Lake Watershed Action Plan Phase 1 at Shadow Lake in Glover, Vermont Final Report

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Disclaimer

The intent of this report is to present the collected data, evaluations, analysis, and recommendations created under a contract between the Orleans County Natural Resources Conservation District (OCNRCD) and Watershed Consulting.

Project Summary

This document and the associated appendices comprise the Phase 1 Lake Watershed Action Plan (LWAP) for Shadow Lake located in Glover, VT. As opposed to a full LWAP, this Phase 1 study does not include stream assessments, project development, or project design. Some limited stream assessments were completed, however, due to specific findings during assessments for other sectors. More information on these assessments is provided in the Stream Assessments section of this report. The prioritized list of identified projects by sector (shoreland, road, and stream) are provided and are well poised to advance to the project development, design, and implementation phases. This project included several partners and stakeholders including Orleans County Natural Resources Conservation District (OCNRCD), the Vermont Department of Environmental Conservation (VT DEC), the Shadow Lake Association, and the Town of Glover including the Planning Commission and the Department of Public Works. OCNRCD with support of the Shadow Lake Association acquired grant funding from the Vermont Department of Environmental Conservation (VT DEC) to fund this project.

This Phase 1 LWAP included field assessments, community engagement and input, and identification and assessment of potential projects. The results of this study indicated that the road related issues (including driveways, private roads, and public roads) made up approximately half of the identified priority sites and these issues were the most prevalent in the watershed. The direct lake shoreline sector had the next highest number of projects (39%), and projects within the stream sector made up 12% of the projects. For the road sector, the most common issues included unstable road shoulders, erodible and unstable ditches, lack of adequate cross drainage (clogged, undersized, or absent culverts), poor grading and grader berms, and direct connection of unmanaged runoff to the lake. Shoreland issues included lack of vegetated buffers, shoreline erosion, and hardscaped retaining walls. For the stream sector, issues included lack of floodplain access, lack of riparian buffers, and unmanaged stormwater inputs to streams, which can increase stream power and erosive capacity and thus results in increased sediment transport and deposition in the lake.

This report and the data collected during this study are intended to be used by stakeholders to advance the identified projects to eventual implementation in a strategic and informed way and also serve as an educational resource for the community. In order to address the issues within the watershed that are decreasing the water quality in Shadow Lake, project partners must work together to complete projects and prevent future negative impacts to the lake. The next steps are expected to include obtaining and administering grants for project advancement and design, completing additional private property shoreline assessments through the VT DEC's Lake Wise Program, educating residents on the impacts of development and the importance of maintaining robust native vegetated buffers, educating recreational ATV users on the potential impacts in disturbing and destabilizing erodible areas that are directly connected to surface waters, and working with the Town of Glover to improve the management of public roads and ditches. This project was not intended to focus on the Shadow Lake dam. However, it should be noted that the dam is currently functioning well below its intended capacity, and it is recommended that steps be taken to repair the dam as soon as possible as higher than normal water levels can contribute to lakeshore erosion.

In addition to recommendations for implementation of specific projects, a bulleted list of recommendations regarding improvements in the watershed that will have a positive impact on Shadow Lake are included in this report. Strategic management of the watershed is critical in protecting Shadow Lake from further water quality degradation, which will be even more important over time as the negative impacts of climate change are felt in the region. Moving forward, an "all in" approach is strongly recommended from the watershed stakeholders to

prevent future negative water quality impacts, improve current conditions, and build resilience.

A more user-friendly version of this Phase 1 LWAP for non-technical stakeholders and interested parties was developed in conjunction with the development of this final report document. It can be accessed via this website[1]. It includes interactive maps and relevant photos that can be explored at the user's pace.

Background

Vermont lakes have more lake shorelands that are in fair or poor condition than the average for the northeast region or the country according to the US Environmental Protection Agency (EPA). Vermont lake shorelines also experience much denser development than even the urban centers of the state, with shoreline development density on average twice as dense as urban areas. In addition to issues related to dense lakeshore development, unmanaged stormwater is also conveyed to lakes via road surfaces, and this concentrated stormwater can transport pollutants to the lake. This stormwater can lead to erosion issues where the stormwater enters the lake. High nutrient loads can also be attributed to the lake's tributaries. These tributaries can transport pollutants from the tributary's drainage area, which is a natural process in low levels and is important for lake and stream health. However, this process can be intensified to a level that can lead to decreased water quality and aquatic habitat health due to the increased volume and velocity of unmanaged stormwater entering the tributaries from alterations in the drainage area including development and disconnection of tributaries from their historic floodplains. This stormwater often transports high pollutant loads, including nutrients such as phosphorus that are harmful in excess, and can lead to unstable stream banks that can result in increased in stream erosion.

The Vermont Shoreland Protection Act (Chapter 49A of Title 10 §1441 et seq.) established a statewide regulation for guiding development within 250 feet of the mean water level as of 2014 to protect lakes from the harmful impacts of development. This regulated area is known as the Protected Shoreland Area. The Act applies to all lakes and ponds greater than 10 acres in size including Shadow Lake. The intent of the Act is to:

- prevent degradation of lake water quality,
- preserve habitat and natural stability of shorelines, and
- maintain the economic benefits of lakes and their shorelands.

This regulation is important to understand in the context of the Shadow Lake Phase 1 LWAP and future development along the lake. This regulation applies to the area bordering the lake and up to 250 ft from the shore. Note that if a shoreland parcel is bisected by a public road, the Shoreland Protection Act only applies to the area between the road and the lake. More information can be found in the Vermont Shoreland Protection Act Handbook for Shoreland Development.

It has been demonstrated that systematic and scientific assessments of Vermont's lakes must be completed to identify the lake-specific threats to water quality, wildlife habitat, and lake ecosystem health to direct limited time and funds to the projects that will be the most impactful for these areas. Shadow Lake, a 217-acre lake located in the Town of Glover, VT, is no exception. To that end, the OCNRCD acquired grant funding through the Vermont Department of Environmental Conservation (VT DEC) to hire a contractor to complete this work. Watershed Consulting was selected as that consultant in July 2022.

A Phase 1 Lake Watershed Action Plan (LWAP), which requires a thorough assessment of potential issues that are contributing to the declining water quality in the lake, was completed between July 2022 and November 2023. This included a focus on stormwater projects including green stormwater infrastructure (GSI) best management practice (BMP) identification, road drainage improvements and stabilization projects, stream restoration projects, and lake shore projects to stabilize the shoreline and reduce erosion and associated

[1] https://arcg.is/GaCyL

nutrient loading. The Phase 1 LWAP includes priority lists of the greatest threats to the lake including 30 prioritized problem areas and potential solutions for mitigating the identified issues. Unlike full LWAPs, this Phase 1 LWAP did not include stream walks, landowner outreach regarding specific projects, or conceptual designs. More information regarding LWAPs can be found on the VT DEC website.

Introduction

Existing Site Conditions

Shadow Lake is an important resource for the Town of Glover and the surrounding communities, providing opportunities for recreation and serving as an aesthetic amenity for many (Figure 1). The lake is a main economic driver for the region. Many people will buy or rent property in the area or visit from other locations specifically to enjoy Shadow Lake, and these people regularly frequent many local businesses. The lake is also important for fish and wildlife habitat.

Figure 1. Shadow Lake is a regional economic driver as well as an aesthetic and recreational amenity.

The lake is located in Glover, VT (Figure 2) in the southern portion of the Lake Memphremagog watershed (Figure 3). The lake's 3,413-acre drainage area, the area that ultimately drains to the lake, includes a mix of primarily residential and forested land use (see Table 1 for a breakdown of key landcover types) and includes five main tributaries (9.5 miles). Three of the tributaries drain north towards the lake from largely forested and relatively steep areas. All three pass under Shadow Lake Rd in culverts and pass through the surrounding residential areas. One tributary flows southeast towards the lake through a largely forested area before intersecting a residential zone and draining to the lake. The final tributary flows east through forested and wetland areas before draining to Shadow Lake. The main stem of this tributary originates at Daniels Pond. There are 178 acres of mapped wetlands and approximately 200 acres of agricultural lands in the watershed. Two main farms are present in the watershed. It is important that these farms are following recommended best management practices to ensure that runoff from these agricultural areas are not adversely impacting the watershed's wetlands and the lake itself. ONCRD has been working with one of these farms to prevent negative water quality impacts. The assistance has included manure storage and nutrient management and there are plans to also improve livestock exclusion and pasture rotation.

The 217-acre lake has a residence time of 1.758 years, the average amount of time a drop of water spends in the lake, and a standard volume of 115.5 acre-feet. This deep lake (139 ft in depth) has a dam that is currently not functioning correctly and is hydraulically inadequate, resulting in higher than normal lake levels. Higher lake levels can result in increased shoreline instability and erosion as well as increased sediment deposition. There have been thirteen dam Inspections between 1952 and 2023, the majority of which rate the dam in poor condition. Four hydrologic and hydraulic (H&H) reports have been completed (1991, 2020, 2021, and 2023) and these reports conclude that the dam is either a significant hazard (1991, 2020, and 2023) or significant hazard bordering on high hazard (2020). The Shadow Lake Association, in an email sent to the Town to contribute to the preparation of the updated Hazard Mitigation Plan noted "The dam has a significant hazard classification and needs to be brought into compliance with the State of Vermont Dam Safety Regulations. With that said there are alternatives to improve the dam while achieving more favorable inspection ratings, hazard classification and mitigate the hazard to the community and its infrastructure in the event of a catastrophic failure and the impending flooding. The

Board of Directors of the Shadow Lake Association strongly encourages that funding be allocated to fix the current conditions, hire an engineering firm to plan the replacement of the 36" valve, design a new debris rack and further review alternatives to the configuration of the dam. These suggestions are in line with the 2014 Town of Glover All Hazards Mitigation Plan where Dam Failure prioritization was listed a highest priority, funding in annual budget and time frame was to be within 2015 to 2020." While the dam is not the focus of this LWAP, it is a very important issue that needs to be addressed as soon as possible.

Figure 2. Shadow Lake is located in the Town of Glover in northeastern Vermont. The watershed boundary is shown in blue.

The primary roads within the Shadow Lake watershed, which includes the Daniels Pond watershed, are Shadow Lake Road, Perron Hill Road, Mud Island Road, Stone Shore Road, and Daniels Pond Road. Of the hydrologically connected road segments assessed as part of a Road Erosion Inventory (REI) in 2019 in the watershed, 19 did not meet standards and 17 partially met standards. The National Hydrograph Dataset (NHD) includes 9.5 miles of streams within the Shadow Lake and Daniels Pond watersheds, although there are also unmapped intermittent tributaries present. These streams are primarily small waterways that consist of hillside drainages into Shadow Lake and Daniels Pond. Ten stream crossings are included in Vermont ANR's Stream Crossings GIS dataset. Of these ten crossings, eight are noted as having a reduced aquatic organism passage (AOP) condition and two are noted as having no AOP. Recent culvert replacements have improved AOP in several areas of the watershed, however. Shadow Lake has approximately 2.6 miles of shoreline, and 106 parcels abut the lake. These parcels are primarily residential and tend to serve as seasonal or, increasingly, year-round housing. Soils in the watershed are

primarily clayey soils that do not allow for significant infiltration. Soils are mapped by the National Resource Conservation Service (NRCS) by hydrologic soil group (HSG) from sandy well drained (HSG A) to clayey poorly drained soils (HSG D). See Figure 5 for a map of the soils within the Shadow Lake watershed. There are 393 Potentially Erosive Features totaling six acres mapped in the watershed, and these mapped areas indicate erosion risk (Figure 4). The watershed has 34.8-acres of Northern White Cedar Swamp, which are classified as Significant Natural Communities. The data library can be accessed via the OCNRCD website.

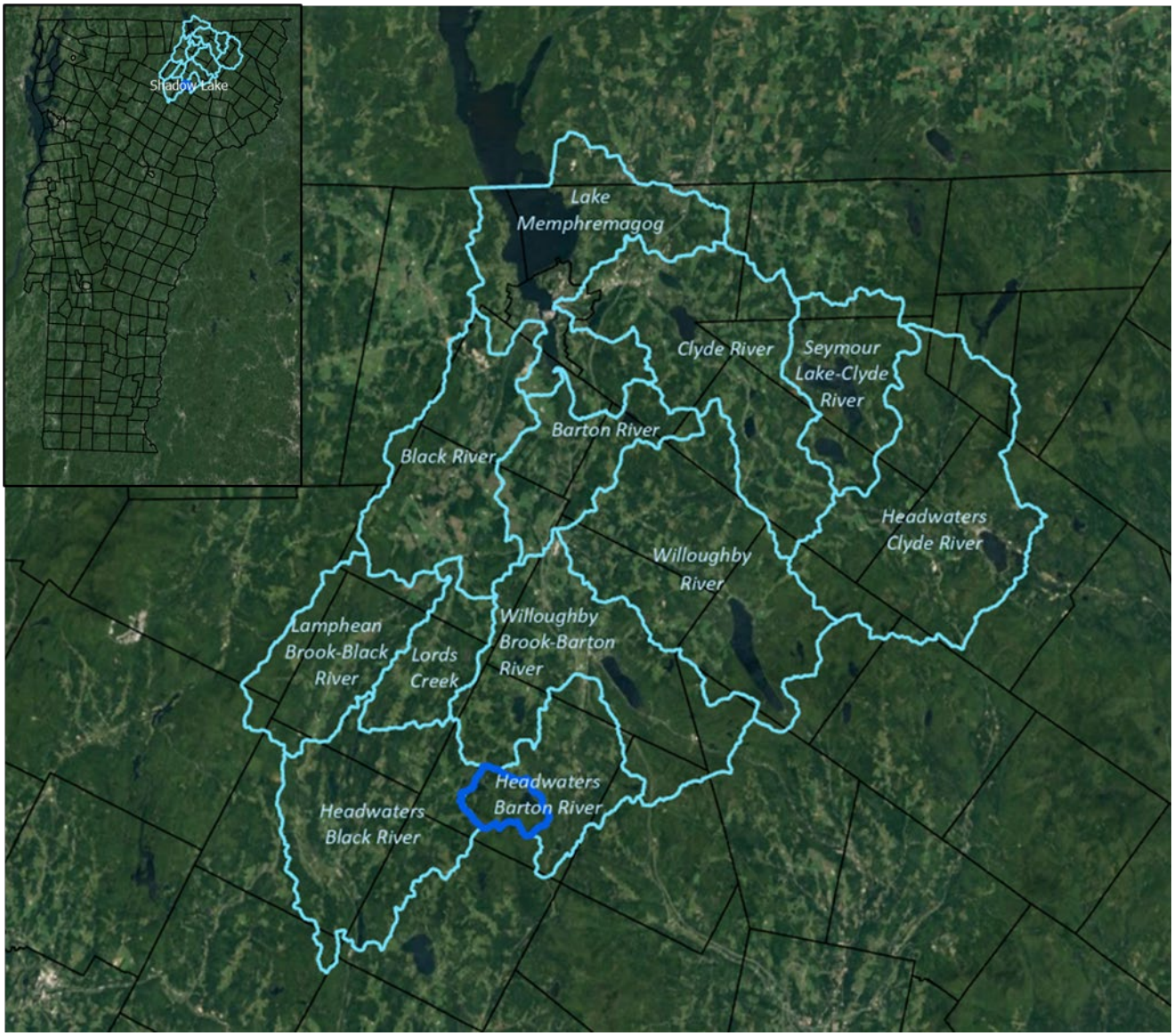

Figure 3. Shadow Lake is within the southern Lake Memphremagog watershed (see the Shadow Lake dark blue watershed boundary). An inset map in the top left shows the location of the Lake Memphremagog watershed within the State of Vermont.

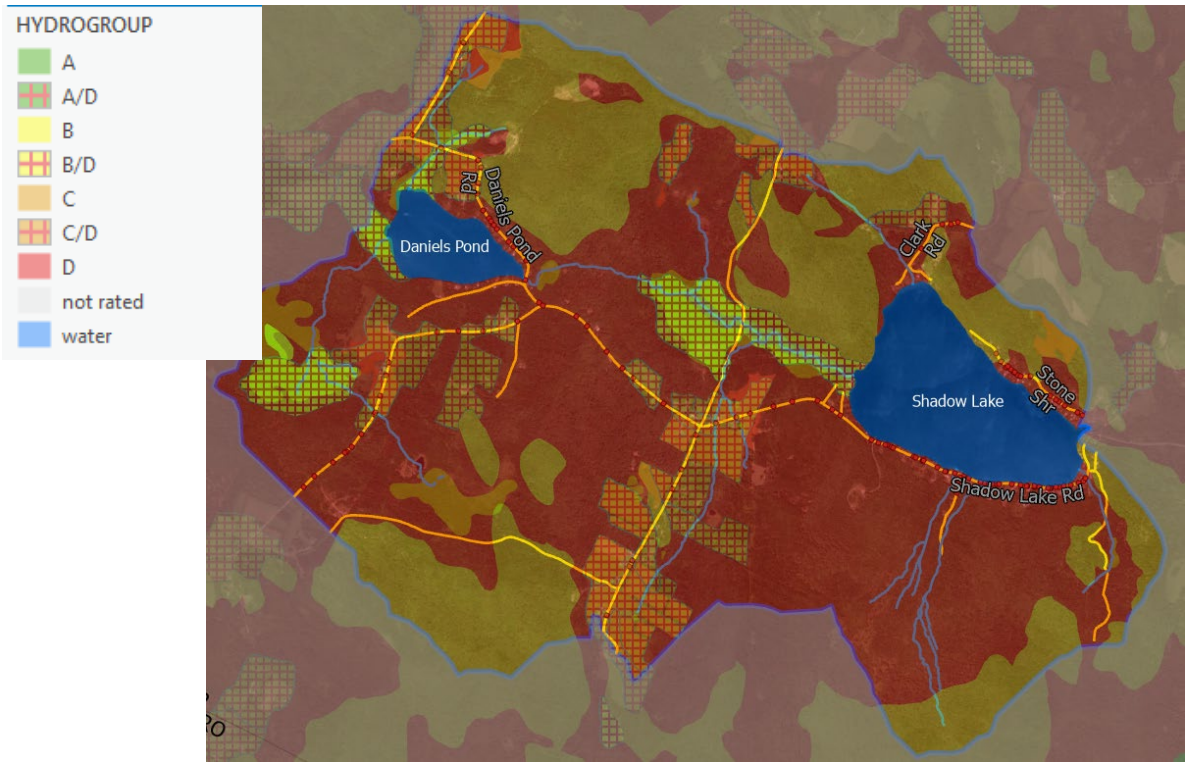

Figure 5. The mapped hydrologic soil groups (HSGs) in the watershed are primarily clayey (HSG D) and do not allow for significant infiltration unlike areas with more sandy soils (HSG A).

Figure 4. 393 Potentially Erosive Features were mapped in the watershed (see areas in red), totaling six acres (data generated by UVM Spatial Analysis lab, 2021).

Problem Definition

The Vermont Inland Lake Score Card indicates that the lake generally has poor water quality trends and has a watershed score of "moderately disturbed" (Figure 6). While overall water quality in the lake is very good with low total phosphorus (TP) concentrations, nutrient trends are poor with mean spring and summer TP steadily increasing. The Scorecard also notes that the lake is negatively impacted by flow alteration due to a dam that is present on Shadow Lake. Note that the dam is not functioning as designed and the dam is hydraulically inadequate due to its configuration according to the Vermont Dam Safety Rules. A recent hydrologic and hydraulic study of the dam can be found in the Data Library (Appendix A.2). This has resulted in higher-than-normal water levels in the lake, which can contribute to shoreline instability and erosion and results in a reduced capacity to manage the significant volume of water that flows to the lake from large storm events before flooding begins. Additionally, property damage has been reported by lakeshore residents related to these high water levels. However, in a positive trend, the lake is no longer host to invasive Eurasian watermilfoil, which had been found previously in the lake and has since been eradicated.

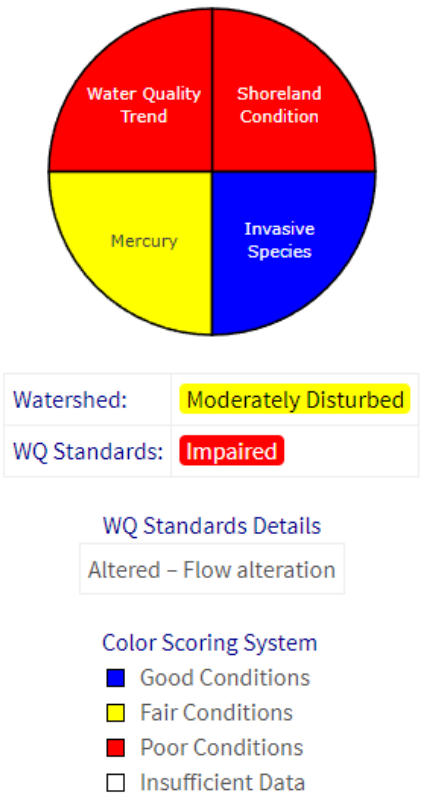

Figure 6. Vermont Inland Lake Scorecard for Shadow Lake (VT DEC, 2023b).

While the watershed is dominated by forested land cover (84.4%), it is notable that within a 100-foot buffer from the lakeshore and a 100-foot buffer from the mapped tributaries, forest cover decreased (from 84.4% to 53.8% and 72% respectively) and impervious cover increased from 1.5% in the watershed to 22.6% along the lakeshore and 2.1% along the tributaries (see Table 1). This increase in impervious cover and decrease in forest cover along the lake shore and stream riparian area is concerning as increased impervious cover is associated with increased stormwater runoff, increased pollutant (including nutrient) loading, and decreased lakeshore stability. Additionally, this landcover data was developed using data from 2016, so it is likely that development has increased in the intervening years. The remaining land cover classes not listed below include grass / shrub, water, and bare soil.

Table 1. Summary of land cover for the watershed, within a 100ft buffer of the lakeshore, and within a 100ft buffer of the tributaries within the watershed (UVM SAL, 2016).

Land Cover Class	Watershed (%)	100ft Lakeshore Buffer (%)	100ft Tributary Buffer (%)
Forest	84.4	53.8	72
Impervious	1.5	22.6	2.1
Agriculture	6.3	0	6.5

Stressors in the lake's watershed have continued to present threats to water quality including seasonal and year-round residential use, unmanaged stormwater runoff, erosion and bare soil, off road vehicle use on unstable trails, unmaintained or inadequate drainage infrastructure, loss of historic floodplains, and reduced shoreline vegetation on erodible banks. These unstable areas are likely to contribute even more pollutants in the future if they are not addressed as a result of the increased rainfall intensity predicted to occur due to climate change.

Routine water quality sampling has been completed at six tributaries along Shadow Lake by the LaRosa Partnership Program (LPP) beginning in 2021 bi-weekly from April to August and during approximately two storm

events. Bi-weekly (June through August) monitoring is also completed in the lake through the Lay Monitoring Program (LMP) from a boat. This monitoring includes Secchi disc depth (an indicator of water clarity), total phosphorus (nutrient) concentration, chlorophyll-a (algae and cyanobacteria) concentration, and caffeine concentration (a wastewater indicator of potentially leaking septic systems). In general, in-lake conditions were good with high water clarity, low chlorophyll-a, and caffeine concentrations below the lab reporting limit (0.5 ug/L). Note that in the 2024 monitoring season, the caffeine threshold will be lowered to ≤0.1 ug/L, which, if detected, could indicate leaking septic systems.

The monitoring information was reviewed and utilized to prioritize key areas of concern, specifically the Burke Culvert and Trib 1 Town Beach tributary monitoring locations (Figure 7). See the Data Library in Appendix A for more information on the LPP monitoring results for Shadow Lake including summary presentations for the 2022 and 2023 monitoring seasons.

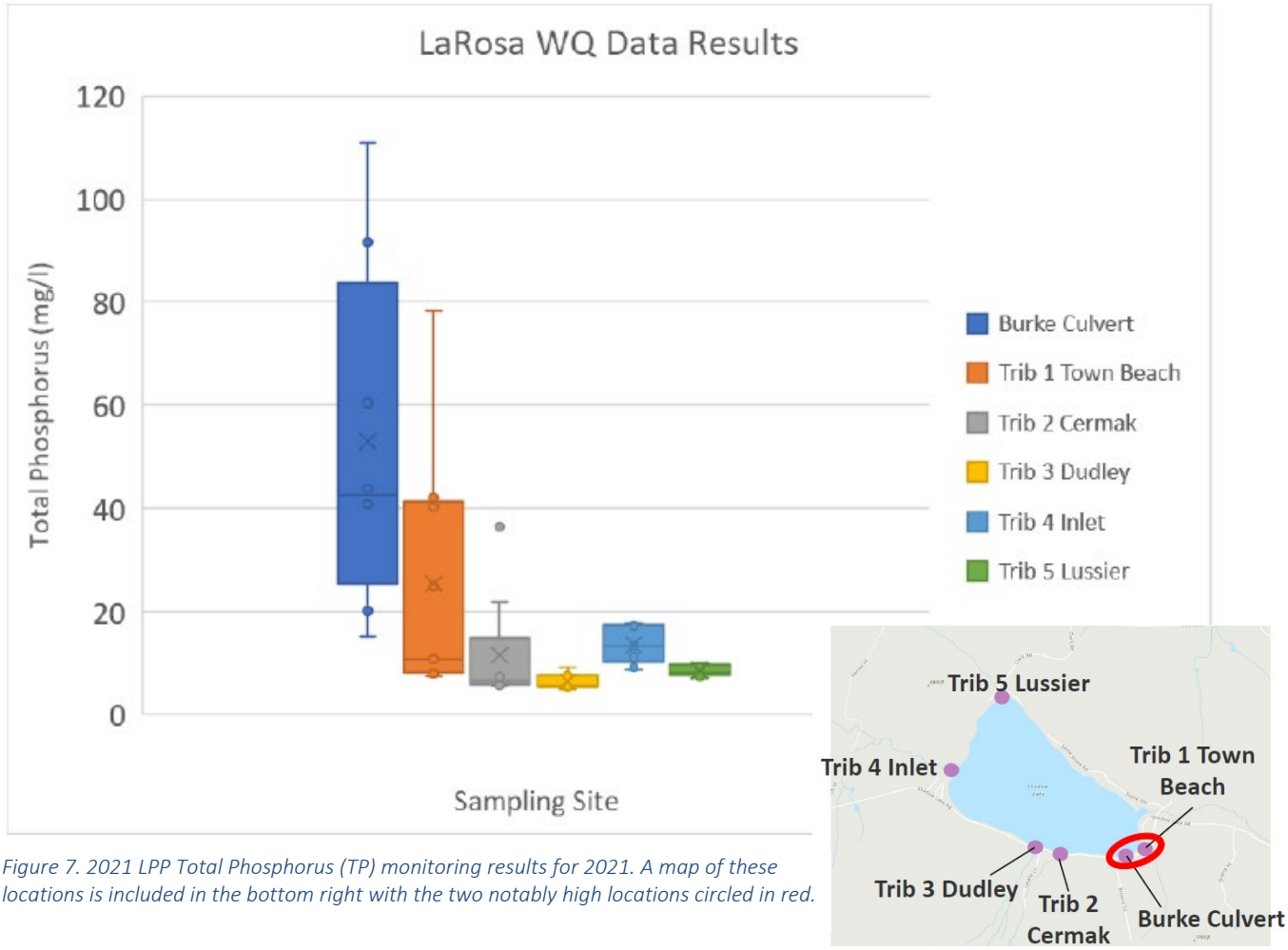

Figure 7. 2021 LPP Total Phosphorus (TP) monitoring results for 2021. A map of these locations is included in the bottom right with the two notably high locations circled in red.

A summary of potential water quality stressors to Shadow Lake include:

- Shoreline instability, reduced shoreline vegetation, and constructed retaining walls
- Stream erosion, channelization, and lack of buffers
- High water levels due to dam decreased dam functionality (operation, maintenance, and spillway design capabilities)
- Roadway grading and grader berms, unmanaged runoff, and instability
- Lack of floodplain access and stormwater storage within the watershed
- Agricultural inputs
- Development and changes in hydrology
- Forestry operations
- Off Road vehicle use
- Septic system failure
- Contamination
- Deicing chemicals
- Winter sand
- Undersized, infrequent, or absent culverts

These stressors were assessed and are further described below.

Community Engagement & Focus Area Identification

Community Kickoff Meeting

Watershed Consulting worked with the OCNRCD and the Shadow Lake Association to engage with community members and identify key areas of interest and understand the priority and focus of the lake's stakeholders. In July 2022, an in-person kickoff meeting was held in Glover with representatives from OCNRCD, VT DEC, the Town of Glover (including the Glover Planning Commission, the Glover Road Foreman, and the Glover Town Administrator), and thirteen representatives from the Shadow Lake Association. The meeting included an introduction to the LWAP process, distribution of the project timeline and outline, a presentation on the developed data library (see Appendix A), and comments and questions from attendees. Attendees were asked to mark any areas of interest or concern on an overview map of the watershed that was provided. The minutes from this meeting and the scanned map with comments is provided in Appendix E.

An annotated presentation was provided to OCNRCD for distribution to stakeholders. The presentation included information regarding the current state of the lake including a series of maps with key features shown. Examples of the types of issues commonly observed in similar communities were also provided in the presentation so that stakeholders could better understand how development and management in the watershed impacts water quality in Shadow Lake. The examples included issues related to road design and management, lakeshore issues, and stream-related issues. Other potential water quality stressors were listed at the end of the presentation. A PDF version of the presentation is provided in Appendix E.

Some of the issues noted by stakeholders included:

- Water is more "mucky" in some areas
- Water levels are higher than normal because the dam is not functioning well
- The Town does not have zoning or local ordinances regulating lakeshore development
- The upsizing of culverts for aquatic organism passage and river health has resulted in more sediment reaching the lake, so a focus should be on slowing and filtering stormwater flows to tributaries
- ATVs may be disturbing upland areas and wetlands
- High *E. coli* has been found in water quality testing results
- Chloride application around the lake is a concern
- Retaining walls and lake encroachment are common on the lake
- Increasing number of camps changing from summer only to multi-season use
- Subdivision of larger parcels is occurring so there are more smaller parcels open for development

These observations were documented in the meeting minutes (Appendix E) and utilized to develop a map showing the areas of concern (Figure 9) so they could be assessed in the field.

Focus Areas

As described in the Vermont Lake and Watershed Action Plans: Technical Guidelines for Conducting a LWAP document, the Vermont Department of Environmental Conservation (DEC) suggests three core assessment areas to focus on during field work for LWAP development (VT DEC, 2023a). These include:

- Shoreland
- Roadways (including driveways and trails)
- Streams and Tributaries

A conceptual diagram of this relationship is provided in Figure 8 below.

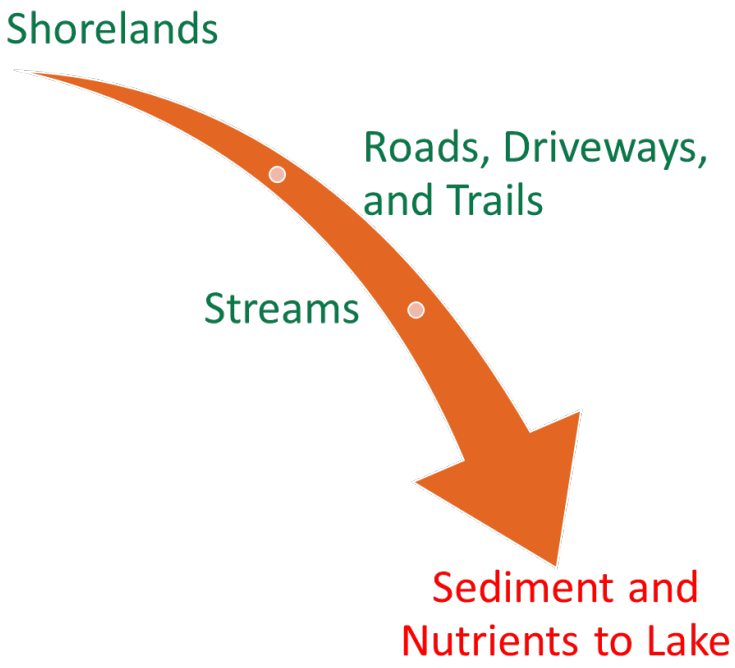

Figure 8. A conceptual diagram of the relationship between sources and sedimentation in Shadow Lake.

Existing data including water quality testing data through the La Rosa program, road erosion inventory data, stream crossings and AOP passage, developed shorelines, and other key areas where land cover, topography, stakeholder input (see the previous section for a summary of the initial stakeholder input process), or other data indicated potential issues or areas presented opportunities for mitigation. A map of these identified focus areas is provided below in Figure 9. These areas were assessed in the field and these assessments are described in the following sections.

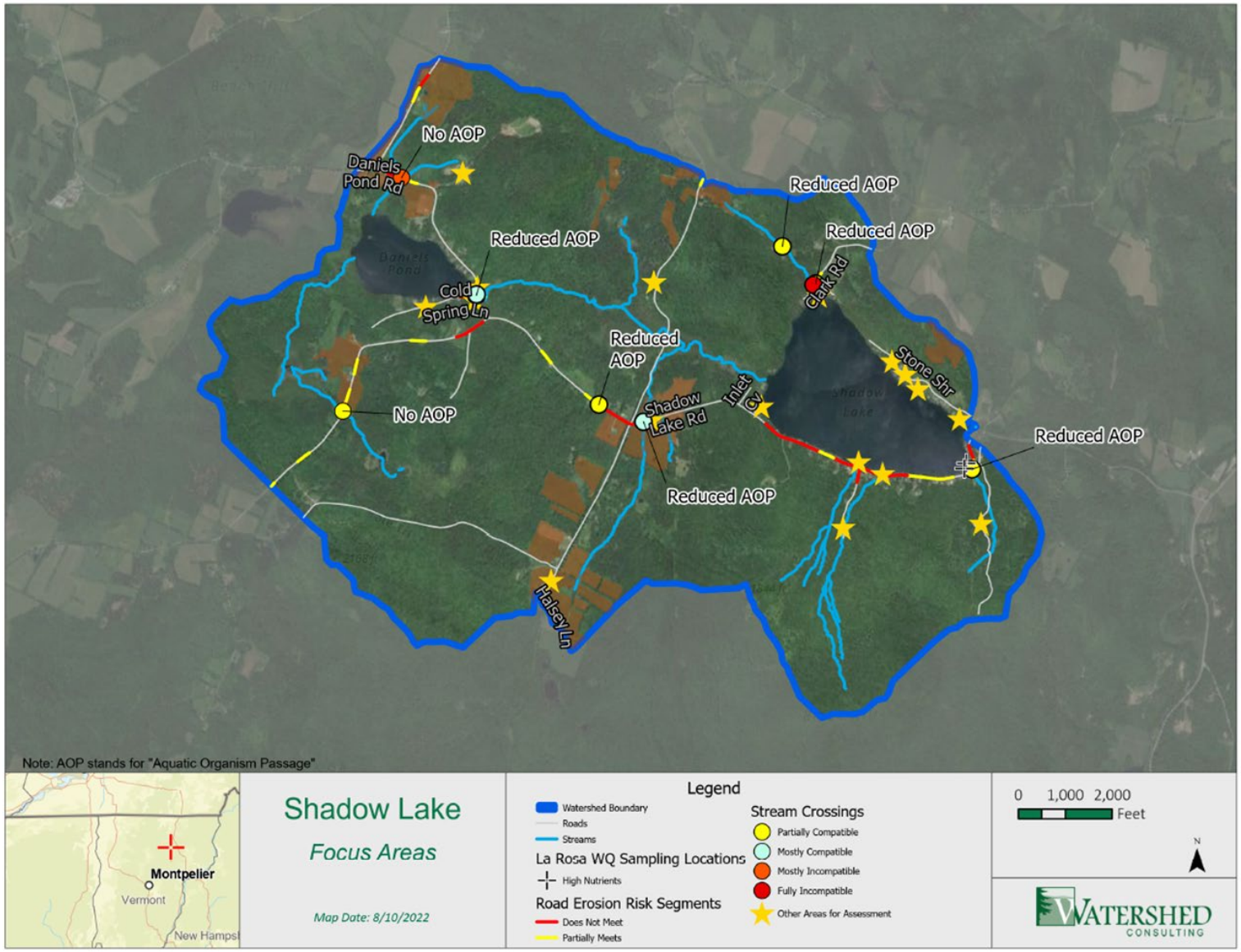

Figure 9. Identified focus areas for field assessment.

Field Assessments & Project Prioritization

Initial Field Assessments

Field assessments were completed throughout the Shadow Lake watershed over the course of several field days in 2022 and 2023. The field site visits focused on the identified focus areas (Figure 9) and documented any other observed issues. Additionally, shoreland site visits were completed along the entirety of the Shadow Lake shoreline. In total 52 projects were identified within the watershed (Figure 10). A larger version of this map with a description of each site is included in Appendix B. The shoreline assessments were completed along the entirety of the shoreline from a boat. The shoreline was broken up into 53 segments with similar characteristics (Figure 11). A larger version of this map is also included in Appendix B. Additional descriptions regarding the observations made are included by sector in the sections below.

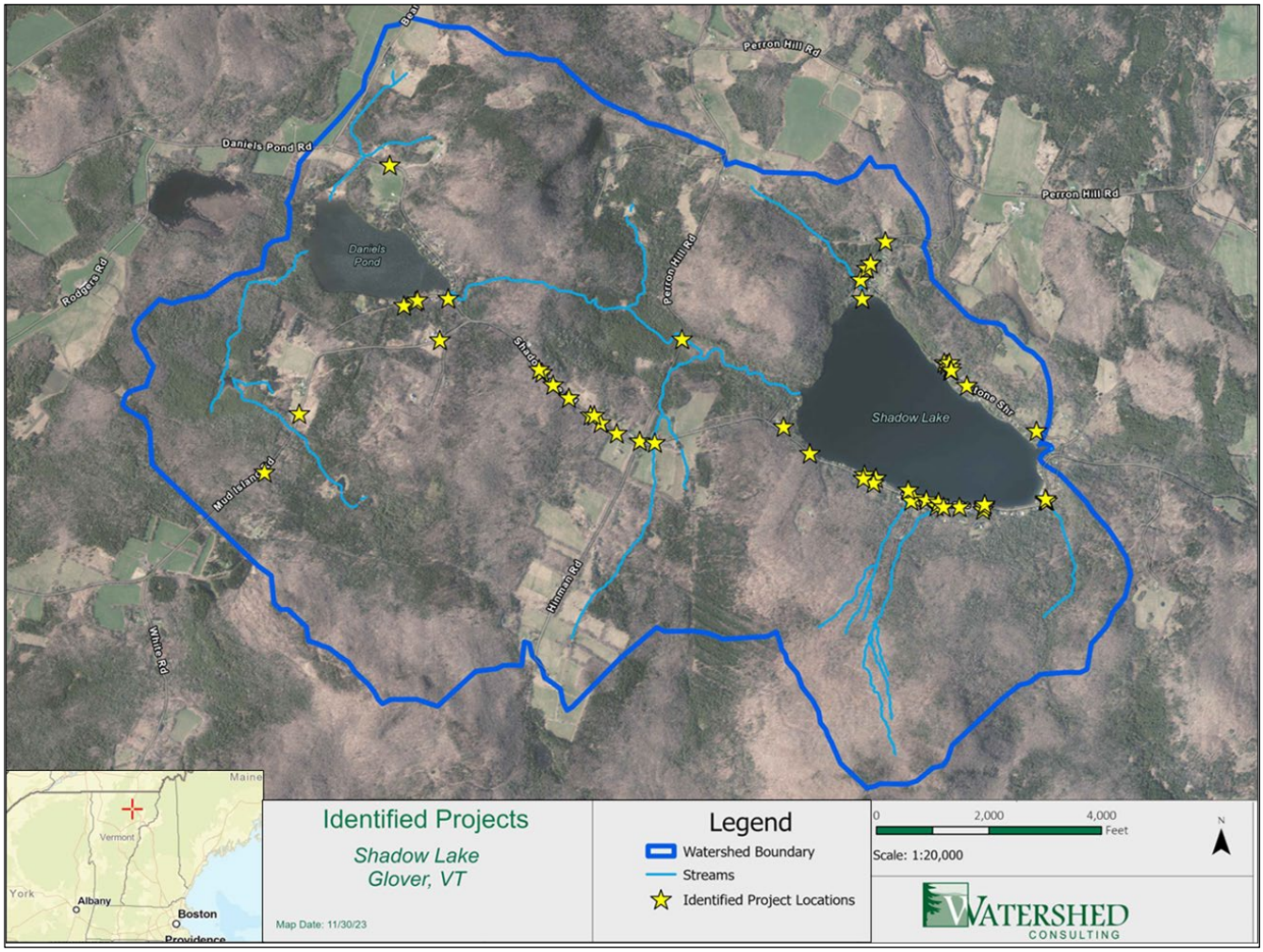

Figure 10. Overview map of the 52 identified projects within the watershed.

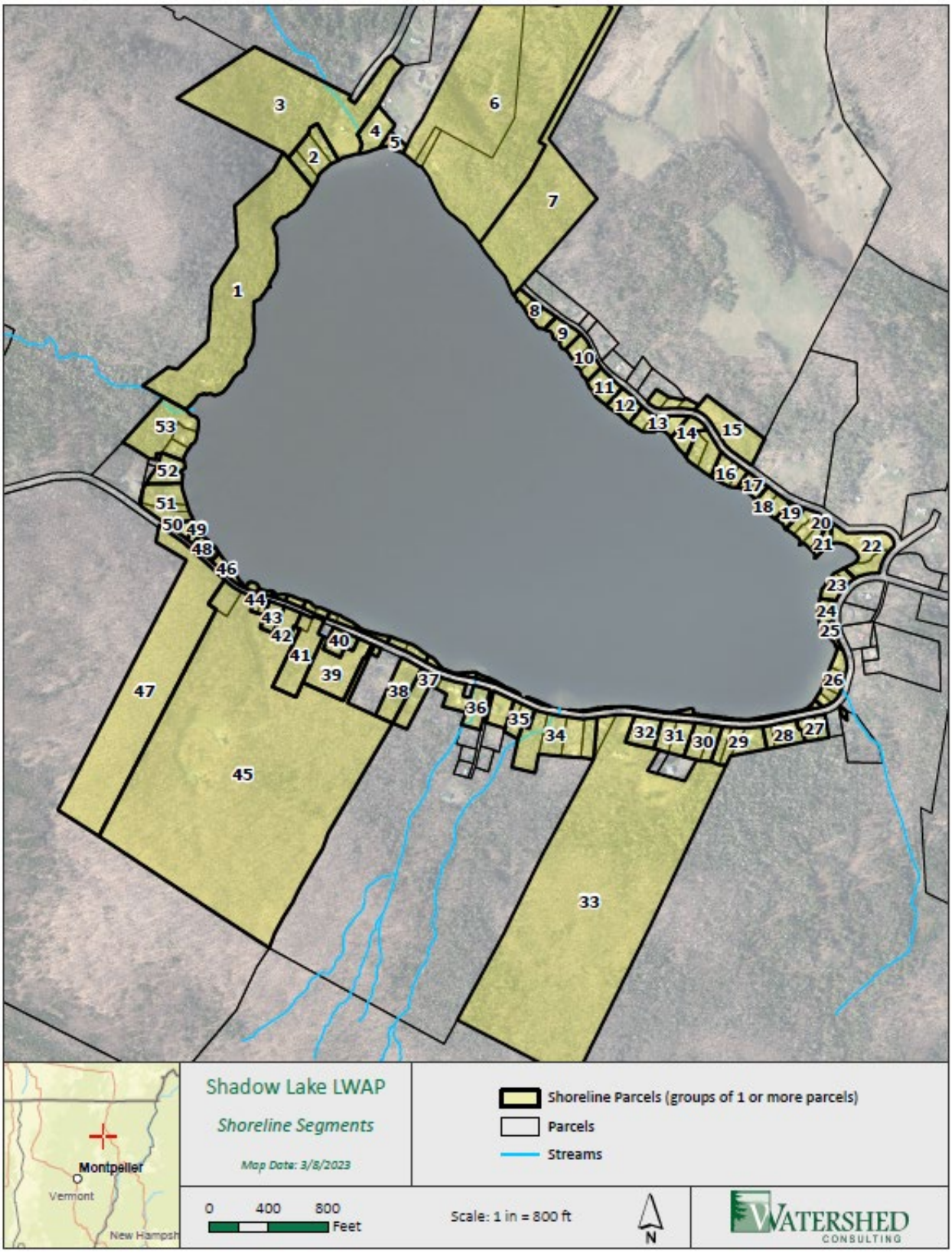

Figure 11. The Shadow Lake shoreline was divided into 53 segments, which were assessed from a boat.

Shoreland Assessments

Shoreland field assessments occurred in August 2022 via a boat. Performing these assessments from the water provided a useful perspective to assess shoreline erosion, buffer vegetation, and land use along the lake shore. A custom mobile data application was used to record observations at various locations along the shoreline and geotagged photos were collected.

The shoreland was assessed in the unit of segments, which are defined as areas that have similar characteristics. In total, 53 segments were scored using indicators of potential water quality issues (Figure 11). The criteria were scored from one to four with four indicating a higher probability of the shore condition resulting in poorer water quality. For example, if the shoreline is primarily unmanaged and well vegetated, that segment would get a score of one for that criterion. If the shoreline segment were mostly developed with little vegetation, it would receive a score of four for that criterion. A list of the criteria and associated scores can be found in Figure 12. These criteria were developed for this project utilizing the VT DEC Lake Wise Assessment categories as a resource. A full table with the segment scores can be found in Appendix C.

A map displaying the shoreline these areas with their associated water quality risk scores is provided below in Figure 13 and in Appendix D. Those areas more at risk of contributing to poor water quality were awarded higher scores. Also included in Appendix D are individual field sheets for each of these locations with a photo, location, and the specific shoreline assessment data. In general, the more densely developed areas along the southern shore of the lake were scored higher and the more undeveloped parcels along the northern and western sections of the lake were scored lower (lower risk to water quality). Examples of the most common issues observed are shown with photo examples in Figure 14 and Figure 15 below. The most common issues included a lack of a robust multi-tiered vegetated buffer, concentration of stormwater flows, and bare soil resulting in shoreline erosion.

Criteria	Categories	Score
Shoreline Natural Condition	>90% Unmanaged	1
	51-89% Unmanaged	2
	26-50% Unmanaged	3
	< 25% Unmanaged	4
Shoreline Stability	Totally Stable	1
	Mostly Stable	2
	Moderately Unstable	3
	Mostly Unstable	4
Shoreline Vegetation Width	>50 ft in width	1
	31-50 ft in width	2
	15-30 ft in width	3
	<15 ft in width	4
Shoreline Erosion	No erosion problems	1
	Minimal (1%-4% eroding)	2
	Moderate (5%-10% eroding)	3
	Significant (> 10% eroding)	4
Stormwater Flow	Entirely sheet flow	1
	Mostly sheet flow	2
	More channelized than sheet	3
	Entirely channelized flow	4
Percent Lawn and Cleared Area	< 7%	1
	Between 7% and 15%	2
	Between 15% and 30%	3
	> 30%	4
Lake Access Stability	Stable	1
	Mostly stable	2
	Somewhat stable	3
	Entirely unstable	4
Slope to Lake	Low	1
	Moderate	2
	High	3
	Very High	4
Bedrock Controls	Most bedrock	1
	Some bedrock	2
	Little bedrock	3
	No bedrock	4
Constructed Structural Stabilization	None	1
	Little of shoreline	2
	Some of shoreline	3
	Most of shoreline	4

Figure 12. The criteria and their associated scores applied to shoreline assessments at Shadow Lake. Score potential range: 10 (least likely to negatively impact water quality) – 40 (most likely to negatively impact water quality).

The Fish and Wildlife Access area is one example where stormwater is flowing over a sparsely vegetated and eroding shoreline and depositing sediment into Shadow Lake (Figure 16 and Figure 17, upper). It is recommended that this area be stabilized with native vegetation (Figure 17, lower). A stable footpath could be included to provide access to the existing bench that overlooks the lake, preserving use and preserving and improving aesthetic appeal. This retrofit would stabilize the area and reduce sedimentation to the lake. As this site is a public area with simple access, this would be a fairly straightforward practice to implement by the Shadow Lake community.

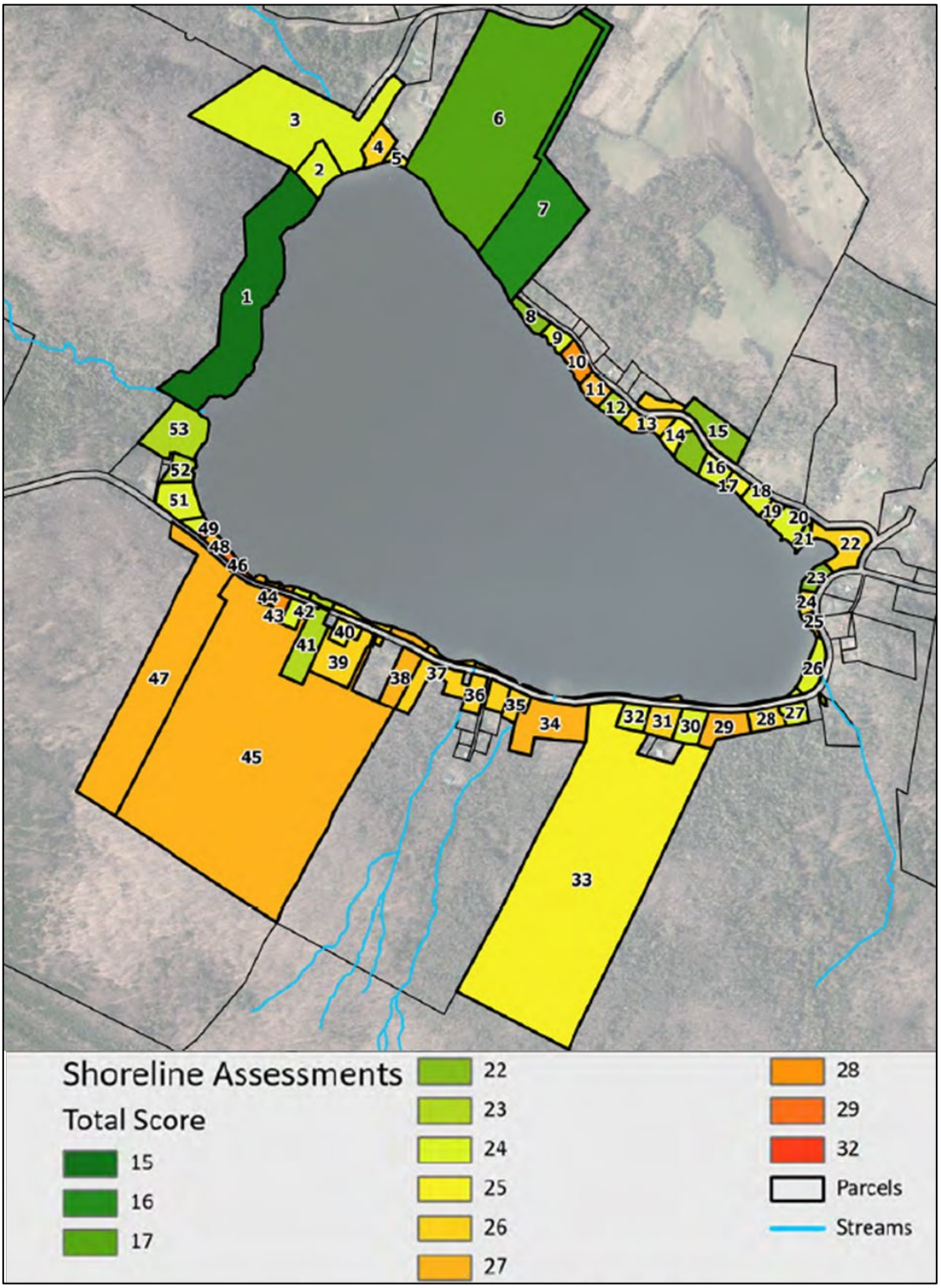

Figure 13. Shoreline assessment scores with the higher scores indicating a higher risk of poor water quality. Note that the numbers displayed on the map are ID numbers that correlate to the ranking tables and summary sheets provided in Appendix D.

Figure 14. Lakeshores lacking robust native buffers can contribute higher nutrient loads to the lake. This can result in shorelines becoming more unstable as turf grass has very shallow roots that do not stabilize the shoreline well.

Figure 15. Bare soils, especially on steep slopes, are especially prone to erosion.

Figure 16. Sediment deposition can be observed adjacent to the boat launch area (see area highlighted by an orange circle).

Figure 17. Currently, stormwater flows pass over loose sparsely vegetated shoreline before entering Shadow Lake (upper). It is recommended that this area is vegetated with native species per the VT Bioengineering Manual (VT DEC, 2022) to stabilize the shoreline and filter stormwater (conceptual retrofit is shown overlaid in lower photo).

Road Assessments

Roads within the Shadow Lake watershed were primarily assessed utilizing the key components of the Road Erosion Inventory (REI) related to the Municipal Roads General Permit (MRGP). Roads that were identified as "does not meet" or "partially meets" MRGP standards during the previous (2019) assessment were revisited, and additional road segments were also assessed in the field. Areas with issues related to known relationships between these characteristics and decreases in water quality were documented, and in total 40 project locations were identified. These projects were assigned a relative priority based on observations by trained field staff. Of these 40 projects, seven were high priority, 5 were moderate / high priority, 18 were moderate priority, five were moderate / low priority, and five were low priority. These priorities are reflected on the map below in Figure 19.

In general, several common types of issues were identified. One common situation included areas where there were unstable ditches that lack stone or vegetative stabilization often coupled with uncompacted ditch slopes and road edges leading to significant sediment transport (Figure 20). Absent or undersized culverts have resulted in erosion and sediment transport, especially during high flow events. These conditions were observed in several locations (Figure 21). Culverts that are not regularly cleaned out, especially in areas where there are these unstable road shoulders, can become clogged over time and limit the transportation capacity of these culverts (Figure 22). As these clogged culverts cannot properly convey stormwater, significant infrastructure damage can result, and these failures can also be associated with sediment loading.

Unpaved roads should be graded to shed water to vegetated areas to stable conveyances like vegetated or stone lined ditches. All grader berms (piles of material that are pushed to the edge of the road by the grader and limit or fully prevent water from leaving the road) should be removed. Several areas where grader berms prevent water from shedding off the road and instead redirect water down the road were observed in the watershed (Figure 24). Additionally, areas where roads and driveways were graded so that water is directed down the transportation surface or left ungraded for so long that tire tracks have caused ruts in the surface were observed in multiple locations (Figure 23). These lead to similar erosion and scour issues as the grader berms because water cannot leave the road or driveway surface.

The number of priority road projects were selected based on the community survey results (see Community Meeting section and see Appendix F), the top 13 public roads projects and top five private driveway projects were further assessed. The projects were scored according to a ranking matrix developed for this project. These criteria and their associated ranking scores are shown in Figure 18 below. These sites were then ranked based on the scores received for each project and one page summary sheets were developed (see Appendix D). A map of these areas can be found in Figure 25 (see Appendix C for detailed information about these areas).

Road assessments were completed before and after the July 2023 storm event, which resulted in nearly six inches of rain

Criteria	Categories	Score
Drainage Area Size	Small	5
	Medium	10
	Large	15
Water Quality Concern	Low	5
	Medium	10
	High	15
Pollutant Reduction Potential	Low	5
	Medium	10
	High	15
Design required	High	5
	Medium	10
	Low	15
Hydrologic Soil Group	A	15
	B/C	10
	D	5
Hydrologic Connectivity	Connected	15
	Semi-Connected	10
	Not Connected	5
Relative Project Cost	High	5
	Medium	10
	Low	15
Retrofit Priority	Low	5
	Medium	10
	High	15

Figure 18. The road project ranking criteria and their associated scores were applied to the 13 priority road projects. Score potential range: 40 - 120.

falling in Glover (NWS, 2023). This historic storm resulted in significant erosion and flooding in the area, which was actively being managed during assessments in the late summer of 2023. Unmanned Aircraft Systems (UAS or "drone") flights were completed to assess the impacts of this flooding and a selection of photos showing this sedimentation can be found in Figure 35. It should also be noted that Shadow Lake Rd, the road that runs parallel to the south side of the lake, was a paved road when the project began. During the time of the study, the pavement was removed from the road and as of the time of this report the road is now an unpaved gravel road. Residents have noted observing wind and traffic related dust being deposited in the lake following this change in road surface. It should also be noted that several culverts were replaced in the watershed in late 2023, but the last assessments completed for this project were completed in the beginning of August 2023, so any upgrades or improvements made after this data are not reflected in this plan. The efforts of the Town of Glover Public Works Department, particularly after this storm event, should be recognized and lauded given the significant amount of work that resulted from this storm.

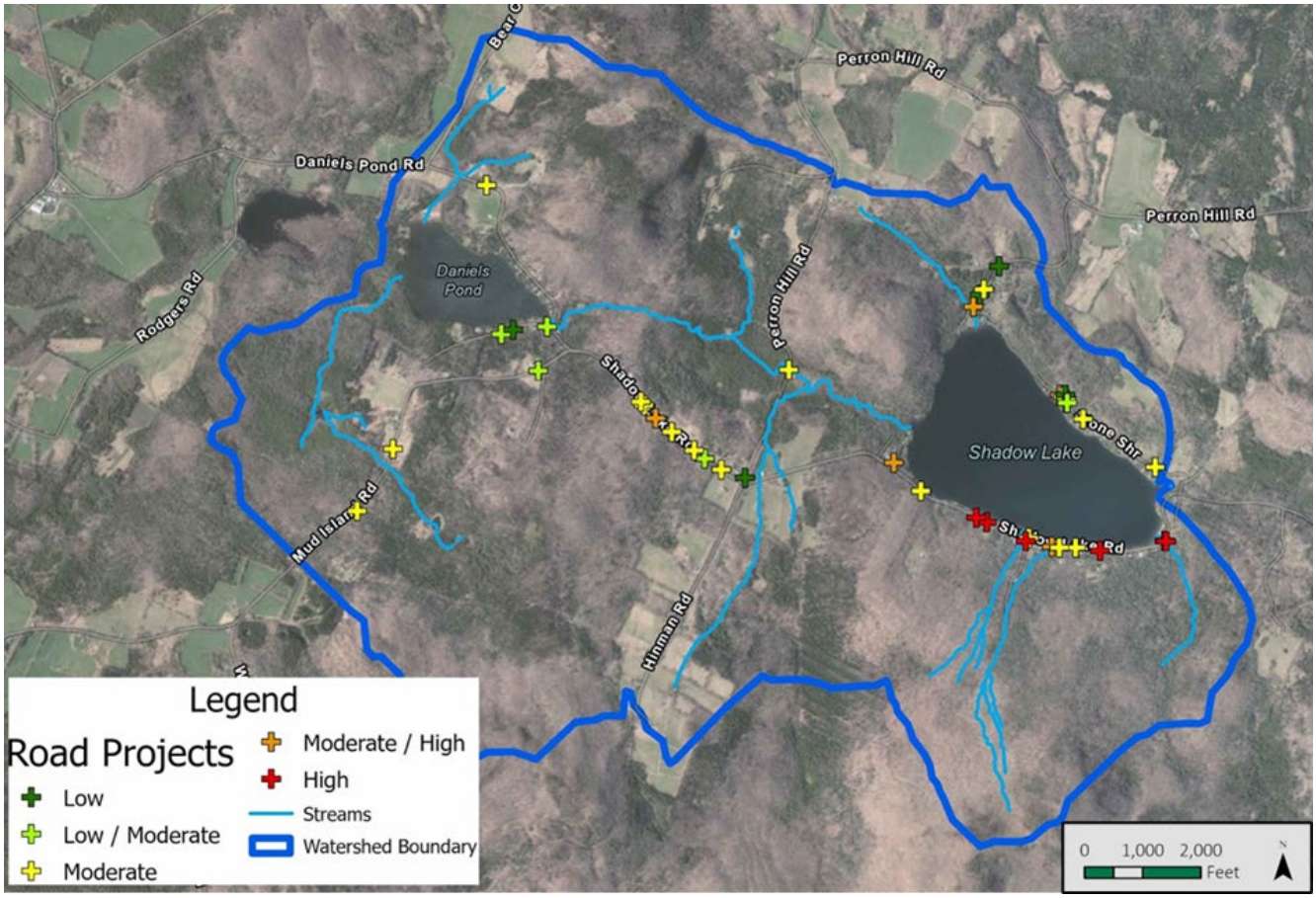

Figure 19. Road projects are shown by priority with those higher priority projects shown in red and lower priority projects shown in green.

Figure 20. Common issues observed in the watershed were unstable ditches and uncompacted ditch slopes leading to sediment transport.

Figure 21. Absent (left; see flow paths across road highlighted with red arrows) and undersized (right) culverts have resulted in erosion during larger storm events.

Figure 22. Clogged culverts cannot transport stormwater effectively and can lead to scour and flooding damage in adjacent areas and the transport of sediment to Shadow Lake.

Figure 24. Improper grading and the creation of grader berms that restrict flow to the road result in erosion and sediment transport. Red arrows show the direction of flow.

Figure 23. Several unpaved driveways in the watershed are graded so that water runs down the center of the driveway rather than shedding water off of the driveways to green areas, resulting in erosion and sediment transport especially during larger storm events. Red arrows show the direction of flow.

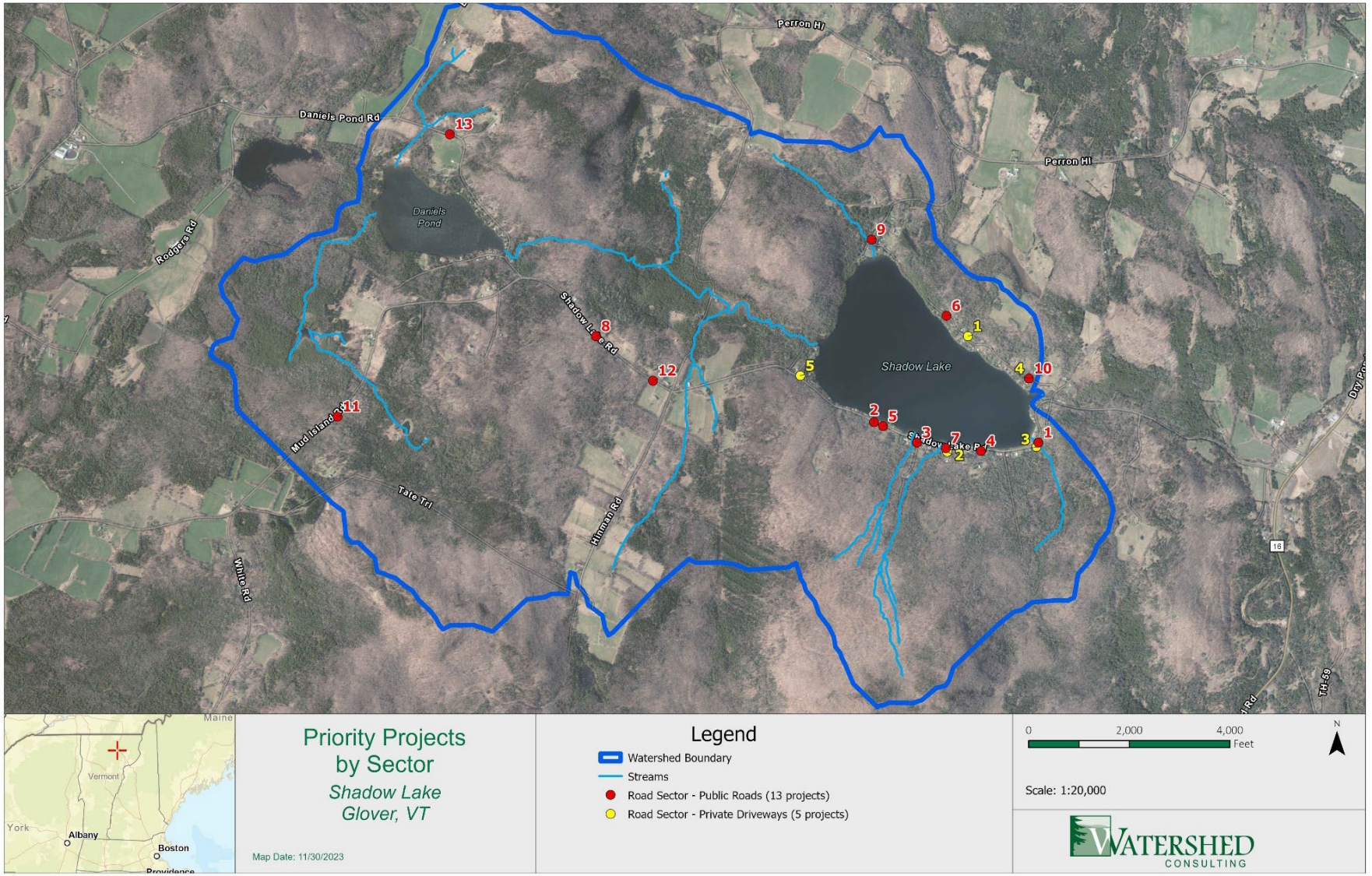

Figure 25. The selected priority road (and driveway) projects are shown within the watershed. The numbers correspond to the project rank within the sector.

Stream Assessments

Limited stream assessments were completed with a focus on the developed areas of the watershed. As this project did not include full stream walks like complete LWAPs, the streams within the wooded upland areas of the watershed were only assessed using remote methodologies including existing GIS data and UAS data collected by the project team in 2022 and 2023. Due to the known issues related to the high sediment and nutrient loads transported by several of the tributaries in the watershed, existing ATV use, and the potential for other stream sector stressors that are currently unknown, it is recommended that additional field-based assessments of these tributaries be completed. The LaRosa Partnership Program (LPP) 2023 monitoring results has shown that high Total Phosphorus (TP) loading was measured at the Burke Culvert, the Trib 5 Lussier Culvert, and the Trib 1 Town Beach monitoring locations (Figure 26). An interactive map of these monitoring sites can be accessed at this link. It is recommended that further investigations including stream walks are performed at these locations at a minimum. These stream walks were not completed during this project as this was not within the scope of the project and the spatial analysis methods used to assess the watershed were limited and limited by dense tree cover. A summary report of the 2023 monitoring results can be found in the Data Library (Appendix A).

The primary stream-related issues that were observed in the watershed include lack of robust vegetated buffers, lack of floodplain access, unstable streambanks, scour and erosion near stream culverts, and unfiltered channelized direct stormwater inputs into streams. Riparian buffers are important to stabilize stream banks, slow and filter stormwater, and provide shading and habitat complexity within the stream (Figure 28). Unstable stream banks were noted in multiple locations (Figure 29). The observed causes are generally related to one or more of the following factors:

- Concentrated stormwater flows such as ditches draining into streams
- Lack of robust vegetated riparian buffers that stabilize streambanks
- Increased high flows due to “flashy” streams that result from a change in hydrology related to development (i.e., higher volumes of stormwater are reaching the streams faster when areas are changed from a pervious land cover type to impervious land cover type)
- Undersized culverts that increase stream power by reducing the size of the stream channel

Figure 26. LaRosa program water quality monitoring locations at Shadow Lake. The three locations with high TP loads in 2023 are highlighted with an orange box.

One area where several of these issues was observed was the Fish and Wildlife Access area. This area lacks a vegetated riparian buffer, has an undersized culvert that restricts flows, and has a straightened stream channel that decreases stream roughness and sinuosity and thus increases stream velocity and erosive power (see Figure 30 and Figure 31). Culverts should be sized to adequately pass at least a 10-year storm event. The recommended minimum diameter of stream culverts is the bankfull width of that stream (in sensitive areas, this recommendation is increased to 1.2 times bankfull width). The bankfull width, not to be confused with the water level at any given time as this can fluctuate greatly, is a measure of how wide a stream is when it is passing channel forming stream flows. These flows occur regularly (generally annually or semiannually) and maintain the shape of that stream channel. See Figure 27 for a diagram showing the concept of bankfull width.

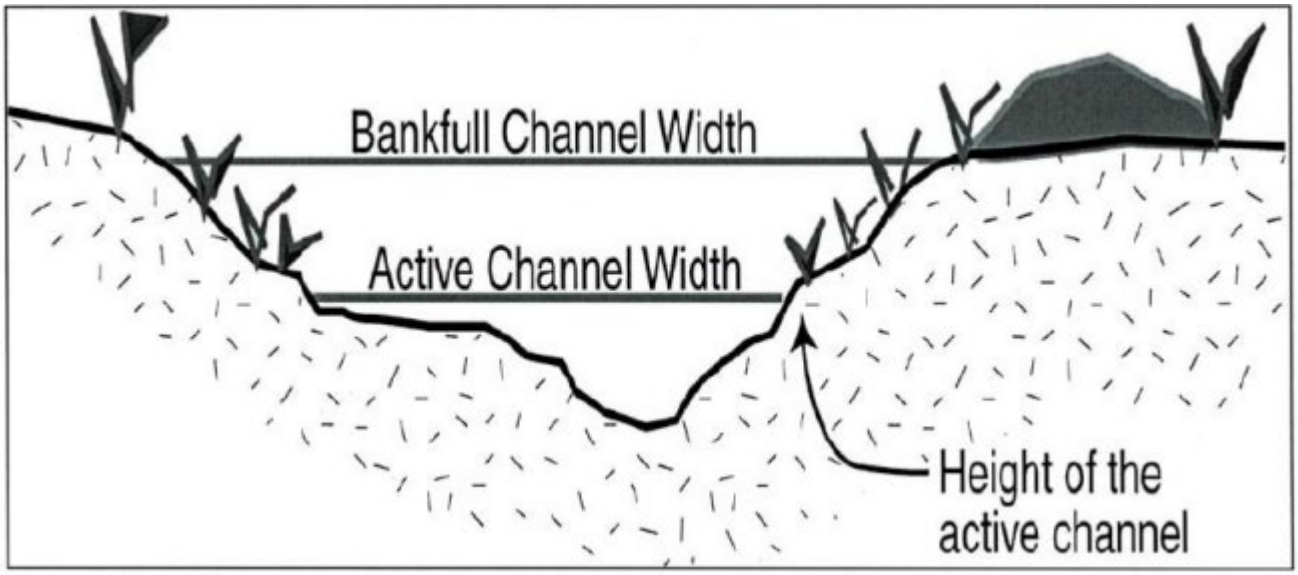

Figure 27. Diagram showing the bankfull channel width as compared to the active channel width in a typical stream (VT DEC MRGP, 2023)

Figure 28. Several stretches of stream within the watershed lack a robust riparian buffer.

Figure 29. Unstable stream banks and direct connections between roadside ditches and streams are recurring problems in the watershed.

Figure 30. The Fish and Wildlife Access parking area abuts a tributary that has been artificially straightened and lacks a robust riparian buffer (upper left and lower left) and has an undersized culvert (bottom right) that contributed to the stream jumping its banks during the July 2023 storm, which caused significant damage and sediment transport (top right).

Figure 31. The tributary along the Fish and Wildlife Access area (shown with red arrows) jumped its banks and flowed through the parking area during the July 2023 storm (blue arrows).

In total 17 projects were identified within the stream sector. These included five high priority, 10 moderate priority, and two low priority projects (Figure 33). Note that these projects identified do also include unmapped tributaries within the watershed in addition to the mapped streams shown on the provided figures.

The five high priority projects were scored according to a ranking matrix developed for this project. These criteria and their associated ranking scores are shown in Figure 32. These five sites were then ranked based on the scores received for each project and one page summary sheets were developed for the top four projects as determined by the community survey results (see Appendix F). A map of these five ranked priority areas can be found in Figure 34 (see Appendix F for detailed information about these areas). Recommendations include restoring floodplain access, increasing riparian buffers, and increasing undersized culverts.

Following the July 2023 storm event, the stream network in the Shadow Lake watershed transported significant sediment that was then deposited in the lake. UAS-collected imagery shows large depositional areas at several stream culvert outlets (Figure 35). While this was an extreme event with much larger than normal stream volumes and velocities, some deposition at these culvert outlets was already observed, which indicates that providing additional floodplain access, increasing stormwater storage within the watershed, reducing and slowing stormwater flows to the stream network, and stabilizing erosion in the watershed are all important in reducing sediment loading to the lake.

Criteria	Categories	Score
Drainage Area Size	Small	5
	Medium	10
	Large	15
Water Quality Concern	Low	5
	Medium	10
	High	15
Pollutant Reduction Potential	Low	5
	Medium	10
	High	15
Design required	Low	5
	Medium	10
	High	15
Hydrologic Soil Group	A	15
	B/C	10
	D	5
Hydrologic Connectivity	Connected	15
	Semi-Connected	10
	Not Connected	5
Relative Project Cost	Low	5
	Medium	10
	High	15
Retrofit Priority	Low	5
	Medium	10
	High	15

Figure 32. The stream project ranking criteria and their associated scores were applied to the five high priority stream projects. Score potential range: 40 - 120.

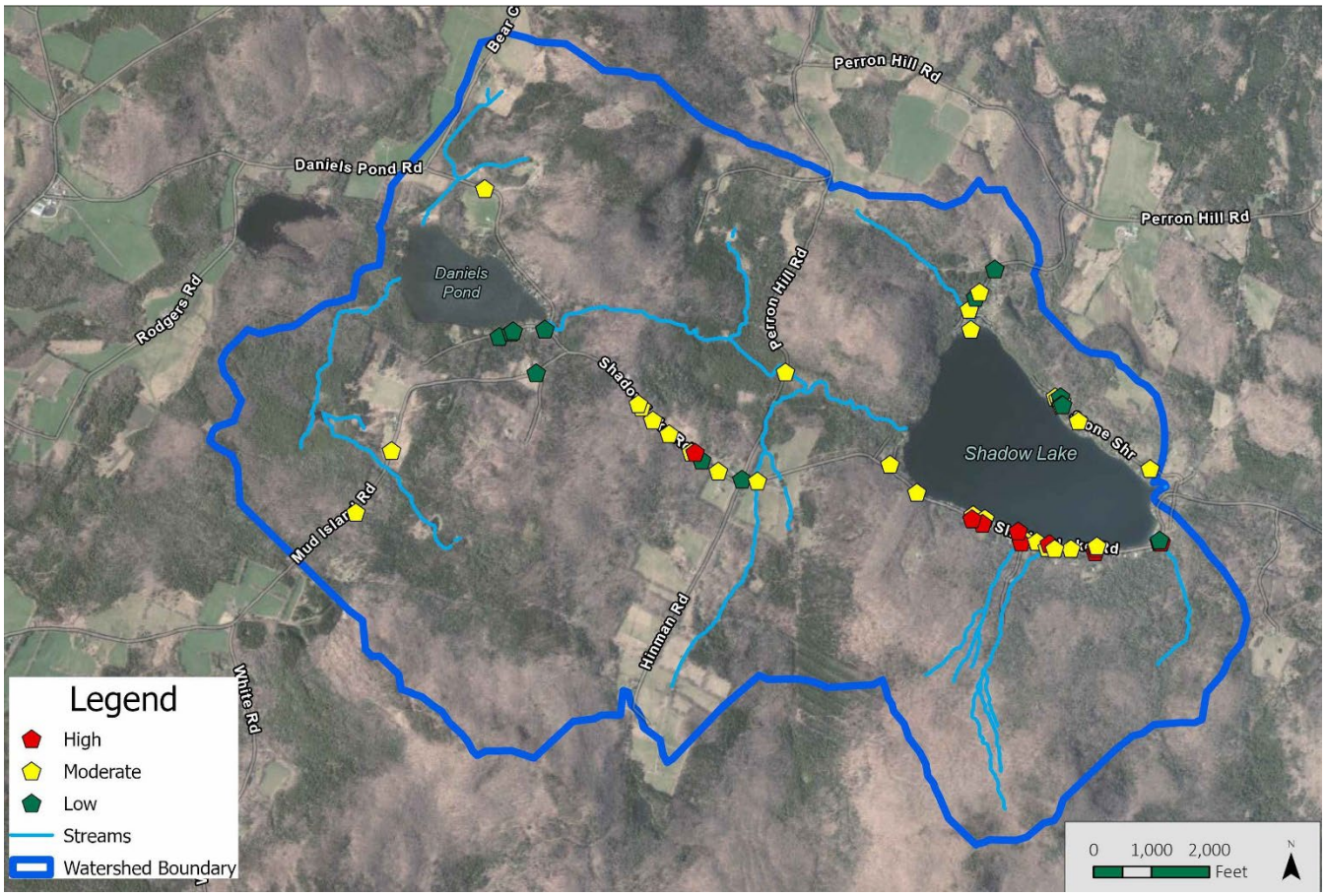

Figure 33. Identified projects within the stream sector were preliminarily ranked into high, moderate, and low priority.

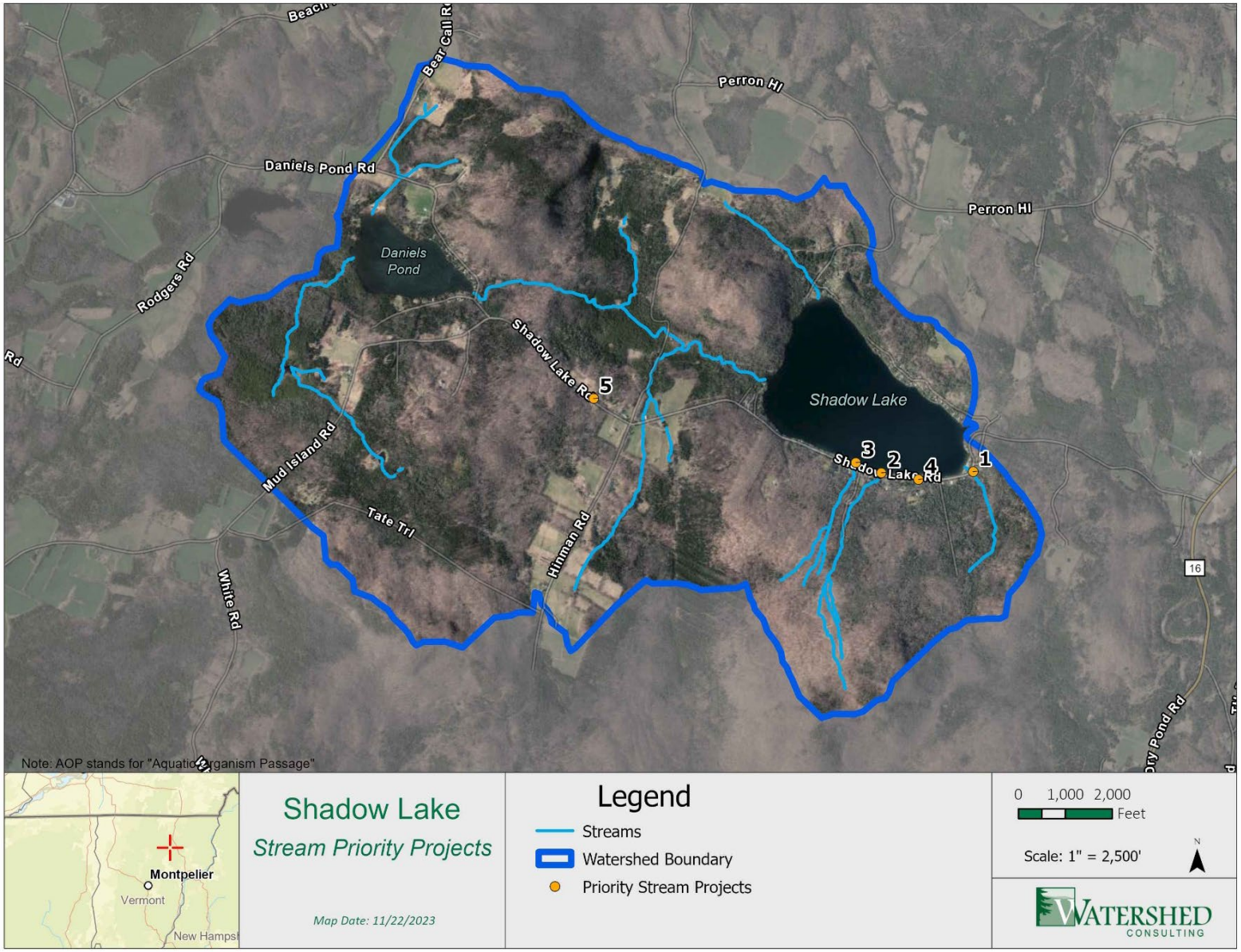

Figure 34. The five selected priority stream projects are shown within the watershed. The numbers correspond to the project rank within the sector.

Figure 35. Significant sediment was deposited in Shadow Lake from stream culverts following the July 2023 storm event.

Priority Projects

In total, 30 priority projects were identified and ranked across the three sectors. This included 18 road projects (13 public road projects and eight private road and driveway projects), eight shoreline projects, and four stream projects (although five are included as priority projects). The number of projects per sector were determined by the watershed's stakeholders utilizing a survey (Appendix F). A map of these projects with their associated ID number can be found in Figure 36 below. A brief summary table can be found in Table 2. The associated one-page summary sheets can be found in Appendix D. The ranking tables can be found in Appendix C. The overview map can be found in Appendix B.

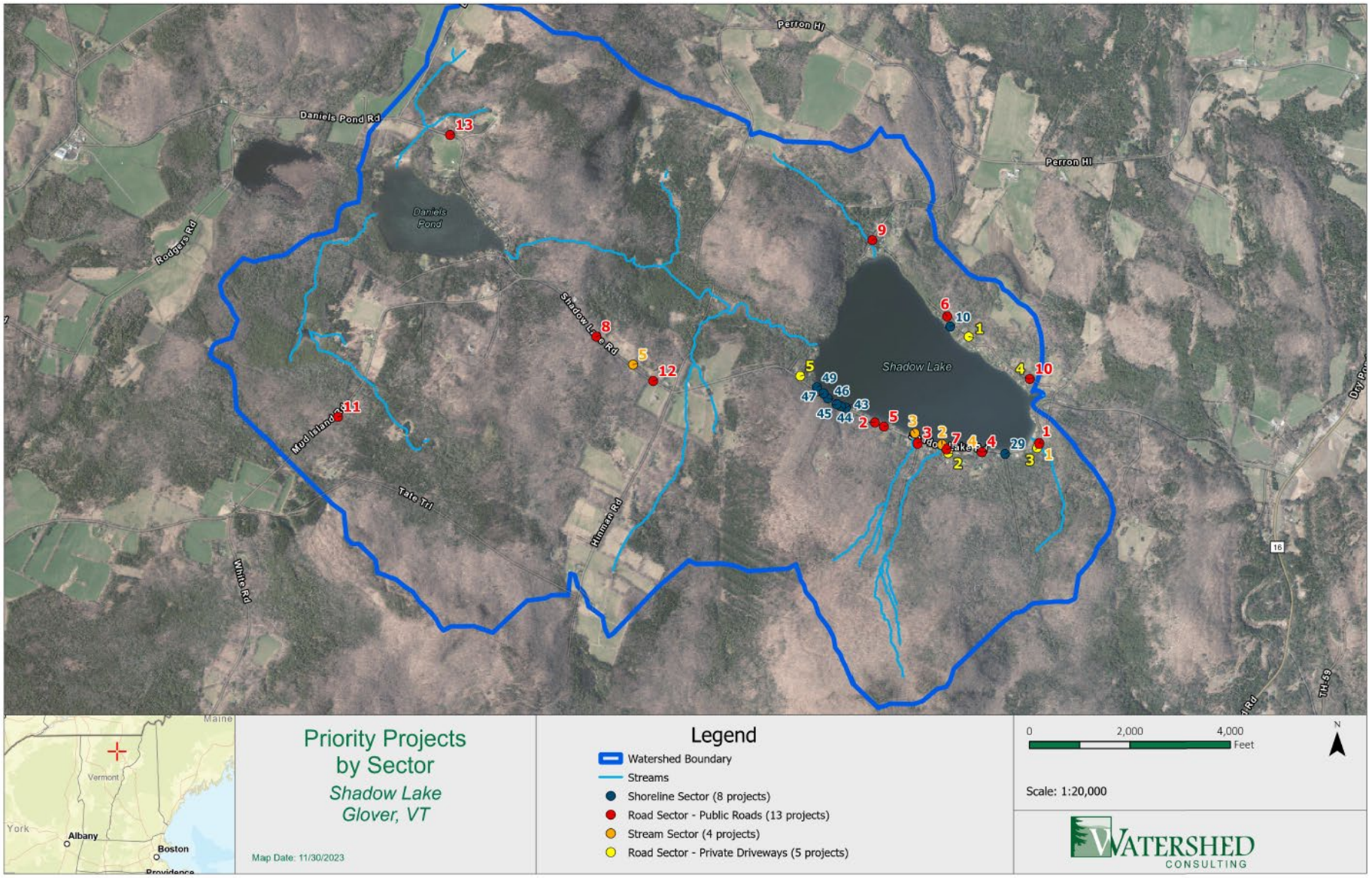

Figure 36. Priority projects by sector. Note that a fifth project was included in the stream sector as the Top 5 were ranked due to their high priority.

Table 2. Summary table of priority projects. Map IDs correspond to IDs shown in Figure 36 above.

Site name / ID:	Map ID (by sector)	Sector Type(s)	Proposed BMP Description:	Site Description	Project rank by sector
Town Beach Stream	1	Stream (and Road)	Stream has jumped banks in July storm; area is depressed so there was significant sediment deposition; floodplain restoration project recommended	Area where stream passes by public parking area to beach and enters culvert to drain to lake. Option to use the area around the public parking lot to provide floodplain access.	1
Trib 2 Cermak	2	Stream (and Road)	Improve flood storage and sediment detention along stream in greenspace between residences. Homeowner noted that there was a natural detention area in this location historically, but it was filled in over time. Homeowner noted that when the detention area was functioning, there was significantly less sediment being transported to the lake. It is proposed to reform this floodplain detention area.	Significant sediment deposition at stream culvert outlet.	2
Trib 3 Dudley	3	Stream (and Road)	Improve flood storage and sediment detention along stream in greenspace between residences.	Significant sediment deposition at stream culvert outlet.	3
Shadow Lake FW Access Area Stream	4	Stream (and Road)	Stream jumped banks and eroded parking area; culvert undersized; culvert by Shadow Lake Rd is partially clogged with sediment. Improve stream access to floodplain and riparian buffer; upsize culvert and ensure proper drainage to lake. Mitigate parking lot (see parking lot BMP sheet).	Area where stream passes by public parking area for boat ramp access and enters culvert to drain to lake.	4
Perron Hill Stream Restoration	5	Stream	Potential for a large floodplain restoration project	Significant sediment accumulated after July storm; flat area adjacent to stream. Noted significant sediment transport.	5
Ditches by Public Beach	1	Public Areas including Roads	It is recommended that the ditches in this area are stabilized, road edges compacted, excess sediment removed, culverts cleaned out, and check dams installed in ditches where slope allows. The remainder of ditches should be well vegetated to prevent further erosion. Floodplain restoration project also recommended in this area.	Public road including ditches and culverts. Stream has jumped banks in July storm; area is depressed so there was significant sediment deposition.	1

Site name / ID:	Map ID (by sector)	Sector Type(s)	Proposed BMP Description:	Site Description	Project rank by sector
Shadow Lake Rd	2	Public Areas including Roads	Potential to manage drainage along road prior to discharge to lake via culvert. Remove grader berm, compact road edge, remove excess sediment, culverts need to be cleaned out, and check dams installed in ditches where slope allows. The remainder of ditches should be well vegetated to prevent further erosion.	Public road including ditches and culverts.	2
Leland Ln	3	Public Areas including Roads	Road is very steep and needs to be better graded to shed water to ditch; add check dams and areas of stone lining in ditches for steeper sections	Steep road sloping towards lake; sediment noted at culvert at bottom of hill.	3
Fish and Wildlife Parking	4	Public Areas including Roads	Provide a vegetated buffer along stream; upsize stream culvert and improve drainage in this area; culvert undersized; culvert by Shadow Lake Rd is partially clogged with sediment. This area should be stabilized and cleaned of sediment. A bioretention is recommended in low area of parking lot.	Stream jumped banks and eroded parking area in July storm.	4
Shadow Lake Rd 2	5	Public Areas including Roads	Potential to manage drainage along road prior to discharge to lake via culvert. Remove excess sediment, culverts need to be cleaned out, and check dams installed in ditches where slope allows. The remainder of ditches should be well vegetated to prevent further erosion.	Public road including ditches and culverts.	5
Stone Store Rd Cross Drainage	6	Public Areas including Roads	Flows ran over road in July storm and caused significant erosion on the road and downstream of this location. Stabilize the road and install adequate cross drainage, conveyance that is stabilized (stone lined), and sediment trap(s).	Road with residences up and downhill.	6
Shadow Lake Rd 3	7	Public Areas including Roads	Potential to manage drainage along road prior to discharge to lake via culvert. Remove excess sediment, culverts need to be cleaned out, and check dams installed in ditches where slope allows. The remainder of ditches should be well vegetated to prevent further erosion.	Public road including ditches and culverts. Significant sediment transport from culvert.	7
Shadow Lake Rd W1	8	Public Areas including Roads	Ditches are full of sediment; grader berm is preventing road from draining to ditches; piles of loose sediment by culvert. Remove excess sediment, culverts need to be cleaned out, and check dams installed in ditches where slope allows. The remainder of ditches	Public road with ditches and culverts	8

Site name / ID:	Map ID (by sector)	Sector Type(s)	Proposed BMP Description:	Site Description	Project rank by sector
			should be well vegetated to prevent further erosion (or stone lined if >8% slope).		
Clark Rd S	9	Public Areas including Roads	Poor grading; grader berm; unstable sediment being transported down towards lake and into stream. Stabilize road, regrade, and install sediment trap prior to stream.	Road that slopes towards stream	9
Stone Shore Rd E	10	Public Areas including Roads	Unstable sediment being transported down towards lake and into stream. Stabilize road, regrade, and install sediment trap prior to stream.	Ditches and culverts along road	10
Mud Island Rd	11	Public Areas including Roads	Ditches are full of sediment with piles of loose sediment by culvert. Remove excess sediment, culverts need to be cleaned out, and check dams installed in ditches where slope allows. The remainder of ditches should be well vegetated to prevent further erosion (or stone lined if >8% slope). Install turnouts and sediment traps prior to culvert, which is currently transporting sediment.	Road with culverts and ditches.	11
Shadow Lake Rd W2	12	Public Areas including Roads	Ditches are full of sediment; grader berm is preventing road from draining to ditches. Remove grader berms. Remove excess sediment, culverts need to be cleaned out, and check dams installed in ditches where slope allows. The remainder of ditches should be well vegetated to prevent further erosion (or stone lined if >8% slope). Install turnouts and sediment traps prior to culverts, which are currently transporting sediment.	Road with culverts and ditches.	12
Driveway 1	1	Private Driveway	Regrade driveway, add water bars along length to break up concentrated flow that is currently flowing down the center of driveway and causing significant erosion. Direct water bars to stable vegetated or stone lined areas or rain gardens.	Private driveway that is fairly steep with unstable substrate and poor grading.	1
Driveway 2	2	Private Driveway	Driveway surface is unstable, and it is recommended that a more appropriate surface be installed. Capture drainage and filter prior to discharge to culvert at bottom of driveway in sediment trap or rain garden.	Significant sediment mobilization, particularly along bottom of driveway prior to culvert.	2
Driveway 3	3	Private Driveway	Private driveway is poorly graded and is constructed of non-ideal materials. The driveway should be regraded to better shed water	Private driveway with significant issues following July storm	3

Site name / ID:	Map ID (by sector)	Sector Type(s)	Proposed BMP Description:	Site Description	Project rank by sector
			and proper substrate should be utilized. Capture sediment at bottom of driveway in sediment trap or rain garden prior to discharge to culvert.		
Driveway 4	4	Private Driveway	Driveway surface is unstable near the bottom of the hill, and it is recommended that a more appropriate surface be installed. Capture drainage and filter prior to discharge to culvert at bottom of driveway in sediment trap or vegetated filtration area. Driveway should be graded to shed water along length to vegetated shoulder.	Long private driveway. Significant sediment mobilization, particularly along bottom of driveway prior to culvert.	4
Driveway 5	5	Private Driveway	Driveway surface is unstable near the bottom of the hill, and it is recommended that a more appropriate surface be installed. Capture drainage and filter prior to discharge to culvert at bottom of driveway in sediment trap or vegetated filtration area. Driveway should be graded to shed water along length to vegetated shoulder.	Long private driveway. Sediment mobilization observed, particularly along bottom of driveway prior to culvert.	5
2078 Shadow Lake Rd	49	Shoreline	Stabilize lakeshore with robust native buffer and/ or bioengineering project. Consider stormwater management upslope from shore.	Private shoreline	1
2004 Shadow Lake Rd	46	Shoreline	Construct lakeshore buffer and / or establish a no mow zone along the lakeshore. Consider managing roof runoff (rain gardens, rain barrels, etc.)	Private shoreline	2
513, 525, 557 Stone Shore Rd	10	Shoreline	Construct lakeshore buffer and / or establish a no mow zone along the lakeshore. Consider managing roof runoff (rain gardens, rain barrels, etc.). Consider bioengineering stabilization when walls need to be repaired or replaced.	Private shoreline	3
1921 Shadow Lake Rd	43	Shoreline	Consider bioengineering stabilization when walls need to be repaired or replaced.	Private shoreline	4
Shadow Lake Rd	44	Shoreline	Consider bioengineering stabilization when wall need to be repaired or replaced with stable lakeshore access.	Private shoreline	5

Site name / ID:	Map ID (by sector)	Sector Type(s)	Proposed BMP Description:	Site Description	Project rank by sector
1289, 1319 Shadow Lake Rd	29	Shoreline	Consider bioengineering stabilization when wall need to be repaired or replaced with stable lakeshore access. Increase lakeshore buffer plantings.	Private shoreline	6
1957, 1967 Shadow Lake Rd	45	Shoreline	Consider bioengineering stabilization when wall need to be repaired or replaced with stable lakeshore access. Increase lakeshore buffer plantings.	Private shoreline	7
2018, 2042 Shadow Lake Rd	47	Shoreline	Enhance native buffer and/ or bioengineering project. Consider stormwater management upslope from shore.	Private shoreline	8
481 Stone Shore Rd	11	Shoreline	This site has been under construction. When complete, it should meet VT shoreline regulations. However, at time of assessment, the area was lacking a robust riparian buffer, particularly in the low point of the shoreline. This is the area most likely to receive higher volumes of stormwater so it is a critical area to ensure stabilization.	Private shoreline	9
1734, 1762 Shadow Lake Rd	38	Shoreline	Construct lakeshore buffer and / or establish a no mow zone along the lakeshore. Consider managing roof runoff (rain gardens, rain barrels, etc.). Consider bioengineering stabilization when walls need to be repaired or replaced.	Private shoreline	10
2058, 2048 Shadow Lake Rd	48	Shoreline	Stabilize lakeshore with robust native buffer and/ or bioengineering project. Consider stormwater management upslope from shore (rain gardens, rain barrels, etc.).	Private shoreline	11
1501, 1511, 1531, 1561 Shadow Lake Rd	34	Shoreline	Consider bioengineering stabilization when walls / access areas need to be repaired or replaced with stable lakeshore access. Increase lakeshore buffer plantings. This area is narrow, steep, and constrained by the road, so more robust native vegetation in this location is recommended.	Private shoreline	12
1070, 1082 Shadow Lake Rd	25	Shoreline	Construct lakeshore buffer and / or establish a no mow zone along the lakeshore. Consider managing roof runoff (rain gardens, rain barrels, etc.).	Private shoreline	13

Lake Wise Assessments

The VT DEC's Lake Wise program[2] seeks to change the culture and understanding of lakeshore property management from a more development focused perspective to one of lake friendly living that incorporates native vegetation to stabilize lake shores and support a healthy lake. Lakeshore instability, erosion, and lack of robust native vegetation have a direct relationship to lake water quality and aquatic habitat health. The Lake Wise program assesses four key areas for each property: lakeshore, recreation area, driveway, and structure and septic. The evaluations require walking the property with the owner and assessing the development impacts, drainage patterns, erosion present, vegetation location and quality, use of the property, and willingness to implement specific recommendations to improve the lakeshore.

At Shadow Lake, five residents received Lake Wise Assessments as a part of the LWAP. See Figure 38 for a map of the five properties assessed. Additionally, several other residents expressed interest in having assessments completed in the future and their information was passed on to the VT DEC Lake Wise Coordinator so that those assessments can be scheduled in the next field season. The property owners that have previously had a Lake Wise Assessment completed should also be commended, especially the previous Lake Wise Award recipients, the Alexander, Ashe, Guilbault properties (Figure 37). Award signs are issued when properties pass all four assessment categories, meaning that they are a model for lake friendly living. Certificates indicate that the property has passed at least two of the categories and are well on their way to an Award.

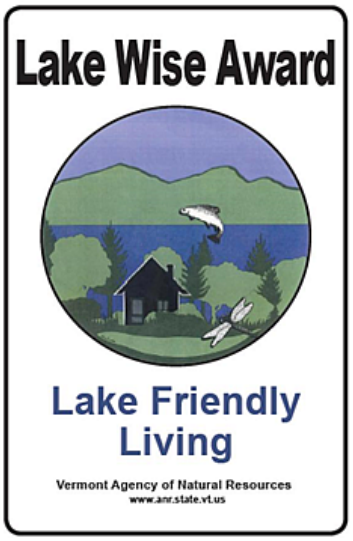

Figure 37. A Lake Wise Award is issued to properties that pass all four assessment categories, exemplifying lake friendly living (source: https://dec.vermont.gov/watershed/lakes-ponds/lakeshores-lake-wise/what).

Of the five assessments that were completed, 80% passed the driveway portion, 60% passed the structures and septic portion, 40% passed the recreation area portion, and 0% passed the shoreline portion. All assessed properties lacked adequate shoreline vegetation and stability. Recommendations were made specific to the observations at each site and informed by discussions with the landowners. In most cases, the shoreline area was constrained either by the location of the house, the location of Shadow Lake Rd, or both. Thus, best fit recommendations were made that sought to balance the use of the area and the health of the lake, stability of the shoreline, and aquatic habitat health. The results are summarized by category in Table 3 below. The complete Lake Wise reports can be found in Appendix G.

Table 3. The results of the five Lake Wise Assessments are shown summarized by pass (✓) or fail (X) status and whether a Lake Wise Award or Certificate was earned.

Property Assessed	Driveway	Structures and Septic	Recreation Area	Shoreline	Lake Wise Award?	Lake Wise Certificate?
Property 1	✓	✓	✓	X	No	Yes
Property 2	✓	X	X	X	No	No
Property 3	✓	✓	✓	X	No	Yes
Property 4	✓	X	X	X	No	No
Property 5	X	✓	X	X	No	No

[2] https://dec.vermont.gov/watershed/lakes-ponds/lakeshores-lake-wise

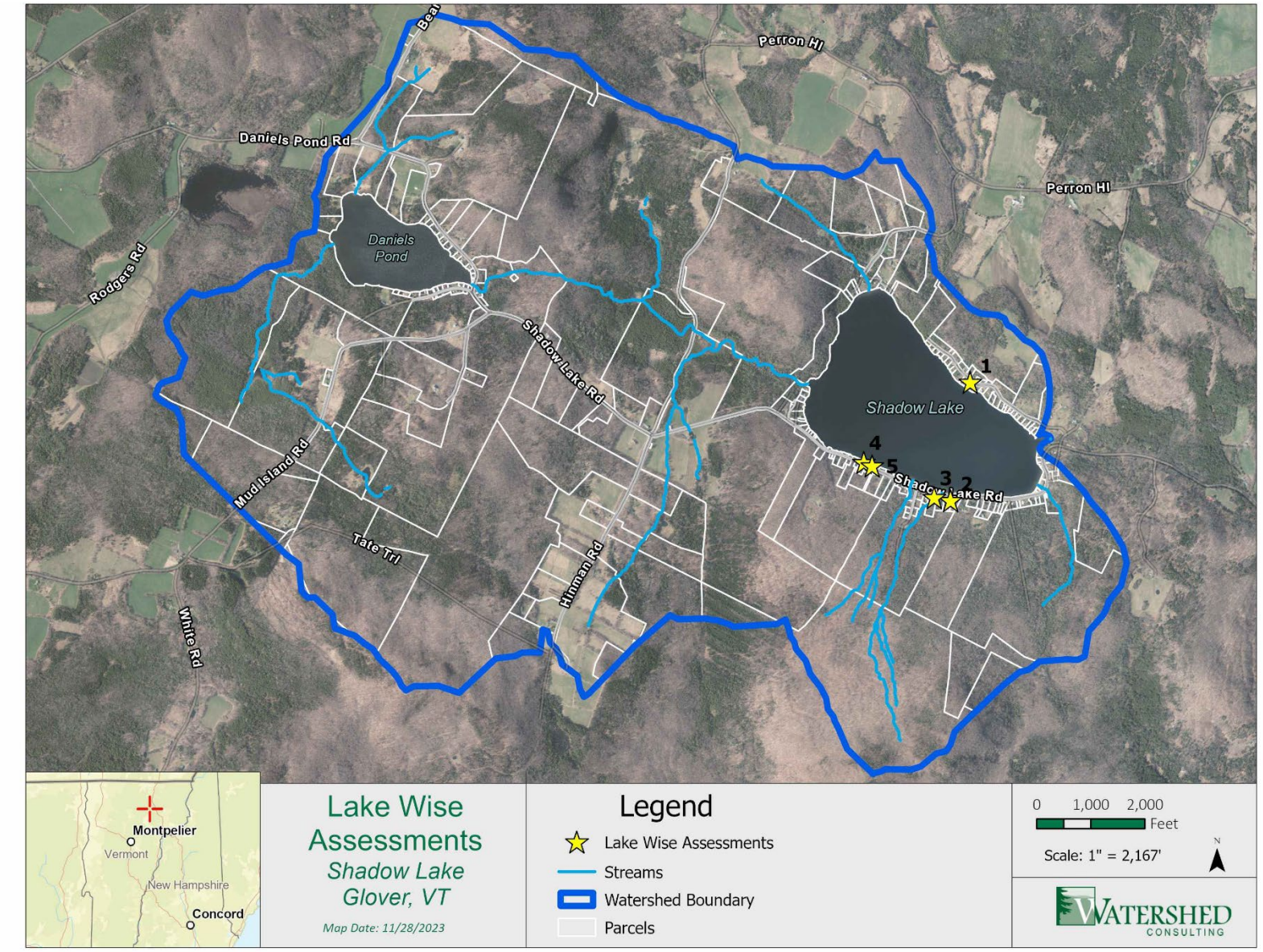

Figure 38. Five Lake Wise Assessments were completed along the Shadow Lake shoreline (see starred locations).

Community Meeting

In August 2023, Watershed Consulting and OCNRCD hosted an in-person presentation to the community in West Glover to review the project progress and identified retrofits. The meeting was attended by eleven residents. The three key sectors were discussed (roads, streams, and lakeshore). Photo examples were provided of the observed issues and solutions to these issues were reviewed. Following the presentation, time was allocated for questions and discussion. Then, a survey was distributed to the attendees to determine the preferred priority and prioritization of the projects identified in the assessed sectors. The results from the survey are included in Appendix E and summarized in Table 4 below. The feedback that was gathered from the survey and meeting was utilized to determine the sectors from which to select the projects to develop the one-page summary sheets for the priority projects.

Table 4. Summary of the community priority survey results.

Category	Average %*	Number of Project Sheets to be Developed
Public Hydrologically Connected Roads; Fish and Wildlife Access	41%	13
Private Lakeshores	26%	8
Private Driveways	18%	5
Stream buffers, bank erosion, and floodplain access	14%	4
Total	**99%**	**30**

* Note that not all survey responses totaled 100%, so the total average percent is slightly lower than 100%

Respondents to the community priority survey were provided with space to leave comments. The comments received are summarized in the following list.

- Road related projects. Very important because of proximity of road to lake
- Roads/culverts are a major contributor!
- Including dam influence on erosion
- Hydraulically connected roads are priority
- Culverts, ditching, improve roads, fish & game
- Landowner projects responding to erosion are important
- I am especially concerned about the high lake level & the resulting shoreline erosion. Somehow tying your work to the dam is equally important with the necessary road & culvert work.
- There have been multiple shore erosions due to the storm
- Lakeshore restoration is a priority
- Lakeshore buffering, improve driveways

An additional outcome of the meeting was that two residences signed up to receive Lake Wise Assessments with the VT DEC representative who was in attendance at the meeting.

Conclusions & Recommendations

Conclusions

The assessments, research, and site visits resulted in a list of identified water quality stressors by sector (roads, streams, and lakeshore). In general, road related issues (including driveways, private roads, and public roads) made up 49% of the identified priority sites. Lakeshore projects made up 39% of the sites, and stream projects made up

12% of the projects. Observations by sector are summarized in the lists below.

Road related stressors:

- Roadway runoff
- Development
- Off Road vehicle use
- Deicing chemicals
- Winter sand
- Undersized or absent culverts
- Clogged culverts
- Unstable ditches
- Poor grading / grader berms

Lakeshore related stressors:

- Lack of buffers
- Erosion
- Septic system failure / contamination
- Retaining walls

Stream related stressors:

- Stream erosion / channelization
- Lack of buffers
- Lack of floodplain access
- Unmanaged stormwater inputs

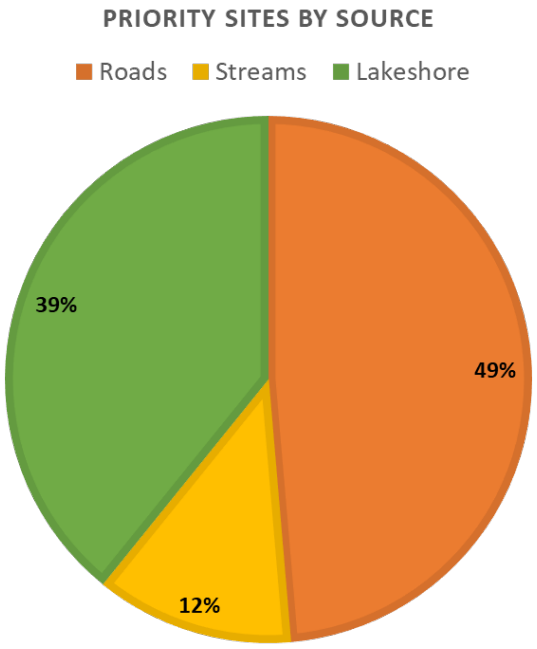

Figure 39. Priority sites by sector are summarized by percentage in the pie chart above.

Recommendations

A list of recommendations was developed that address the major concerns that were identified within the watershed. These recommendations are provided in bullet form to be easily digestible.

- **Implement site-specific BMPs to capture, slow, infiltrate, and filter sediment and nutrients from stormwater runoff** beginning with the priority lists of projects provided in Appendix D, E, and F. Decreasing the volume and velocity of stormwater inputs into the lake and its tributaries will better mimic an undeveloped watershed where significant stormwater runoff is infiltrated and slowed through native vegetation, soil absorptive capacity, and topography (Figure 41). This is a critical step in building resiliency in the Shadow Lake watershed as climate change impacts including more frequent high intensity storm events are predicted to increase. This is important because these storm events will increase stormwater and stream velocity, which results in increased erosion and thus transport of additional sediment and nutrients to the lake. The increased temperatures in combination with the increased phosphorus loading can lead to an increase in aquatic plant growth including algae. These changes in climate overall result in increased flooding and decreased water quality, and these negative impacts will continue to be observed unless these impacts are mitigated within the watershed.
- **Reassess road segments** post-July 2023 storm and plan for safe passage of larger storm events including upsizing of culverts, cleaning of ditches and culverts, and installation of new culverts where they are lacking. This will be critical for **building resiliency** and ensuring that the impacts of climate change are minimized within the watershed.

- **Preserve and protect large undeveloped parcels** within the watershed. Large, forested tracts are important for many reasons including slowing, filtering, and infiltrating stormwater, providing wildlife habitat, and preserving stream riparian buffers. One option would be a **conservation easement** for protection of these areas. The locations of the identified parcels can be found in a map in Appendix H. Note that some of these parcels have a portion of the parcel developed, such as a residential home site, but the majority of them remain forested. The Shadow Lake Association is in a good position to establish a land trust division to support these land conservation efforts.

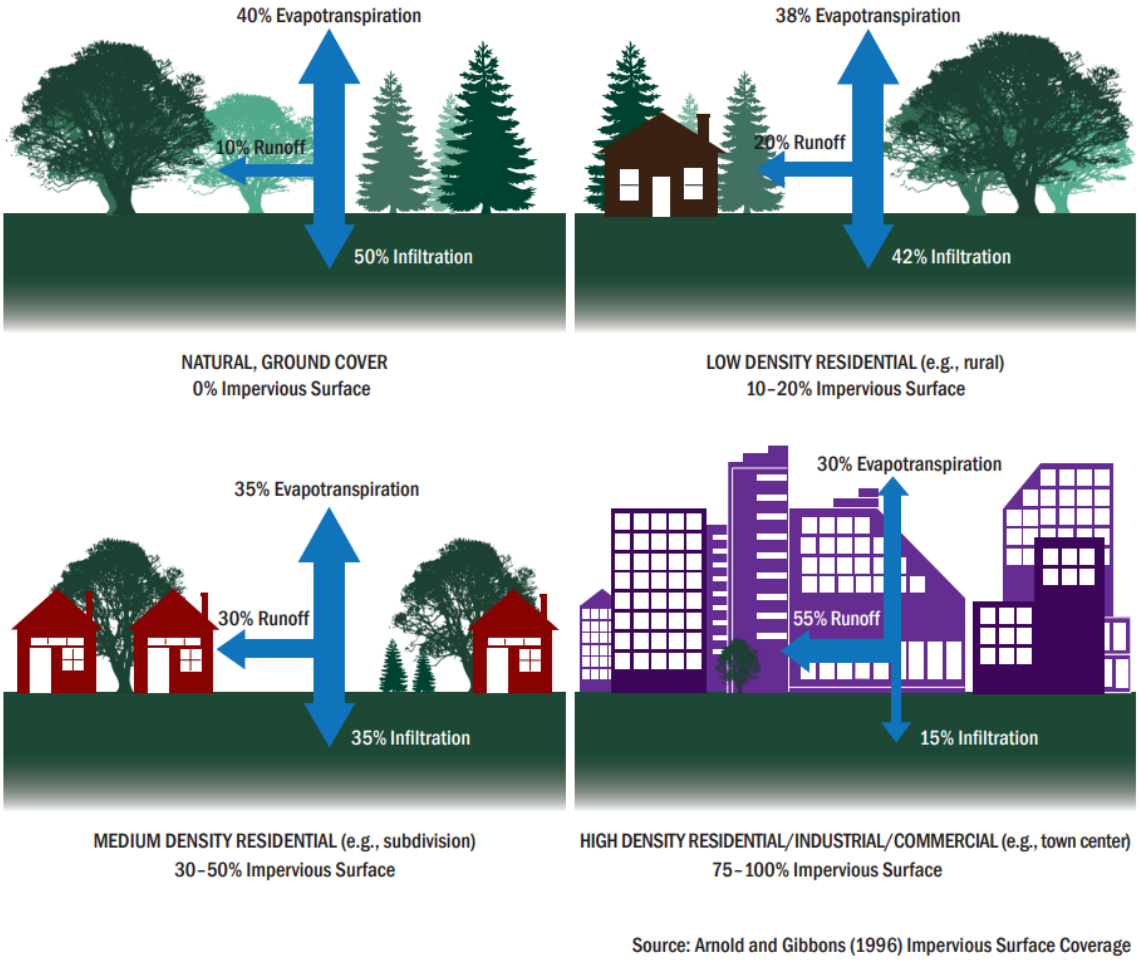

Figure 40. Undeveloped areas provide more infiltration and reduce stormwater runoff. As more development occurs, more runoff is observed. Source: Arnold and Gibbons (1996) and reproduced in VT DEC (2018).

- OCNRCD should **continue working with the agricultural property owners** within the watershed to implement additional practices such as livestock exclusion and manure and nutrient management to prevent negative impacts to water quality. Additionally, the farm along Shadow Lake Rd has been identified as a good candidate for a stream restoration and buffering project and this could be pursued in conjunction with other agriculture management projects.
- **Complete stream walks of the drainage areas for key tributaries** with a focus on the Burke Culvert, the Trib 5 Lussier Culvert, and the Trib 1 Town Beach tributaries. These three tributaries were selected due to high nutrient loads as determined by the LPP water quality monitoring results (see map in Figure 26).

Sediment plumes at tributary culvert outlets were also noted in several locations along Shadow Lake where development-based sediment loading is unlikely to be the only source of sediment transport. Additionally, the stream crossing along Perron Hill Rd (also referred to as Swamp Rd) is an area of concern and should be further investigated to determine the appropriate solution, which could include improving the crossing or restricting access.

- **Complete an illicit discharge survey** within the watershed to determine if there are any illicit connections to surface waters and, if so, to disconnect them. Potential pollutants may include broken or leaking septic systems, improperly plumbed black or gray water pipes, or dumping of prohibited substances. The most critical focus areas include the Burke Culvert and Town Beach areas as indicated and directed by the LPP water quality monitoring results (see map in Figure 26). Note that some initial sampling was completed in the catchbasin adjacent to the Burke Culvert in late 2022, but the results were inconclusive. Also note that caffeine monitoring will be completed in 2024 with a lower detection threshold (≤0.01 ug/L) than was utilized in 2023 (0.5 ug/L), so the results of this and other water quality monitoring results should inform this investigation.
- **Stabilize trails** (motorized and non-motorized), **especially adjacent to wetlands and upstream of streams and stream crossings** and prevent future damage and erosion as a result of ATV use. Consider prohibiting ATV use along and through wetland areas including along Perron Hill Rd (known locally as Swamp Rd). The area where Barton River intersects with Perron Hill Rd is a particular area of interest. If use is not prohibited, the stream crossing should be improved to prevent further sedimentation.
- **Stabilize roadside ditches and ensure they are maintained regularly.** It is recommended that the Town purchase (or work out a loan with a neighboring town) a roller to compact road edges to ensure that road shoulders are stable and not eroding into ditches. Ditches should be stabilized per VT Municipal Roads General Permit (MRGP) standards as shown in Figure 43 below per the Vermont Better Roads Manual (VTrans, 2019). This manual also provides information regarding the "proper ditch profile and grading technique [that] will redirect water efficiently, decrease erosion, and increase longevity of the ditch, thus decreasing maintenance costs."

MRGP Ditch Requirements		
Slope Range	**Lining**	**Required Infrastructure**
0% > 5%	Grass	None
5% ≥ 8%	Grass	Check Dams
		Cross Culvert and/or Turnouts*
	Stone	None
>8%	Stone	None

*When installing a cross culvert and/or turnouts the MRGP requires a minimum of 2 installations every road segment, or every 328 feet.

Figure 41. VT MRGP ditch stabilization standards (VTrans, 2019).

- **Add additional velocity controls (i.e., check dams and turnouts) along roadsides** including roadside ditches to reduce the erosive capacity of this channelized stormwater.
- Both **stream and drainage culverts should be regularly cleaned, sized appropriately, and installed in a great enough frequency** to ensure that large contributing areas are not directed to one culvert,

concentrating drainage and increasing erosion potential. **Culvert inlets and outlets should be stabilized** to prevent erosion and undermining by using rock aprons, headwalls, wingwalls, and / or plunge pools. In general, intermittent stream or drainage culverts should be a minimum of 18" and driveway culverts should be a minimum of 15". For perennial streams, it is recommended that the regional River Management Engineer be contacted for specific design guidance. Consult the VT Better Roads Manual (VTrans, 2019) for specific guidance on the design and sizing of culverts as well as maintenance recommendations.

- **Ensure that unpaved roads are graded regularly.** When grading occurs, ensure that roads are **well crowned and that grader berms are not left** in place. Roads should shed water quickly to stabilized vegetated roadsides or stable ditches. For this to be successful, this will require discussions with the Town of Glover Public Works Department. A good working relationship between all stakeholders in the watershed including the Town will be critical in ensuring successful implementation of these improvements and alterations to current practices.
- Work with the VT DEC Lake Wise program to **complete additional Lake Wise assessments** at more properties around both Shadow Lake and Daniels Pond. Work with private property owners to design and implement site-specific recommendations for assessed properties.
- **Improve vegetated lake and stream buffers in public and private areas**. This will reduce the likelihood of streambank and lakeshore erosion, reduce the impacts of climate change, reduce the impacts of lake water fluctuations, filter stormwater that flows directly into the lake and tributaries, provide habitat, and improve lake and stream shading. This recommendation includes coordination with the Town to ensure that vegetation is not cleared along Shadow Lake Rd. If needed, select vegetation can be topped to preserve views but should not be removed. Several residents noted that the Town has previously cleared shoreline vegetation along the road and this clearing should not continue.
- **Rain Barrels** are recommended for residences where roof drains are present where residents will utilize the collected water. There is potential for these to be sold and purchased in the OCNRCD plant sale.
- **Installation of residential green stormwater infrastructure (GSI) practices** are also recommended. It is recommended that residents of the watershed are informed about potential practices they can implement on their own properties. These resources can include but are not limited to: Vermont Guide to Stormwater for Management for Homeowners and Small Business, Shoreland Best Management Practice Fact Sheets, and the Vermont Rain Garden Manual. This information could include that appropriate native plants for lakeshore and stream buffer plantings or other vegetated GSI practices are available at the OCNRCD plant sale.
- Shadow Lake Association should consider a **raise the blade campaign** to improve the functionality of lawns in slowing and filtering stormwater and stabilizing slopes. The Lake Champlain Basin Program has many resources to support education regarding raising mower blades (Figure 43).

Figure 42. Allowing grass to grow to at least three inches helps soils capture more rainwater and more filter pollutants than shorter grass (LCBP, 2023).

- As existing retaining walls fail over time and need to be replaced, encourage residents to **pursue bioengineering practices** in place of a hardscaping such as retaining walls. If new stabilization projects are needed along the lake, a bioengineering approach should be strongly encouraged. The Vermont Bioengineering Manual is a valuable resource that can be distributed to residents to educate them about lakeshore health and the potential practices that can be used to stabilize shorelines in a lake friendly way. A selection of previously constructed bioengineering projects can be explored in this StoryMap, which can be easily shared. One example of encapsulated soil lifts, an effective and aesthetic bioengineering practice relevant to the Shadow Lake watershed can be found in Figure 44.

Figure 43. An example of a bioengineering project, encapsulated soil lifts, on Lake Raponda in Wilmington, VT (Source: VT DEC Lakes and Ponds). Prior to the installation this project, the road bordering the lake was eroding, the lakeshore was narrow and steep, and the road was being undercut causing sediment and pollutants to enter the lake.

- Work with the VT DEC stream flow protection program staff including the Streamflow Protection Coordinator and River Ecologist, to **improve dam functionality and reduce hazards**. This will include collaboration with the community, the Town, and the dam safety staff implement a solution. Recommendations are presented in the 2023 Dubois and King H&H report (Appendix A). This is important to water quality as the dam is functioning at reduced capacity and contributing to higher than normal lake levels, which can reduce shoreline stability and the viability of shoreline vegetation. The high lake levels have been particularly notable in 2023 following a summer and fall with above average precipitation and two extreme storm events (July and December 2023). The limited functionality of the dam has impacted lake levels significantly following these weather patterns and has artificially increased the resonance time in Shadow Lake. In order to allow for lake capacity to accommodate these more extreme storm events, the dam must be repaired. In the short term, repairs to the dam's valve and improved maintenance to improve the functionality of the debris rack should be prioritized.
- **Ensure that winter sand and salt are not applied excessively**. Training such as the Green Snow Pro program in New Hampshire or utilization of the Lake Champlain Sea Grant resources is recommended for Town staff (if not already completed) and any commercial operators in the watershed. Strategies for reducing chloride application in the watershed can include pre-wetting, increasing plowing prior to de-icing, monitoring sand and salt application and road surface temperature, regular calibration of spreading equipment, and the use of brine as opposed to rock salt (due to the high percentage of salt that can bounce off of the roadway).
- It is recommended that the Glover Planning Commission **adopt a lakeshore ordinance** that encourages the adoption of increased lake friendly practices. Of particular note along Shadow Lake is that the 2014 Lakeshore Protection Act only applies to the area 250 feet from the lake's mean water level unless the parcel is bisected by a Town road such as Shadow Lake Road. As such, the regulated area along the southern shoreline of Shadow Lake Rd is very limited in some areas. A town-specific ordinance, however, could be written to apply to the areas within the road right of way and on the upland side of the road, which do contribute stormwater runoff to the lake often through direct connection via culverts. The Vermont Federation of Vermont Lakes and Ponds (FOVLAP) may be a valuable partner in developing this ordinance.

It is highly recommended that the momentum gained during the course of this study is continued and design and implementation of identified practices to improve water quality is pursued. Priority projects have been uploaded to the VT DEC Watershed Projects Database and will be in good standing for further grant funding for design and implementation. Project partners are likely to involve OCNRCD, Town of Glover, the Shadow Lake Association, residents within the watershed, and the VT DEC. This must be a collaborative effort as the watershed is comprised of private parcels, public parcels, private roads and driveways, and public roads. It is clear that Shadow Lake has been impacted by development within the watershed as well as the impacts of climate change, and the Shadow Lake community must respond to preserve, protect, and restore this important amenity.

Funding Opportunities

There are several potential funding opportunities available to assist with funding of the implementation of many of the recommendations provided, especially those that reduce phosphorus loading to surface waters. Potential avenues include the Vermont DEC's Clean Water Initiative Program (CWIP). The CWIP releases notice of funding opportunities from CWIP through the CWIP Grants Notification Listserv and the Vermont Business Registry. Funding opportunities are posted on the Memphremagog Clean Water Service Provider (CWSP) website, and these grants fund projects that reduce phosphorus loading. Watersheds United Vermont (WUV) also offers block grants for project design and implementation as well as woody buffer block grants.

The Vermont Clean Water State Revolving Fund provides funding in the form of low interest loans to municipalities and private entities for eligible projects. Eligible project types applicable to the projects include stormwater

treatment and green infrastructure projects. This program includes funding for the planning and final design phase and the construction phase. Repayment of planning and final design loans can be rolled into a subsequent construction loan or begins five years following completion of the relevant engineering documents or the last loan disbursement, whichever occurs first. Repayment of the construction loan begins one year following project construction completion. Clean Water SRF recipients are required to follow the Qualifications-Based Selection Process and Request for Qualifications (QBS-RFQ), develop Fiscal Sustainability Plans (FSP), and follow Cost and Effectiveness Guidelines (C&E). These documents can be found in the link above.

The VT Fish and Wildlife Watershed Grant Program would be an appropriate option for many recommendations as it was developed to fund projects that are "watershed related and can include monitoring, education, conservation, recreation, or historic enhancement[3]." One fundable example of this type of project relevant to this LWAP is the reduction of phosphorus and sediment, which many of these projects achieve. They can also be used for educating people about watershed resources.

As there are many road-related projects recommended for the Shadow Lake watershed, another potential grant avenue would be the VTrans Grants in Aid Program. This program "provides technical support and grant funding to municipalities to promote the use of erosion control and maintenance techniques that save money while ensuring best management practices are completed in accordance with the Vermont Department of Environmental Conservation's Municipal Roads General Permit (MRGP)."

The Natural Resources Conservation Service (NRCS) is a potential funding option for the protection and conservation of large tracts of land or agricultural areas as is recommended for the Shadow Lake watershed. The goal of the Vermont NRCS is to conserve Vermont's soil, water, air, and other natural resources. The NRCD Trees for Streams program can help to assess, plan, and plant riparian buffer plantings to protect and stabilize stream banks, increase wildlife habitat connectivity, and filter nutrients. Grants may also be available from the Vermont Department of Forests – Parks and Recreation's Recreational Trails Program for formalizing, improving, and preventing erosion and damage from public recreational trails including non-motorized and motorized (ATV) users.

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