormwater Improvement	Install French Drain and Reduce Surface Water Flow on Beach	Aloha Camp	2	1	3	3	3	2.35	**High**	The beach near the boathouse at the Aloha Camp is eroding. Groundwater from the hillside and surface water flow are contributing to the problem. Create a French drain to intercept groundwater and consider improvement to small tributary to reduce surface water flow onto beach.
3-3	16	Shoreland	Stormwater Improvement	Install Water Bars and Rebuild Existing Water Bars	Driveway off of Lake Morey Road	0	0	3	2	3	1.45	**Low**	A private driveway on the north side of Lake Morey Road is eroding. Groundwater seeps are contributing to the problem during non-storm events. Reduce the concentration of stormwater by installing additional water bars and rebuilding existing water bars.
3-4	17	Shoreland	Stormwater Improvement	Install Water Bars	Driveway off of Lake Morey Road	0	0	3	2	3	1.45	**Low**	A steep, private driveway on the west side of Lake Morey Road is eroding. Install two water bars to break up the concentration of stormwater runoff.
3-5	18	Shoreland	Stormwater Improvement	Close steep walking path, repair pavement on access drive	VDFW Boat Launch	0	0	3	1	3	1.25	Low	There are minor erosion issues at the VDFW boat launch. The access road and lower launch area needs to be repaved to prevent erosion. The steep access path has eroded and could be fenced off.

Lake Morey LWAP - Projects Listed by Priority Ranking
Fairlee, Vermont
White River Natural Resources Conservation District
March 19, 2024

Project Number Segment	Project Order	Project Category	Project Type	Project Description	Project Location	Improve Water Quality (P reduction Calculator)	Cost Effectiveness ($/kg/yr)	Landowner Support	Improves or Protects Habitat	Additional Benefits	Average Score (out of possible score of 3)	Priority	Comments
						25.0%	20.0%	25.0%	20.0%	10.0%			
2-4	11	Road	Stormwater Improvement	Install Cross Culvert, Regrade Parking Lot, and Rock Lined Drainage Ditch	Northwestern Access Drive at Aloha Camp	3	2	3	3	3	2.80	**High**	Stormwater runoff is causing erosion of northeastern access drive of the Aloha Camp. Add a cross culvert at the upper end of drive to reduce concentration of stormwater runoff. Rock line the ditch along the drive and regrade the parking lot.
2-2	9	Road	Stormwater Improvement	Install Water Bars, Check Dams, and Cross Culverts	Upper Bald Top Road	3	1	3	3	3	2.60	**High**	Bald Top Road near the Reservoir access drive is steep and is eroding. Sediment is reaching Pine Grove Brook upslope of Lake Morey. Crown the road and add several new cross culverts. Clean out existing cross culvert and add sump at outlet. Add check dams to reduce velocities in steep
1-3	3	Stream	Culvert Replacement	Replace Twin Culverts on Access Drive	Big Brook - Access Drive at Hulbert Outdoor Center	3	0	3	3	3	2.40	**High**	The twin culverts on the Hulbert Outdoor Center's access drive are undersized. This has resulted in geomorphic incompatibility and fish passage issues.
3-2	15	Shoreland	Stormwater Improvement	Install French Drain and Reduce Surface Water Flow on Beach	Aloha Camp	2	1	3	3	3	2.35	**High**	The beach near the boathouse at the Aloha Camp is eroding. Groundwater from the hillside and surface water flow are contributing to the problem. Create a French drain to intercept groundwater and consider improvement to small tributary to reduce surface water flow onto beach.
1-5	5	Stream	Culvert Replacement	Replace Culvert on Access Drive	Garden Side - Hulbert Outdoor Center	3	1	3	2	1	2.20	**High**	Replace small culvert at Hulbert Outdoor Center; possible it is fish passage barrier (only 0.25 sq. mile drainage area)
2-3	10	Road	Stormwater Improvement	Extend Water Bars and Create Small Sedimentation Basin	South Access Drive at Aloha Camp	1	1	3	3	3	2.10	**High**	Stormwater runoff is causing erosion of steep access road, which is in close proximity to Lake Morey. Reduce erosion by extending the water bar down slope and creating a small sedimentation basin at the outlet. Move top of access road slightly to east.
1-4	4	Stream	Buffer Enhancement	Widen and Enhance Buffers Along Stream	Big Brook - Hulbert Outdoor Center	0	1	3	3	3	1.85	**Moderate**	Expand stream buffer by increasing area where no mowing occurs or trees can be planted on Hulbert Outdoor Center campus.
3-1	14	Shoreland	Buffer Enhancement	Create No Mow Zone or Plant Adjacent to Lake	Aloha Camp	0	1	3	3	3	1.85	**Moderate**	Create no mow zone or plant along Lake Morey shoreline and small tributary, where land use allows.
1-6	6	Stream	Culvert Replacement	Replace Culvert on Lake Morey Road	Garden Side - Lake Morey Road	3	0	1	2	1	1.50	**Moderate**	Replace culvert on Lake Morey Road.
3-3	16	Shoreland	Stormwater Improvement	Install Water Bars and Rebuild Existing Water Bars	Driveway off of Lake Morey Road	0	0	3	2	3	1.45	**Low**	A private driveway on the north side of Lake Morey Road is eroding. Groundwater seeps are contributing to the problem during non-storm events. Reduce the concentration of stormwater by installing additional water bars and rebuilding existing water bars.
3-4	17	Shoreland	Stormwater Improvement	Install Water Bars	Driveway off of Lake Morey Road	0	0	3	2	3	1.45	**Low**	A steep, private driveway on the west side of Lake Morey Road is eroding. Install two water bars to break up the concentration of stormwater runoff.

Lake Morey LWAP - Projects Listed by Priority Ranking
Fairlee, Vermont
White River Natural Resources Conservation District
March 19, 2024

Project Number Segment	Project Order	Project Category	Project Type	Project Description	Project Location	Improve Water Quality (P reduction Calculator)	Cost Effectiveness ($/kg/yr)	Landowner Support	Improves or Protects Habitat	Additional Benefits	Average Score (out of possible score of 3)	Priority	Comments
						25.0%	20.0%	25.0%	20.0%	10.0%			
2-1	8	Road	Stormwater Improvement	Raise and Grade Road	Lower Bald Top Road	1	0	3	1	2	1.40	Low	Lower Bald Top Road is steep and is eroding. Raise the road and grade toward the existing rock lined ditch to reduce rilling.
3-5	18	Shoreland	Stormwater Improvement	Close steep walking path, repair pavement on access drive	VDFW Boat Launch	0	0	3	1	3	1.25	Low	There are minor erosion issues at the VDFW boat launch. The access road and lower launch area needs to be repaved to prevent erosion. The steep access path has eroded and could be fenced off.
1-1	1	Stream	Stormwater Improvements	Create turn outs and install Water Bar	Pine Grove Brook - Right-of-way to Water Tanks	0	0	3	1	2	1.15	Low	Create two turnouts and install one water bar along the access road to the water tanks.
2-6	13	Road	Stormwater Improvement	Improve Roadside to reduce Sediment	Lake Morey Road at Northeast End of Lake Morey	0	0	3	1	2	1.15	Low	Stormwater runoff is causing erosion of the roadside on Lake Morey Road. Sediment is depositing in roadside ditches and on an adjacent lawn. Roadside improvements, particularly to the shoulder, will reduce volume of sediment generated.
1-2	2	Stream	Stream Restoration	Large Wood Addition to Reduce Incision	Glen Falls Brook - Mouth	2	0	1	1	1	1.05	Low	The lower reach of the brook is an alluvial fan. The channel has been historically managed. Beaver dam breach in 2016 that affected this property.
2-5	12	Road	Stormwater Improvement	Stone Line Drainage Ditches and Install Sedimentation Basin	Brushwood Road at Hulbert Outdoor Center Shop Parking Lot	0	0	2	2	1	1.00	Low	Stormwater runoff is creating erosion of shop parking lot at the Hulbert Outdoor Center and the edges of Brushwood Road. Stone line ditches and construct a small sediment basin to reduce sediment reaching Big Brook

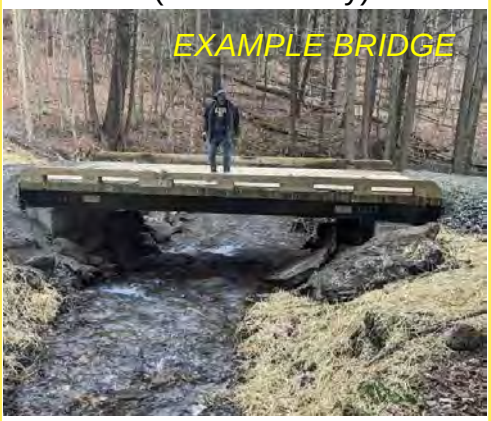
APPENDIX F

CONCEPTUAL DESIGNS

Project 1-3: Twin Culvert on Big Brook Stream Crossing Structure Replacement

RECONSTRUCT WINGWALLS BOTH SIDES WITH EXISTING STONE

NEW 20' BRIDGE
* Concrete block abutments
* Steel beams
* Wooden deck
* 1.5-lane (17' travel-way)



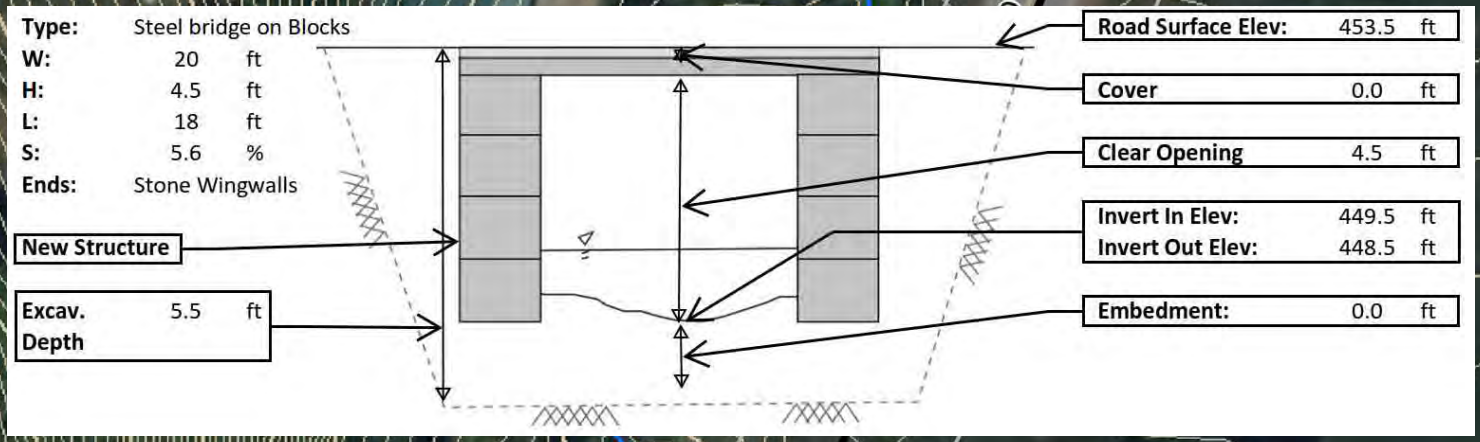
Hulbert Outdoor Center Access Road

1-3

FAIRLEE

Big Brook

SITE INFO:
Drainage Area: 1.42 sq mi
Bankfull Width: 15.2 ft (Regional Curve)



RIPPLE Natural Resources LLC

Bear Creek Environmental

Conceptual Design
Lake Morey Watershed Action Plan
White River NRCD

Drawn by Matthew Murawski, PE
and Mary Nealon, CPESC
10/09/2023

N

0 12.5 25 50 Feet

Project 1-4: Buffer Enhancement on Big Brook Hulbert Outdoor Center

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Bear Creek Environmental

Conceptual Design
Lake Morey Watershed Action Plan
White River NRCD

Drawn by Matthew Murawski, PE
and Mary Nealon, CPESC
12/19/2023

N

0 35 70 140 Feet

Project 1-5: Culvert Replacement on Garden Side Brook
Hulbert Outdoor Center

RECONSTRUCT WINGWALLS BOTH SIDES WITH EXISTING STONE

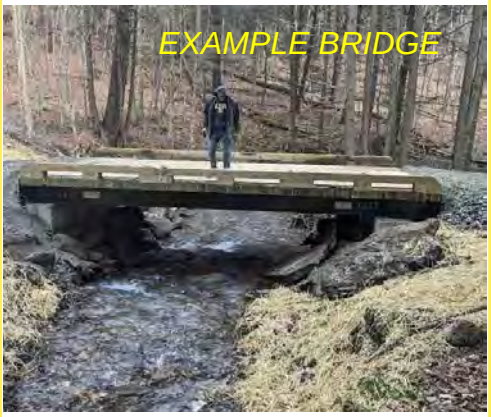
Hulbert Outdoor Center Access Road

FAIRLEE

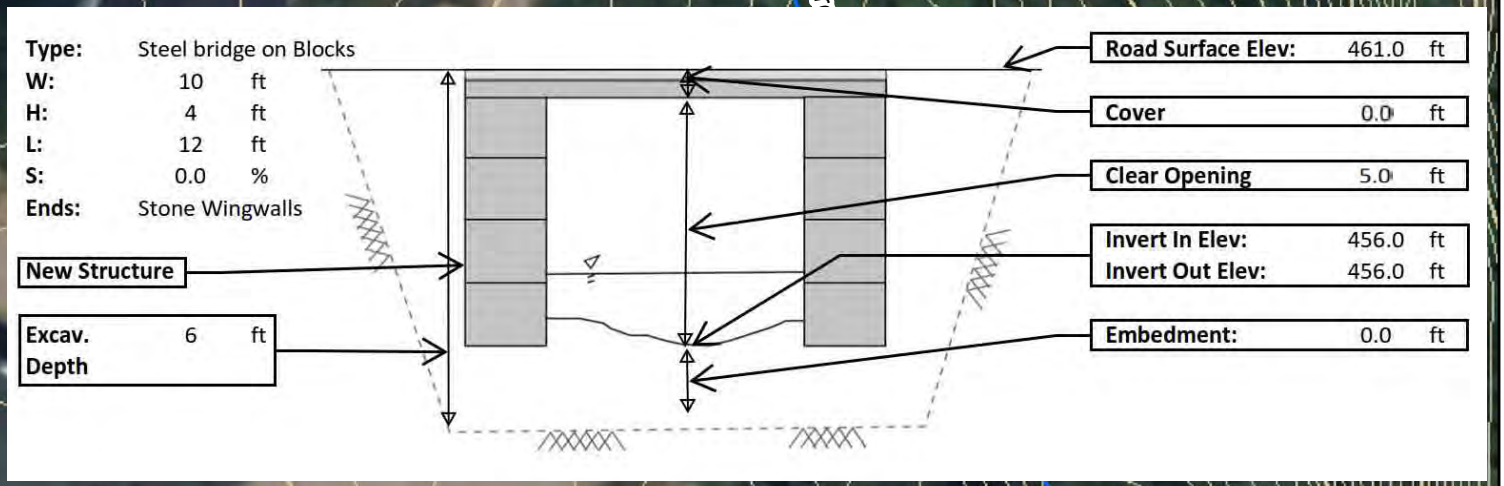
1-5

Garden Side Br

NEW 10' BRIDGE
* Concrete block abutments
* Steel beams
* Wooden deck
* Single Lane



SITE INFO:
Drainage Area: 0.38 sq mi
Bankfull Width: 8.6 ft (Regional Curve)



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White River NRCD

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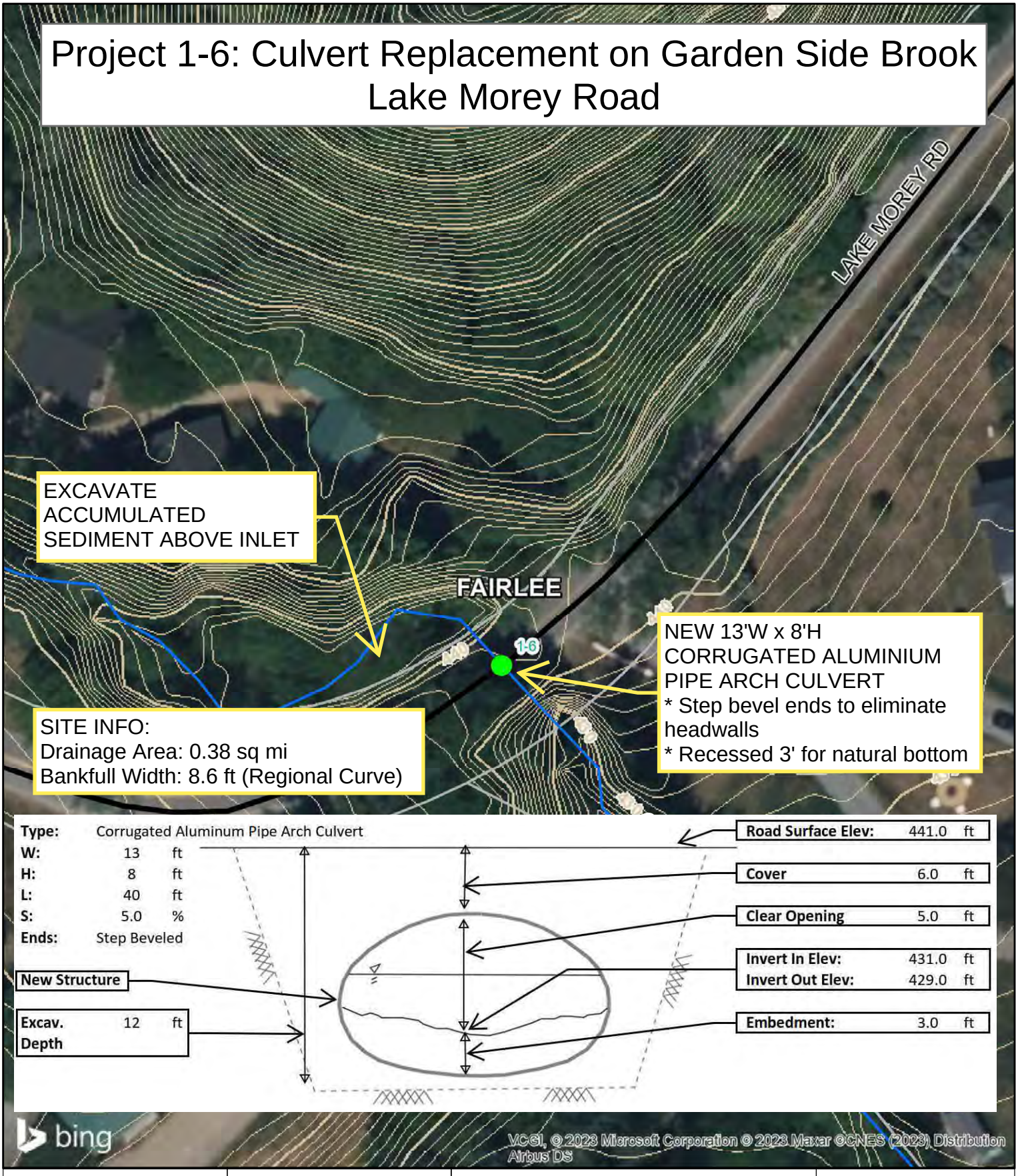
10/09/2023

N

0 12.5 25 50 Feet

Project 1-6: Culvert Replacement on Garden Side Brook Lake Morey Road



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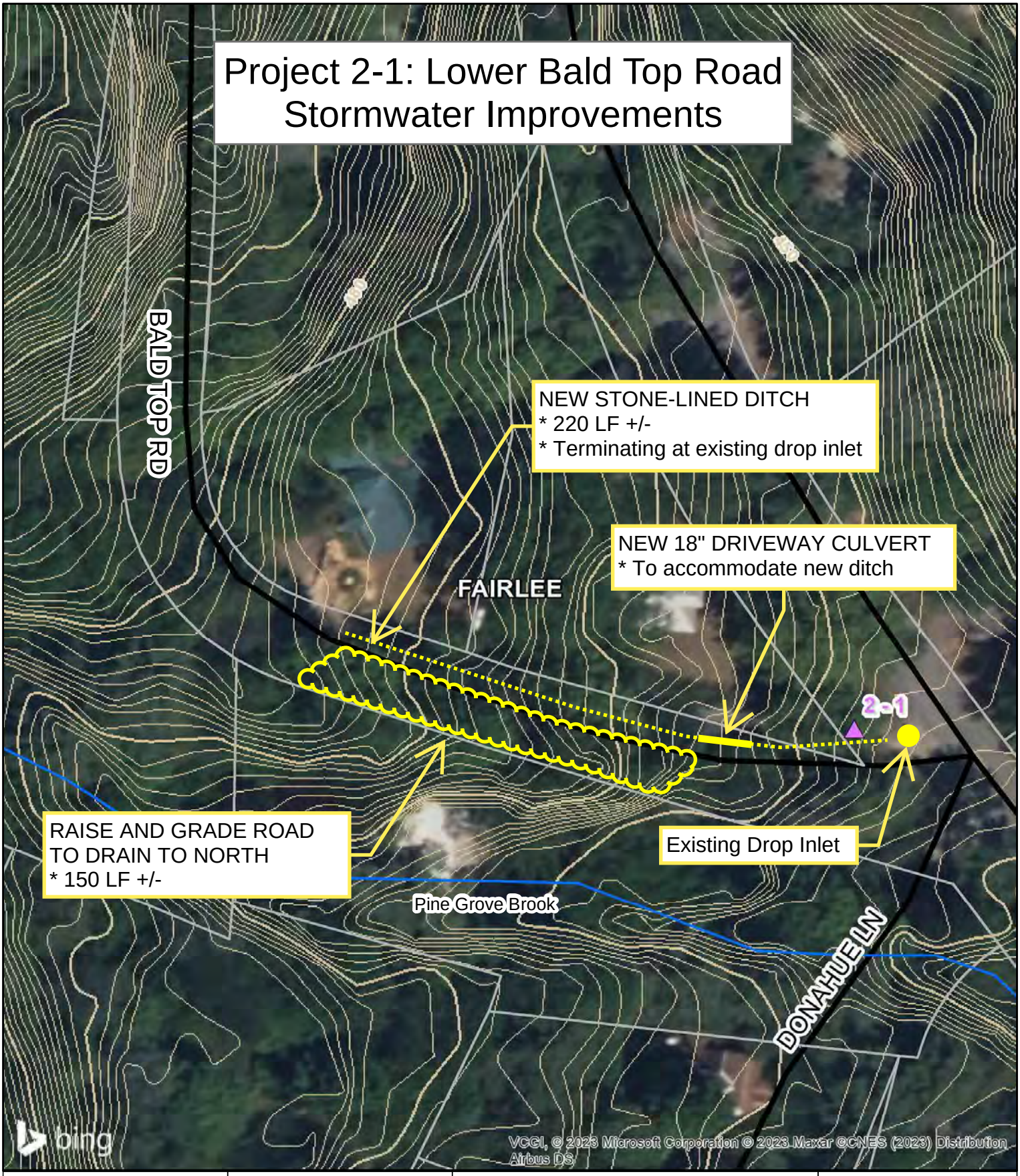
0 12.5 25 50 Feet



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White River NRCD

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12/11/2023

N

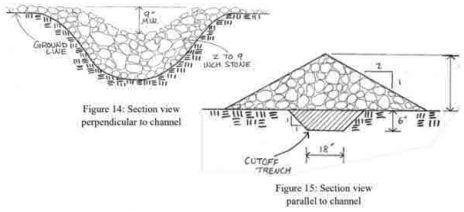
0 12.5 25 50 Feet

Project 2-2: Upper Bald Top Road Stormwater Improvements

BALD TOP RD

NEW 18" CROSS CULVERT (TYP)
Purpose: Remove water from road-way ditch before sufficient volume to cause erosion
1) 4 new on road
2) Use 18' HDPE

STONE CHECK DAMS
* Intended to slow water and accumulate sediment
* Remove sediment annually or as necessary



Source: Vermont Better Back Roads Manuals, VTrans 2019

FAIRLEE

2-2

LAKE MOREY RD

IMPROVE EXISTING CULVERT
* Clean outlet
* Create maintainable sump to collect sediment

NEW CHECK DAMS -- UPPER SECTION
* 30' spacing
* 10 total

UPGRADED 18" DRIVEWAY CULVERT
* Landowner permission needed

NEW CONCRETE DROP INLET STRUCTURE
Purpose: To connect two culverts and drain driveway ditch
1) Use grated top
2) Grade driveway ditch to drain to grate
3) Road culvert outlets to top of structure
4) Driveway culvert starts in structure

NEW CHECK DAMS -- LOWER SECTION
* 30' spacing
* 8 total

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Bear Creek Environmental

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Lake Morey Watershed Action Plan
White River NRCD

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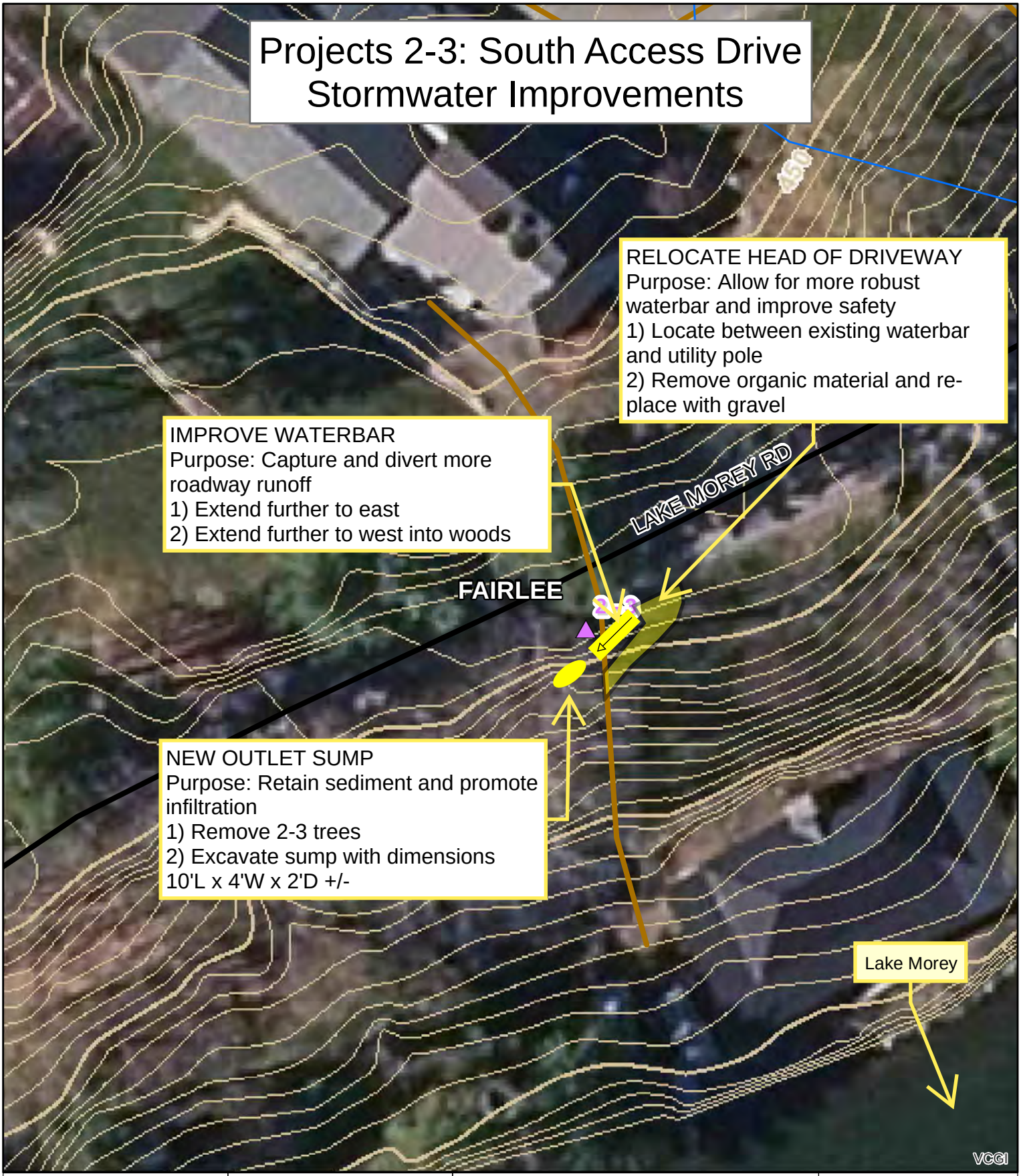
12/11/2023

N

0 55 110 220 Feet

Projects 2-3: South Access Drive Stormwater Improvements



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Bear Creek Environmental

Conceptual Design
Lake Morey Watershed Action Plan
White River NRCD

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and Mary Nealon, CPESC
12/06/2023

N

0 5 10 20 Feet

Project 2-4: Northwestern Access Drive at Aloha Camp Stormwater Improvements

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Bear Creek Environmental

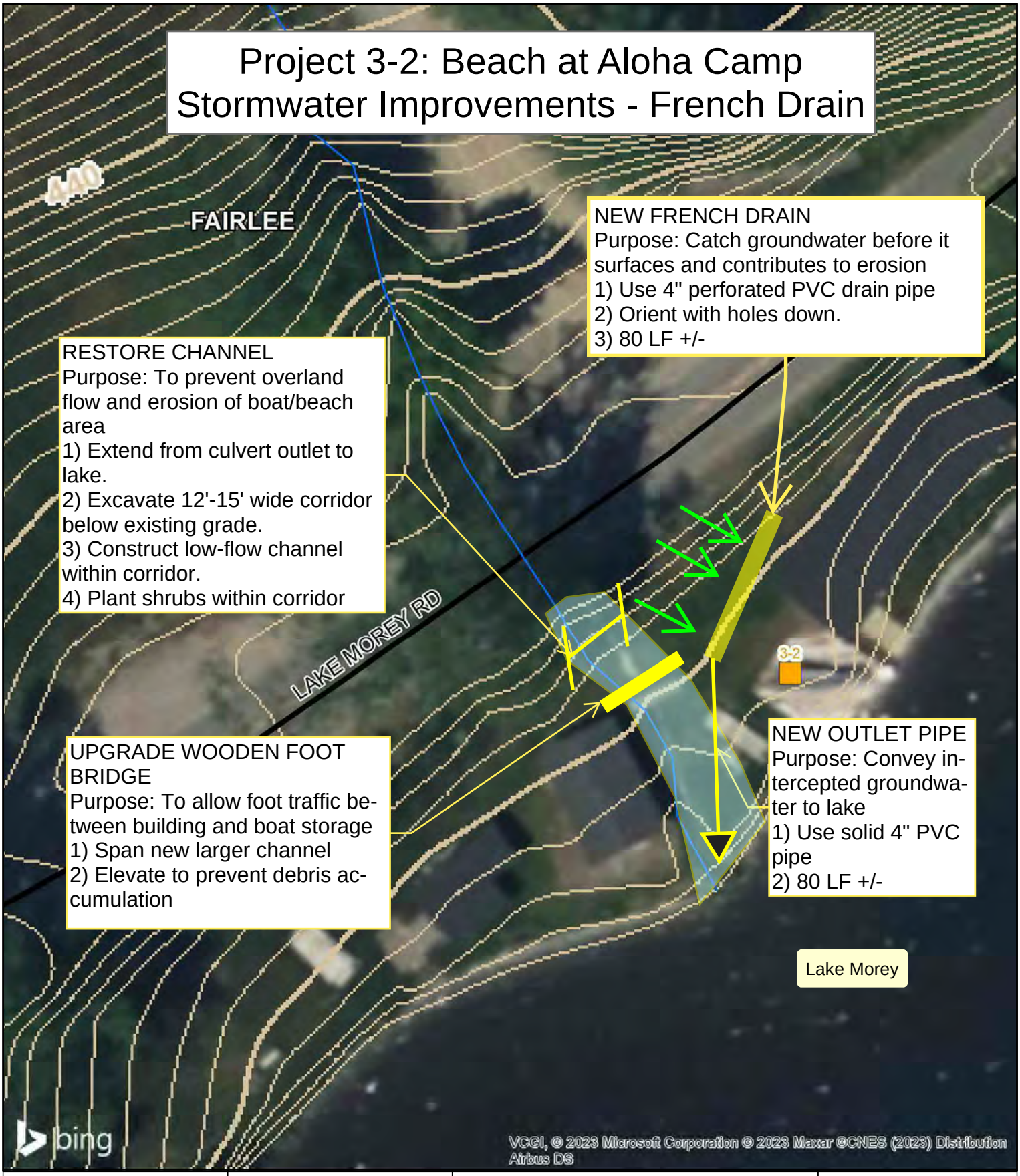
Conceptual Design
Lake Morey Watershed Action Plan
White River NRCD

Drawn by Matthew Murawski, PE
and Mary Nealon, CPESC
12/06/2023

N

0 12.5 25 50 Feet

Project 3-2: Beach at Aloha Camp Stormwater Improvements - French Drain



NEW FRENCH DRAIN
Purpose: Catch groundwater before it surfaces and contributes to erosion
1) Use 4" perforated PVC drain pipe
2) Orient with holes down.
3) 80 LF +/-

RESTORE CHANNEL
Purpose: To prevent overland flow and erosion of boat/beach area
1) Extend from culvert outlet to lake.
2) Excavate 12'-15' wide corridor below existing grade.
3) Construct low-flow channel within corridor.
4) Plant shrubs within corridor

UPGRADE WOODEN FOOT BRIDGE
Purpose: To allow foot traffic between building and boat storage
1) Span new larger channel
2) Elevate to prevent debris accumulation

NEW OUTLET PIPE
Purpose: Convey intercepted groundwater to lake
1) Use solid 4" PVC pipe
2) 80 LF +/-

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Bear Creek Environmental

Conceptual Design
Lake Morey Watershed Action Plan
White River NRCD

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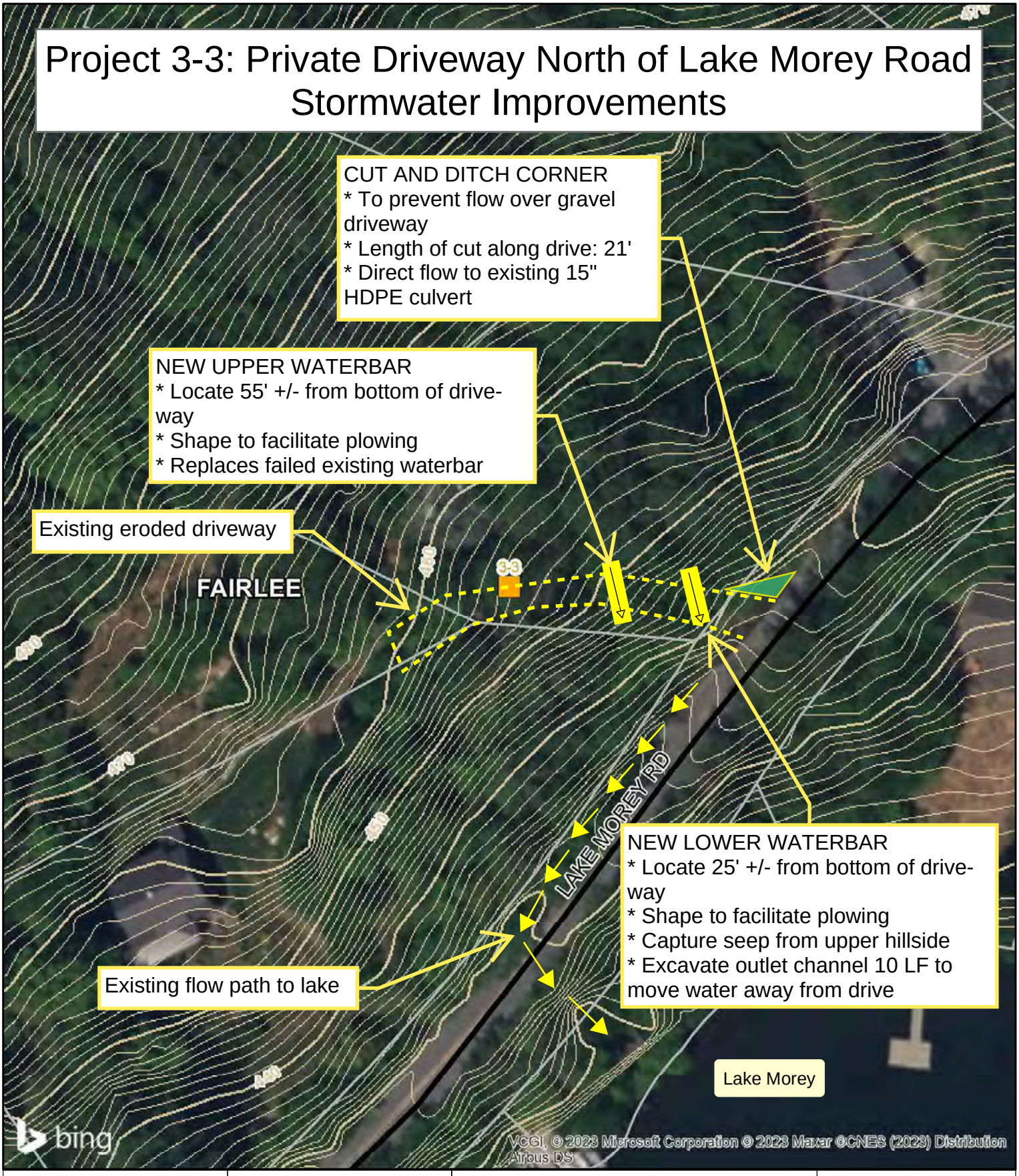
and Mary Nealon, CPESC
12/11/2023

N

0 5 10 20 Feet

Project 3-3: Private Driveway North of Lake Morey Road Stormwater Improvements



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Bear Creek Environmental

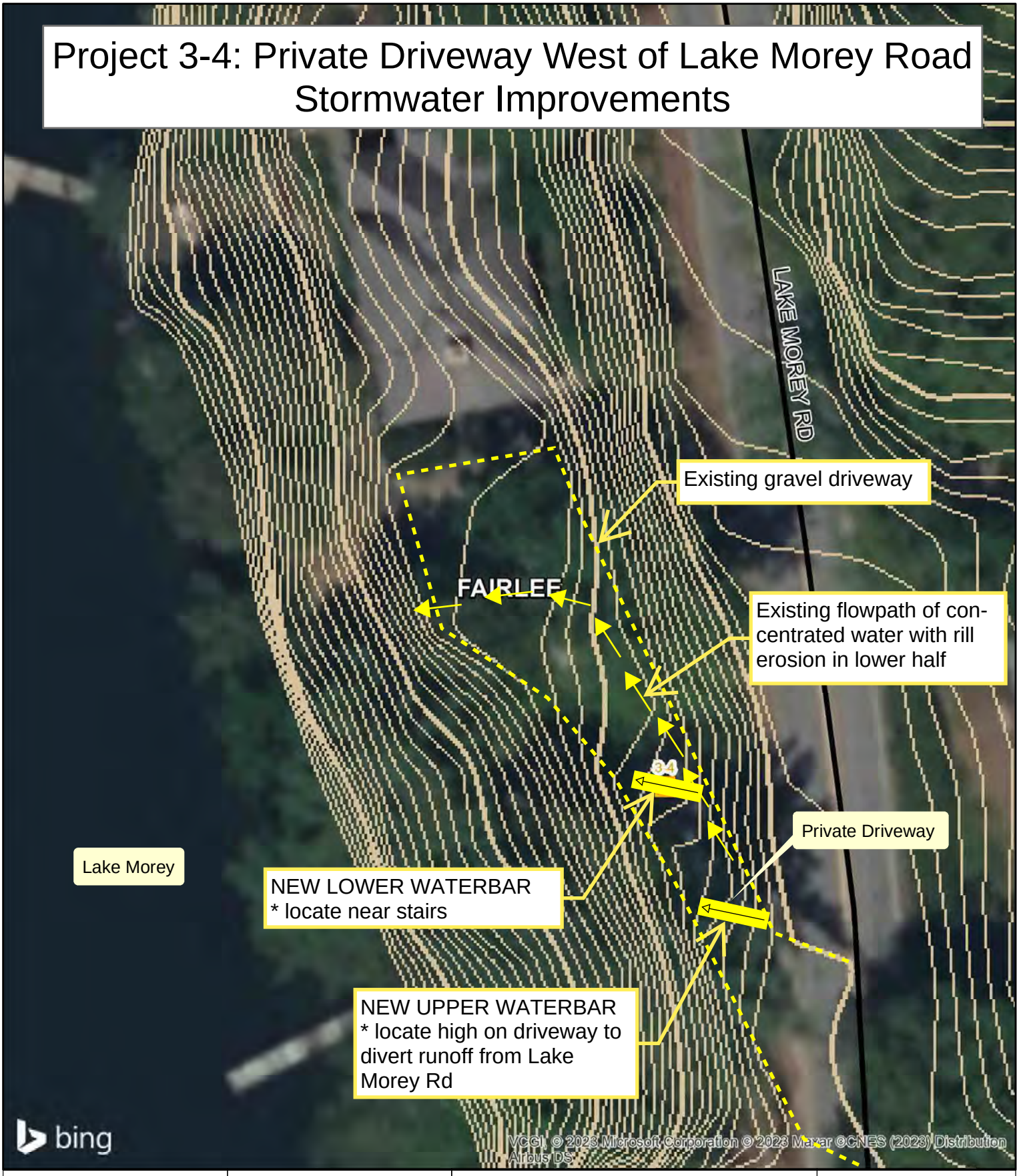
Conceptual Design
Lake Morey Watershed Action Plan
White River NRCD

Drawn by Matthew Murawski, PE
and Mary Nealon, CPESC
12/19/2023

N

0 12.5 25 50 Feet

Project 3-4: Private Driveway West of Lake Morey Road Stormwater Improvements



RIPPLE Natural Resources LLC

Bear Creek Environmental

Conceptual Design
Stormwater - Private Driveway #2
White River NRCD

Drawn by Matthew Murawski, PE
and Mary Nealon, CPESC
12/06/2023

N

0 5 10 20 Feet

Lake Morey Watershed Action Plan
Construction Cost Estimates

Project 1-3: Big Brook Twin Culvert Replacement

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/ Demobilization	1	Lump	$ 6,200	$ 6,200
2	Eros Control and Surface Rest.	1	Lump	$ 1,000	$ 1,000
3	Water Diversion and Control	1	Lump	$ 1,000	$ 1,000
4	Furnish Bridge	1	EA	$ 30,000	$ 30,000
5	Install Bridge	1	Lump	$ 15,000	$ 15,000
6	Backfill and Roadway Improvements	1	Lump	$ 4,000	$ 4,000
7	Grout Pad (if Necessary)	2	EA	$ 2,500	$ 5,000
8	Reconstruct Stone Wingwalls	1	Lump	$ 4,000	$ 4,000
9	Miscellaneous Site Work	1	Lump	$ 2,000	$ 2,000
10	Survey, Engineering, and Permitting	1	Lump	$ 11,000	$ 11,000
11	Contingency			25%	$ 19,800
	TOTAL				$ 99,000
				USE	$ 99,000

Project 1-4: Big Brook Buffer Enhancement

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Harvest and Install Plants	1	Lump	$ 4,000	$ 4,000
2	Project Management	1	Lump	$ 1,500	$ 1,500
3	Contingency			25%	$ 1,400
	TOTAL				$ 6,900
				USE	$ 7,000

Project 1-5: Gardenside Brook @ Hulbert Culvert Replacement

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/ Demobilization	1	Lump	$ 3,900	$ 3,900
2	Eros Control and Surface Rest.	1	Lump	$ 1,000	$ 1,000
3	Water Diversion and Control	1	Lump	$ 1,000	$ 1,000
4	Furnish Bridge	1	EA	$ 18,000	$ 18,000
5	Install Bridge	1	Lump	$ 9,000	$ 9,000
6	Backfill and Roadway Improvements	1	Lump	$ 2,000	$ 2,000
7	Grout Pad (if Necessary)	2	EA	$ 2,000	$ 4,000
8	Reconstruct Stone Wingwalls	1	Lump	$ 3,000	$ 3,000
9	Miscellaneous Site Work	1	Lump	$ 1,000	$ 1,000
10	Survey, Engineering, and Permitting	1	Lump	$ 9,000	$ 9,000
11	Contingency			25%	$ 13,000
	TOTAL				$ 64,900
				USE	$ 65,000

Project 1-6: Gardenside Brook @ Lake Morey Rd Culvert Replacement

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/ Demobilization	1	Lump	$ 12,500	$ 12,500
2	Eros Control and Surface Rest.	1	Lump	$ 4,000	$ 4,000
3	Water Diversion and Control	1	Lump	$ 5,000	$ 5,000
4	Furnish Culvert	1	EA	$ 35,000	$ 35,000
5	Install Culvert	1	Lump	$ 35,000	$ 35,000
6	Backfill and Roadway Improvements	1	Lump	$ 6,000	$ 6,000
7	Paving	1	Lump	$ 20,000	$ 20,000
8	Guardrail	1	Lump	$ 6,500	$ 6,500
9	Traffic Control	1	Lump	$ 3,000	$ 3,000
10	Miscellaneous Site Work	1	Lump	$ 10,000	$ 10,000
11	Survey, Engineering, and Permitting	1	Lump	$ 20,000	$ 20,000
12	Contingency			25%	$ 39,300
	TOTAL				$ 196,300
				USE	$ 197,000

Project 2-1: Lower Bald Top Road

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/Demob	1	Lump	$ 2,300	$ 2,300
2	Erosion Control	1	Lump	$ 2,000	$ 2,000
3	Excavation and Hauling	163	Cubic Yards	$ 40	$ 6,519
4	Culvert	1	Each	$ 2,500	$ 2,500
5	Stone Fill Type I	122	Cubic Yards	$ 50	$ 6,111
6	Roadway Gravel	111	Cubic Yards	$ 50	$ 5,556
7	Misc Site Work	1	Lump	$ 2,000	$ 2,000
8	Survey, Engineering, and Permitting	1	Lump	$ 8,000	$ 8,000
9	Contingency			25%	$ 8,700
	TOTAL				$ 43,685
				USE	$ 44,000

Project 2-2: Upper Bald Top Road

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/Demob	1	Lump	$ 3,600	$ 3,600
2	Erosion Control	1	Lump	$ 1,000	$ 1,000
3	Excavation and Hauling	30	Cubic Yards	$ 40	$ 1,200
4	Culverts	5	Each	$ 2,500	$ 12,500
5	Drainage Structure (Concrete DI)	1	Each	$ 5,000	$ 5,000
6	Roadway Gravel	150	Cubic Yards	$ 50	$ 7,500
7	Stone for check dams	18	Each	$ 300	$ 5,400
8	Misc Site Restoration	1	Lump	$ 3,000	$ 3,000
9	Survey, Engineering, and Permitting	1	Lump	$ 12,000	$ 12,000
10	Contingency			25%	$ 12,800
	TOTAL				$ 64,000
				USE	$ 64,000

Project 2-3: Aloha Camp South Access Drive

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/Demob	1	Lump	$ 2,000	$ 2,000
2	Erosion Control	1	Lump	$ 500	$ 500
3	Excavation and Hauling	16	Cubic Yards	$ 40	$ 640
4	Gravel	32	Cubic Yards	$ 50	$ 1,600
5	Site Restoration	1	Lump	$ 1,000	$ 1,000
6	Survey, Engineering, and Permitting	1	Lump	$ 4,000	$ 4,000
7	Contingency			25%	$ 2,400
	TOTAL				$ 12,140
				USE	$ 13,000

Project 2-4: Aloha Camp Northwest Access Drive

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/Demob	1	Lump	$ 2,000	$ 2,000
2	Erosion Control	1	Lump	$ 1,000	$ 1,000
3	Excavation and Hauling	15	Cubic Yards	$ 40	$ 600
4	Gravel	20	Cubic Yards	$ 50	$ 1,000
5	Culvert	1	Each	$ 2,500	$ 2,500
6	Stone Fill Type I	35	Cubic Yards	$ 50	$ 1,750
7	Site Restoration	1	Lump	$ 2,000	$ 2,000
8	Survey, Engineering, and Permitting	1	Lump	$ 5,000	$ 5,000
9	Contingency			25%	$ 4,000
	TOTAL				$ 19,850
				USE	$ 20,000

Project 3-2: Aloha Camp French Drain

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/Demob	1	Lump	$ 2,000	$ 2,000
2	Erosion Control	1	Lump	$ 2,000	$ 2,000
3	Excavation and Hauling	89	Cubic Yards	$ 50	$ 4,450
4	French Drain and Channel Materials	1	Lump	$ 5,000	$ 5,000
5	Plantings	1	Lump	$ 1,000	$ 1,000
6	Footbridge	1	Lump	$ 2,500	$ 2,500
7	Site Restoration	1	Lump	$ 2,000	$ 2,000
8	Survey, Engineering, and Permitting	1	Lump	$ 8,000	$ 8,000
9	Contingency			25%	$ 6,700
	TOTAL				$ 33,650
				USE	$ 34,000

Project 3-3: Private Drive 1

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/Demob	1	Lump	$ 1,000	$ 1,000
2	Erosion Control	1	Lump	$ 500	$ 500
3	Excavation and Hauling	16	Cubic Yards	$ 40	$ 640
4	Gravel	27	Cubic Yards	$ 50	$ 1,333
5	Site Restoration	1	Lump	$ 500	$ 500
6	Survey, Engineering, and Permitting	1	Lump	$ 2,000	$ 2,000
7	Contingency			25%	$ 1,500
	TOTAL				$ 7,473
				USE	$ 8,000

Project 3-4: Private Drive 2

Item	Description	Quantity	Units	Unit Cost	Total Cost
1	Mobilization/Demob	1	Lump	$ 1,000	$ 1,000
2	Erosion Control	1	Lump	$ 500	$ 500
3	Excavation and Hauling	0	Cubic Yards	$ 40	$ -
4	Gravel	27	Cubic Yards	$ 50	$ 1,333
5	Site Restoration	1	Lump	$ 500	$ 500
6	Survey, Engineering, and Permitting	1	Lump	$ 2,000	$ 2,000
7	Contingency			25%	$ 1,300
	TOTAL				$ 6,633
				USE	$ 7,000

NOTES:

1. This is our opinion of probable construction cost based on conceptual designs.
2. The costs assume projects are advanced through design and construction as stand-alone efforts. Economies of scale that may be achieved by lumping projects together are not reflected.
3. Ripple has no control over the cost or availability of labor, equipment or materials, market conditions, or the Contractor's method of pricing, and we can make no warranty, express or implied, with respect to the accuracy of this cost estimate relative to actual costs. Actual costs will differ.

Bear Creek Environmental, LLC
131 Elm Street, Suite 1 / Montpelier, VT 05602
Phone: (802) 223-5140 / Web: www.BearCreekEnvironmental.com

Permits Expected for Conceptual Design Projects

December 20, 2023

The table below provides preliminary information about which permits will likely be needed for the conceptual design projects. As projects move through the final design phase, it is recommended a request for a project review sheet be submitted to an ANR permit specialist. This project review is intended to assist the applicant with a list of potential permits that will be required.
https://fpr.vermont.gov/sites/fpr/files/Recreation/Recreation_Grants/Requesting%20a%20PR%20sheet.pdf

Project	No Permits Required	Vermont Shoreland Permit	Vermont Wetlands Permit	Vermont Stream Alteration Permit	Section 404 Permit
1-3: Twin Culvert on Big Brook Stream Crossing Replacement				X	X
1-4: Buffer Enhancement on Big Brook Hulbert Outdoor Center	X				
1-5: Culvert Replacement on Garden Side Brook at Hulbert Outdoor Center				X	X

Project	No Permits Required	Vermont Shoreland Permit	Vermont Wetlands Permit	Vermont Stream Alteration Permit	Section 404 Permit
1-6: Culvert Replacement on Garden Side Brook at Lake Morey Road				X	X
2-1: Lower Bald Top Road Stormwater Improvements	X				
2-2: Upper Bald Top Road Stormwater Improvements	X				
2-3: South Access Drive Stormwater Improvements		X[1]			
2-4: Northwestern Access Drive at Aloha Camp	X				
3-2: Beach at Aloha Camp Stormwater Improvements – French Drain		X			X
3-3: Private Driveway North of Lake Morey Road Stormwater Improvements	X				
3-4: Private Driveway West of Lake Morey Road Stormwater Improvements	X				
[1] May require a shoreland permit for tree removal					