WILLOUGHBY LAKE WATERSHED ACTION PLAN
FINAL REPORT

Prepared for:

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1.1 Acknowledgements

This work was funded by a Willoughby Lake Watershed Action Plan (LWAP) contract awarded to the Orleans County Natural Resources Conservation District (OCNRCD) by VT Department of Environmental Conservation (DEC). Orleans County NRCD subcontracted the Memphremagog Watershed Association (MWA) to provide technical support on various aspects of the LWAP; this included field assessments, project identification, prioritization, development of 30% conceptual designs for water quality projects, and reporting. Team members from OCNRCD and MWA would like to thank the Town of Westmore staff and selectboard, members of the Westmore Association, the Town Road Foreman, members of the Westmore Community Church, and staff from VT DEC Lakes and Ponds Program for support and assistance during the development of the Willoughby LWAP.

1.2 Purpose & Process

This final report is the culmination of nearly two years' work evaluating, prioritizing, and developing water quality improvement projects to reduce phosphorus and sediment loading to Lake Willoughby. **The purpose of this report is to summarize the results of desktop and field assessments, project prioritization efforts, and project development activities while providing an actionable plan for implementing meaningful water quality projects at both site-specific and watershed scales.** This report documents the methods used and results produced by MWA and OCNRCD following DEC's LWAP Technical Guidance and serves as a guide for the Town of Westmore and conservation project partners to continue to develop and implement projects now and into the future.

A total of four public stakeholder meetings were held during the LWAP process, with the goal of engaging as many community members as possible. The meetings were well attended by the various groups and stakeholders mentioned above, including a broad representation of Westmore residents (permanent and seasonal, lakeshore and elsewhere) and property owners. These meetings were supported and co-hosted by the Town of Westmore and the Westmore Association. A public kick-off meeting was held at the Westmore Fellowship Hall on July 27, 2022, where the Team introduced the LWAP process and shared the data library, proposed assessment areas, and solicited input from the public. On July 6, 2023, the LWAP Team organized a public meeting at the Fellowship Hall to present the results of the field assessments, project prioritization efforts, and share our recommendations for designing high-priority projects. Two follow-up meetings were organized with Westmore residents and Town representatives to further discuss projects that were proposed for the 30% design phase, occurring on July 31 and September 25, 2023. A final public meeting hosted on March 7, 2024, wrapped up the LWAP process by presenting the final report, 30% concept designs, and answering questions about next steps.

1.3 Watershed Planning

Lake Willoughby resides within the Lake Memphremagog watershed and is included in the Memphremagog Watershed Basin 17 Tactical Basin Plan (VTDEC, 2023). The updated 2023 TBP provides an assessment of the health of the Lake Memphremagog basin through the lens of the phosphorus ("P") Total Maximum Daily Load (TMDL), and "defines ongoing and future strategies to address high-priority surface water stressors" (VT DEC, 2017a). In this plan, Lake Willoughby is identified as a high-quality surface water in the top 10% of Vermont's healthiest lakes. However, Willoughby is subject to several stressors that threaten its status as an oligotrophic lake. The Lake Scorecard for Willoughby, summarized in Table 3 of the TBP and Figure 1 below, identifies nutrient trends and aquatic invasive species as the primary water quality concerns. In addition, mercury (Hg) and shoreland development are listed as secondary stressors to Willoughby.

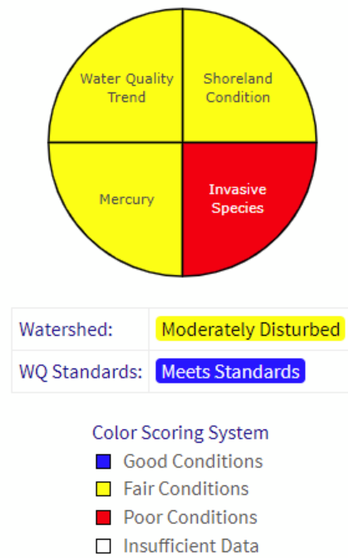

Figure 1. Lake Scorecard for Willoughby.

The 2017 and 2023 TBPs provide several strategies to address water quality stressors in Lake Willoughby (VTDEC, 2017b). In the regulatory realm, reclassification of the Lake Willoughby Tributary as B(1) high-quality or A(1) excellent surface water would protect the watershed by prohibiting direct discharge of untreated wastes, development of new septic systems >1,000 gallons per day, and solid waste management facilities or application of biosolids or septage. Going one step further, the TBP expressed a willingness on behalf of VTDEC to explore Outstanding Resource Waters (ORW) designation for Lake Willoughby and the Willoughby River. Another strategy recommends chemical monitoring and watershed surveys to locate substantial sources of the increasing nutrient trends. This effort is underway through the LaRosa Volunteer Monitoring Program.

Beyond monitoring and regulatory protections, both the 2017 and 2023 TBP recommend addressing water quality stressors by assessing, identifying, and implementing water quality projects in several work sectors. This includes agricultural BMPs, gravel road BMPs, developed lands BMPs, LakeWise master planning, shoreland restoration, riparian buffer plantings, and limiting development and encroachments. As of the 2017 TBP, Lake Willoughby had 3 Lake Wise awards, 0 certifications, and only 2 completed projects. These numbers have increased slightly as a result of the LWAP process. The 2023 TBP implementation table Strategies recommended focusing efforts on:

1. Targeted outreach, technical assistance, and funding for agricultural Best Management Practices (BMPs; #1),
2. P trapping and control practices identified through Agricultural Conservation Planning Framework (ACPF)(#2),
3. Performing private road erosion inventories (REIs; #23),
4. Conducting Stream Geomorphic Assessments (SGA) on priority river reaches (#33),

5. Developing a Lake Watershed Action Plan (#43), and
6. Achieving A(1) designation for outstanding water quality (#49).

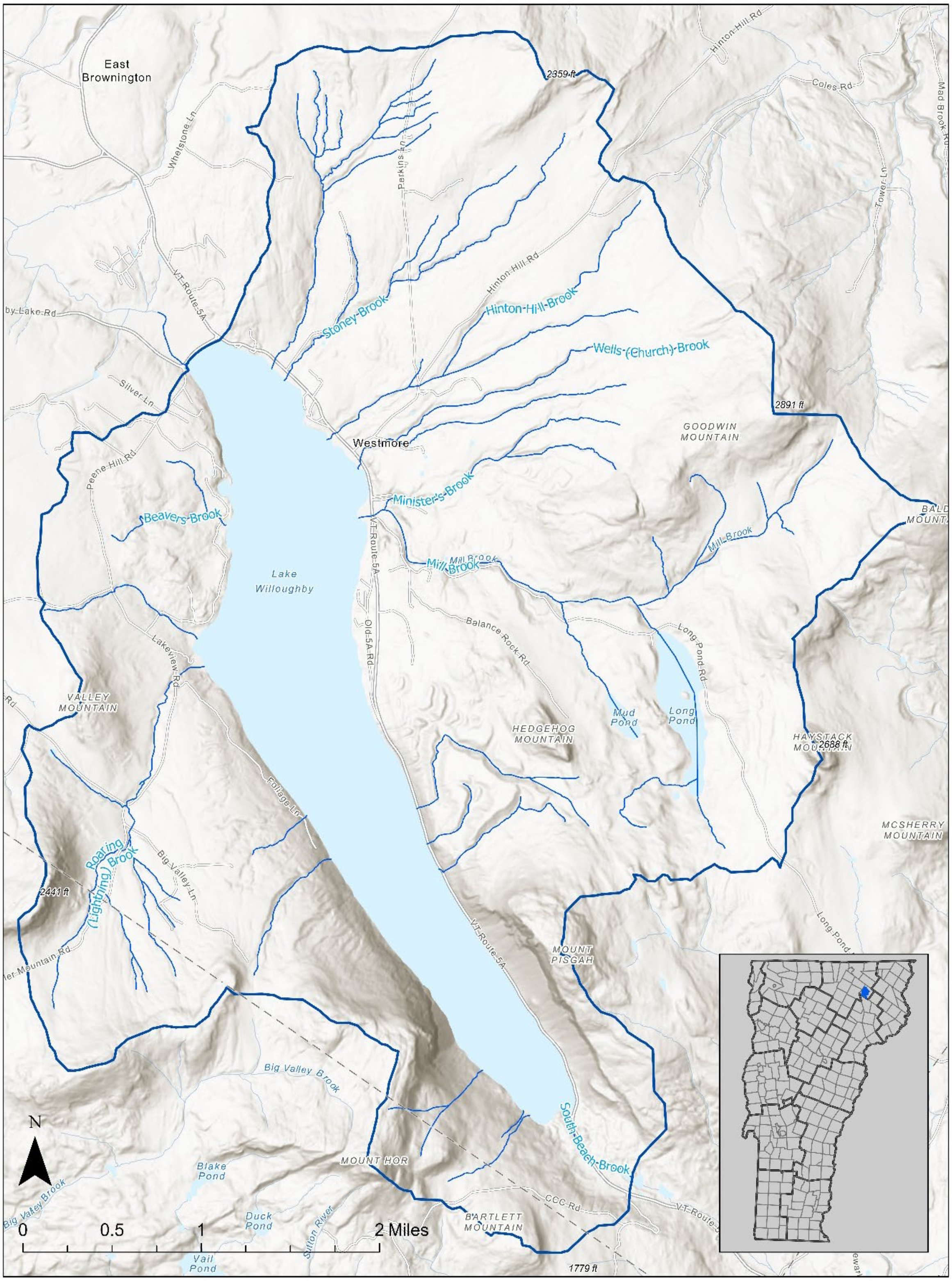

Figure 2. The Willoughby Lake watershed in Westmore & Sutton, Orleans & Caledonia County, Vermont.

In addition to nutrients, other watershed health stressors include invasive species and aquatic organism passage (AOP). Populations of Rainbow Smelt, Rainbow Trout, and White Sucker in Lake Willoughby would benefit from AOP improvements on Wells Brook, according to Table D1 of the TBP. Moreover, invasive Eurasian watermilfoil is an ongoing issue in the littoral zones of the lake and is being addressed through diver-assisted removal efforts (AE Commercial Diving Services, 2020).

1.4 Goals & Objectives

Lake Willoughby is often referred to as Vermont's "hidden gem" because of its crystal-clear water, abyssal depths, sheer cliffs, and undeveloped mountain landscape. It is partly because of this that the DEC Lakes and Ponds program selected it as a priority for development of a Lake Watershed Action Plan. By taking steps to identify water quality problem areas and remedies, the Town of Westmore and its residents can work to protect and preserve the quality of water and habitat in the Willoughby watershed. However, Lake Willoughby is not unique in the sense that its pristine state is under constant threat from common water quality issues such as sedimentation, excess phosphorus loading, loss of natural lakeshore habitat, forest fragmentation, and degradation of tributary streams and wetlands. As such, the goals for the Willoughby LWAP are to:

- Identify water quality stressors.
- Develop discrete water quality projects related to these stressors.
- Rank and evaluate the potential benefits of each project.
- Develop several projects that will reduce sediment and nutrient loading to the lake.

Specific objectives are outlined in the DEC LWAP Technical Guidance, but include individual project summary sheets, compiling an overall project prioritization table, and drafting 30% conceptual designs for multiple high-priority projects that will enable the Town and partners to seek grant funding for final design and implementation.

2.0 Study Area

Lake Willoughby is a 1,687-acre glacial lake located in the Town of Westmore, Orleans County, VT (Figure 2). The lake reaches a depth of 320 feet and is the deepest lake entirely within Vermont. The contributing drainage area under this study is approximately 17.8 $miles^2$ (11,387 acres) located predominantly in the Town of Westmore, with small portions of the southern headwaters in Sutton, VT.

According to the 2020 census, the Town of Westmore has 357 residents, however, many seasonal residents and visitors result in large increases in summer populations around the unincorporated village area (US Census Bureau, 2022). Lake Willoughby drains into the Willoughby River, which flows 11.6 miles to its confluence with the Barton River in Orleans Village. From there, the Barton River flows approximately 15 miles to its terminus in South Bay, Lake Memphremagog.

Within the lake's contributing drainage area is 37.6 linear miles of roads, based on the VT Agency of Transportation's (AOT) Road Centerline dataset (Figure 3). Of these, the majority are Town roads (57%, 21.48 miles), followed by Private roads (24%, 8.9 miles), State Highways (16%, 6.16 miles) and forest roads (3%, 1.07 miles).

Analyses performed by VTDEC and reported in the Lake Land Cover Maps indicate more than 80% of the watershed is forested (VTDEC, 2022a; Table 1). Other dominant land cover types include hay (6%), grass/shrubs (6%), and wetlands (5%). While impervious surfaces such as buildings, roads, paved areas, and bare soil collectively amount to less than 2% of the total land cover in the watershed, these land cover types are most concentrated along the periphery of the lake. Residential and commercial development are most dense along Route 5A, Old Cottage Lane, Hinton Hill Road, and Peene Hill Road.

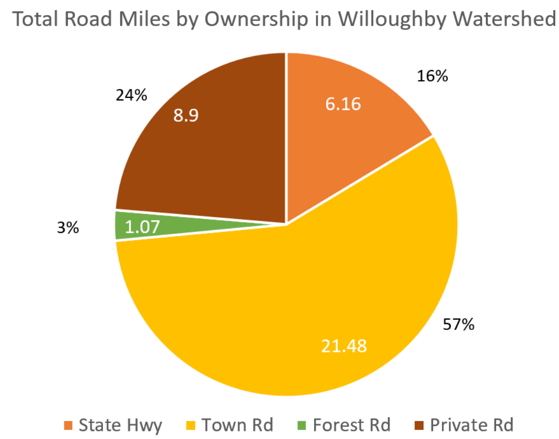

Figure 3. Breakdown of road length by ownership in the Lake Willoughby watershed.

Table 1. Land cover in the Lake Willoughby watershed based on the 11,387-acre contributing upland drainage area (VT DEC Lake Land Cover Maps).

Land Cover	Acres	% of Watershed Area
Forest	9,171.7	80.5%
Agriculture (Hay)	685.5	6.0%
Grass/Shrubs	682.1	6.0%
Bare Soil	27	0.2%
Open Water (not Lake)	129.2	1.1%
Buildings	19	0.2%
Roads	54.7	0.5%
Other Paved	48.9	0.4%
Railroads	0	0.0%
Wetlands	568.3	5.0%
Lake Willoughby	1,687	N/A

3.0 Data Library

The Willoughby LWAP assessments began with a thorough desktop review of all information and documentation available from town, state, regional, and other sources. Relevant information ranges from water quality monitoring data and road erosion inventories (REI) to land use/land cover and stream crossing structures. In addition to a written data library memo that outlines the findings from our research (Appendix A), MWA developed an online Lake Willoughby Data Library Web Map using the ArcGIS Online service. This web hosted tool is accessible for free to any person with the link; the public may also contact MWA or OCNRCD for access to the web map. Data were thoroughly reviewed and utilized to plan for and propose key target assessment areas within the three core sectors of an LWAP: Lake Shorelands, Streams, & Roads. These data were critical during the selection of the proposed target field assessment areas as well as an additional sector – large forested, agricultural, or developed lands – since they gave the most complete picture of the watershed to date. For instance, water quality data from the LaRosa Partnership Program were used to select target stream reaches for streamwalks, while Road Erosion Risk scores were used to identify which road segments required additional field screening. Refer to the *Willoughby Data Library Memo* in Appendix A for more information. Sources utilized in the data library include:

- Lake Memphremagog TMDL
- Basin 17 Tactical Basin Plan
- International Joint Commission Report
- Hydrologically Connected Roads
- Road Erosion Inventory
- Land Cover Dataset
- Lake Scorecard
- Vermont Bridges & Culverts
- Fish & Wildlife Stream Crossings
- VT Hydrography Dataset
- Ephemeral Streams
- LiDAR DEM & 1-ft contours
- Potentially Erosive Features
- NRCS Soils & Erodibility
- Vermont Integrated Watershed Information System
- Volunteer Lay Water Quality Monitoring Database
- Stream Geomorphic Assessment Data Management System
- Aquatic Invasive Species Control Reports
- Significant Natural Communities
- Rare, Threatened, & Uncommon Species
- Stormwater & Wastewater Infrastructure
- Westmore Town Bylaws
- Vegetative Buffer Disturbance Permit

4.0 Water Quality Project Identification

Identification of potential water quality improvement projects was a primary objective of the Willoughby LWAP assessments. While the LWAP territory spans a relatively large area, a significant portion of the watershed is owned by the State of Vermont and managed as state forest. Given the long history of conservation protection for these lands and the regulatory requirements for managing state park roads, trails, and stream crossings, the LWAP Team determined that these public tracts would be excluded from field assessments so that resources could be focused on those lands under the greatest development pressures. As such, MWA and OCNRCD elected to focus on 1) streams with the greatest visible encroachment issues or highest phosphorus concentrations, 2) roads with the highest road erosion risk scoring, 3) shoreland areas with the greatest development density, and 4) private parcels with the largest single ownership or broadest management activities (e.g., working forests, farms, subdivisions). In total, MWA and OCNRCD identified 75 potential water quality and habitat improvement projects across the watershed.

As mentioned above, selection of proposed target areas for field assessments was determined using information gleaned from the development of the data library. In addition, MWA and OCNRCD solicited input from stakeholders during the public kick-off meeting by providing blank maps of the watershed and instructing participants to highlight and describe areas they are familiar with that may host a potential water quality project. For more information about how the LWAP Team selected target field assessment areas, see the *Proposed Core Assessment Areas Memo* in Appendix B. The following sections summarize project identification efforts undertaken for each of the core sectors.

4.1 Streams

4.1.1 Stream Assessments Planning & Approach

LWAP technical guidance suggested using Phase 2 Stream Geomorphic Assessments (SGA) or StreamWise Assessments for this work. However, after conversations with the Rivers and Lakes & Ponds Programs, it was determined that Phase 2 was not cost-effective to cover multiple streams across this large of a watershed. StreamWise was also considered an option, however, it has not been applied outside of the Champlain Basin, is not recognized by Westmore residents, and includes few opportunities to segment reaches within a single property ownership. Thus, the LWAP Team opted to utilize the Riparian Streambank Assessment protocols, which was developed by Vermont Fish & Wildlife Department's Fisheries Division for use on State Owned Streambank Management Areas. Since 2020, MWA has been applying these approaches to public and private lands in the Memphremagog Basin. To date, more than 120 miles of streams in Basin 17 have been assessed using these methods. Riparian assessments from the Willoughby watershed now complement those collected in the Johns and Clyde River basins.

The use of the Riparian Streambank Assessment protocols enabled MWA to apply rapid assessments to characterize the condition of streams in the Willoughby watershed while identifying opportunities for conservation, restoration, or enhancement that improves water quality and fish and wildlife habitat. MWA utilized this protocol and applied principles of SGA Phase 2 to evaluate stream conditions as it relates to riparian vegetation quality/quantity, bank armoring, bank erosion, mass wasting, encroachment, aquatic organism passage, flood hazard risks, and stream crossing issues.

According to available State culvert data, 39 stream crossings in the watershed are not geomorphically and/or AOP compatible. Of these, 23 were identified as having potential need for field screening (Figure 4). Given the widespread nature of culverts, the LWAP Team elected to perform rapid sedimentation and erosion screening at all stream crossings encountered during stream walks. Where the LWAP Team encountered inputs to the stream such as stormwater outfalls, gullies, or other point features, efforts were taken to follow these inputs to their source and determine whether they presented as problem areas or water quality project opportunities. **Where the LWAP Team proposed 30% concept designs for active stream/floodplain restoration, MWA returned to the stream to perform SGA Phase 2 to gather all relevant parameters for channel and**

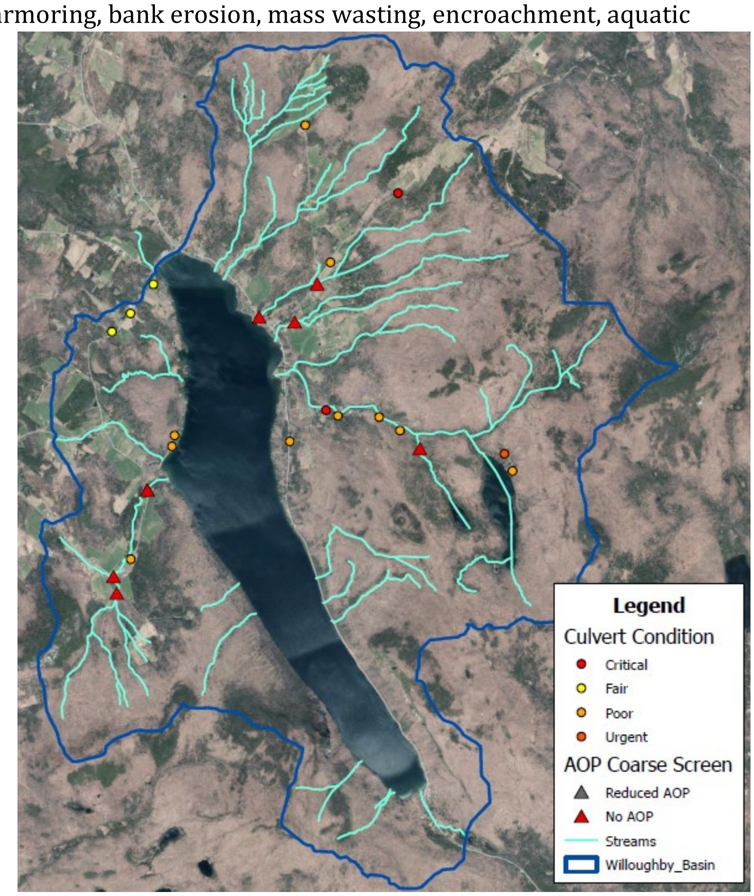

Figure 4. Culverts and crossing structures selected for field screening based on poor overall condition, geomorphic incompatibility, and/or AOP barriers.

floodplain morphology. Scans of the datasheets for SGA Phase 2 are available from MWA upon request.

4.1.2 Findings from Riparian Assessments

MWA proposed to complete 15.3 miles of stream assessments across the Willoughby watershed. Ultimately, over 21.5 miles of streams were assessed on foot, spanning 137 individual properties and amounting to over 530 geotagged observations (Figure 5). This included eight major tributaries to the lake and numerous small perennial and ephemeral streams. MWA identified numerous opportunities to improve water quality, enhance aquatic organism passage, manage stormwater runoff, and reduce fluvial erosion and flood risk hazards. In general, findings indicate the best opportunities for improving water quality and habitat to protect the health of the lake lie in improving riparian buffers, promoting geomorphic stability, and managing runoff from developed and agricultural lands.

Over 80% of the Willoughby watershed is forested and, as such, the streams tend to have mature riparian buffers. However, MWA identified 13 properties with stream frontage that were suitable for woody riparian buffer creation or enhancement projects. Smaller buffer planting opportunities were concentrated on lakeshore properties along Route 5A where both lakeshore and streambank buffers are needed. Larger buffer planting opportunities are concentrated on agricultural lands off Perkins Lane and Lakeview Rd. These are typically greater than 500 feet in length and generally not confined by infrastructure, development, or property boundaries.

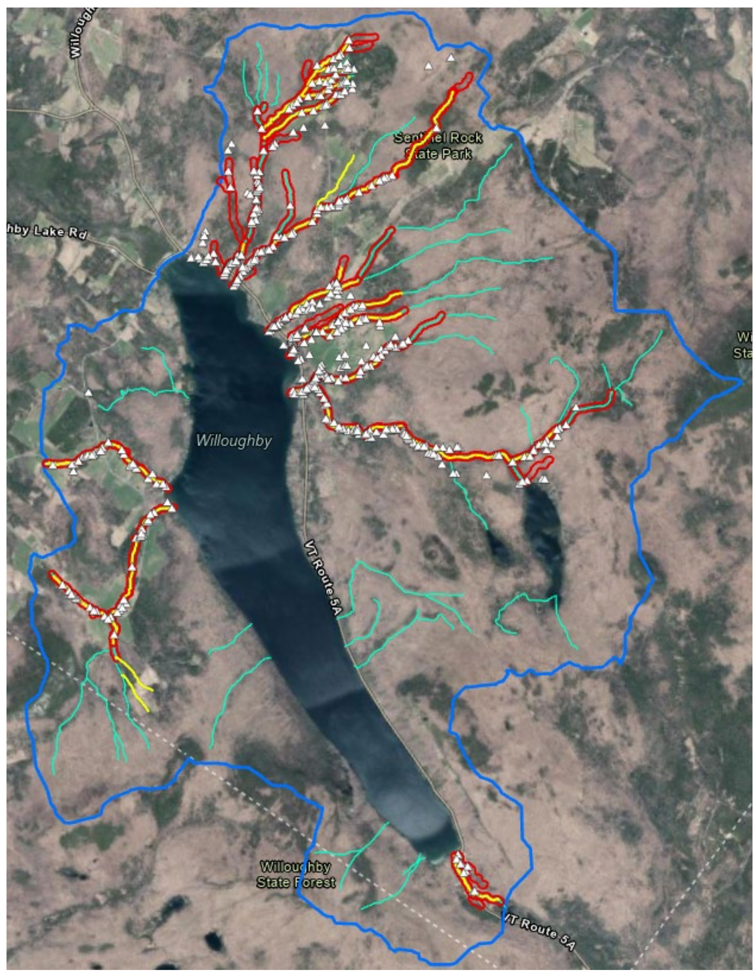

Figure 5. Map illustrating all major streams and tributaries (cyan), stream reaches that were proposed for assessment (yellow) and reaches that were assessed (red). Over 530 field observations were recorded during stream walks (white triangles).

Bank erosion and mass wasting was frequently observed during riparian assessments. More than 65 instances of accelerated bank erosion were observed (Figure 6). Bank erosion was concentrated in forested reaches on Ministers Brook, Wells (Church) Brook, Stoney Brook, and the unnamed tributary to the north of Hinton Hill Rd. In general, bank erosion seemed to be the result of channel adjustment processes acting in response to undersized crossing structures and excessive bank armoring along the lower reaches of the rivers. While bank erosion is a natural and expected process, concerns arise when there is accelerated bank erosion and a loss of attenuation areas (e.g., floodplain) where depositional processes can occur upstream of the lake. Increases in the frequency and magnitude of rainstorms as a result of climate change may play a role in channel adjustment processes, as Vermont is anticipated to see an increase of more than nine inches of rain per year. Mass wasting, considered here to be erosion that extends above average top of bank height and more characteristic of a localized landslide, was observed 18 times. The smallest mass wasting measured approximately 5'x30', while the largest measured approximately 20'x100'. One instance of mass wasting was large enough to warrant inclusion in the Batch Import File as a potential project – this location is on the lower reaches of the unnamed brook to the north of Hinton Hill Rd.

Approximately 50 stream crossings were screened during MWA's riparian assessments (Figure 7). In general, culverts in the Willoughby basin are undersized and often poorly aligned, perched, or impeding aquatic organism passage (AOP). This generalization is based on field observations of the crossing structure width compared to stream channel bankfull width, apparent velocity barriers, scoured-out plunge pools, and failing abutments.

From this work, MWA identified 19 potential stream/floodplain restoration projects (including 10 stream crossing structures), 13 potential riparian buffer plantings, one (1) potential wetland restoration project, one (1) potential dam removal, and one (1) potential invasive species control project.

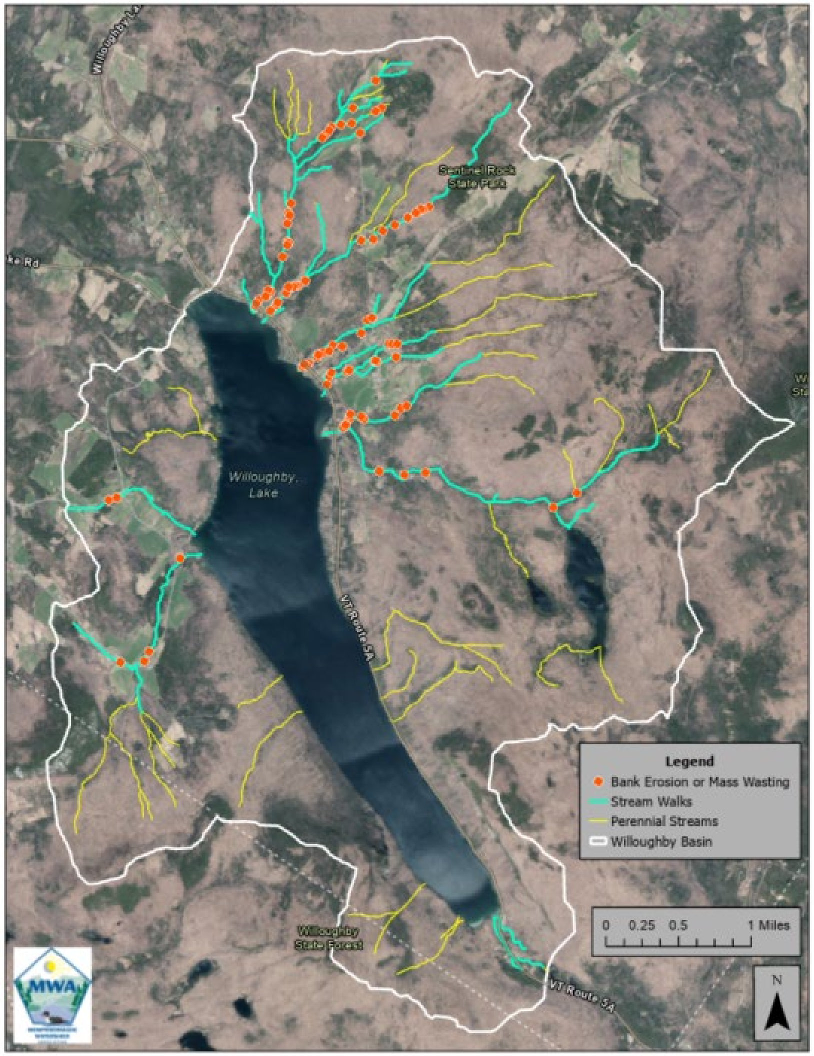

Figure 6. Recorded observations of bank erosion or mass wasting on major tributaries of Lake Willoughby.

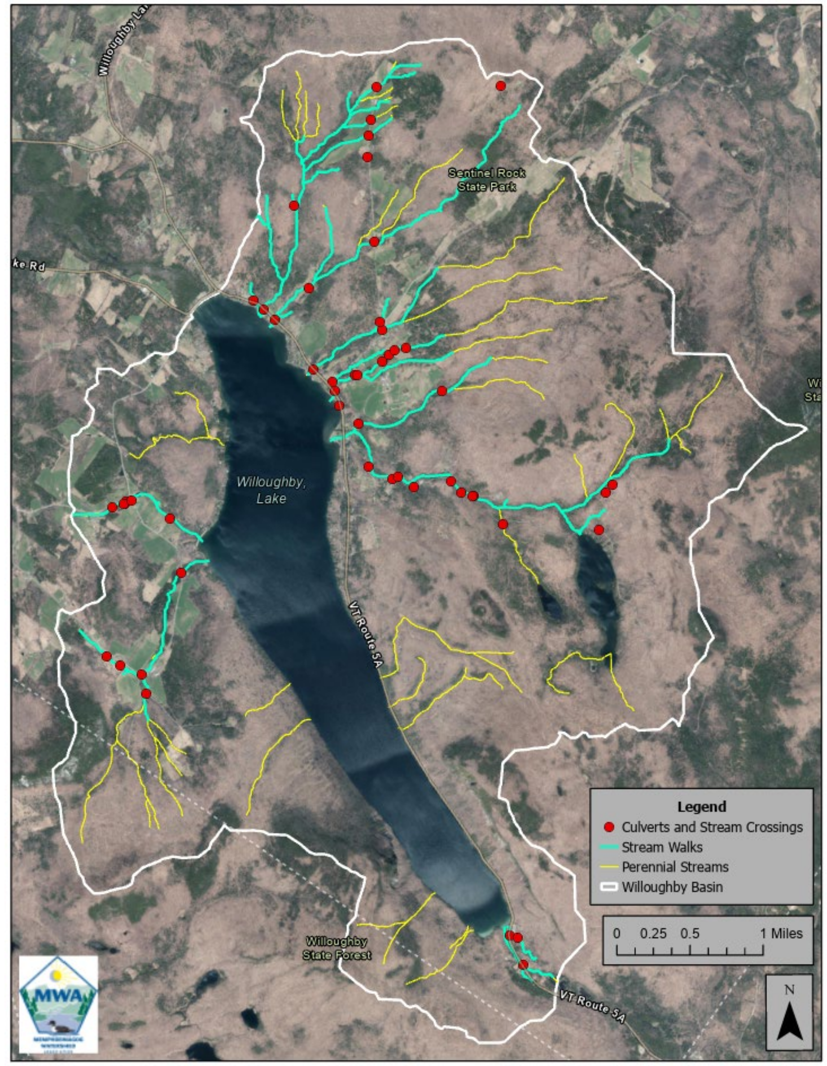

Figure 7. Inventory of culverts and other stream crossing structures that were evaluated during stream walks.

4.2 Town Highways, Private Roads & Private Drives

4.2.1 Road Surveys Planning & Approach

MWA utilized a GIS-based approach to select public road segments for field assessments. Using Road Erosion Risk (REI) Scoring attribute data, MWA selected 82 segments classified as "Incomplete Data", "Does Not Meet", or "Partially Meets" MRGP standards to evaluate for field assessments. Most of these segments are located on Long Pond Road (27), Lakeview Road (13), Perkins Lane (10), and Hinton Hill Road (7). As these data are from 2019 and may be outdated, the LWAP Team worked with the Westmore Roads Commissioner and Foreman to further narrow down the list of road segments to be evaluated during field assessments. Public road segments proposed for field assessments are illustrated in Figure 8.

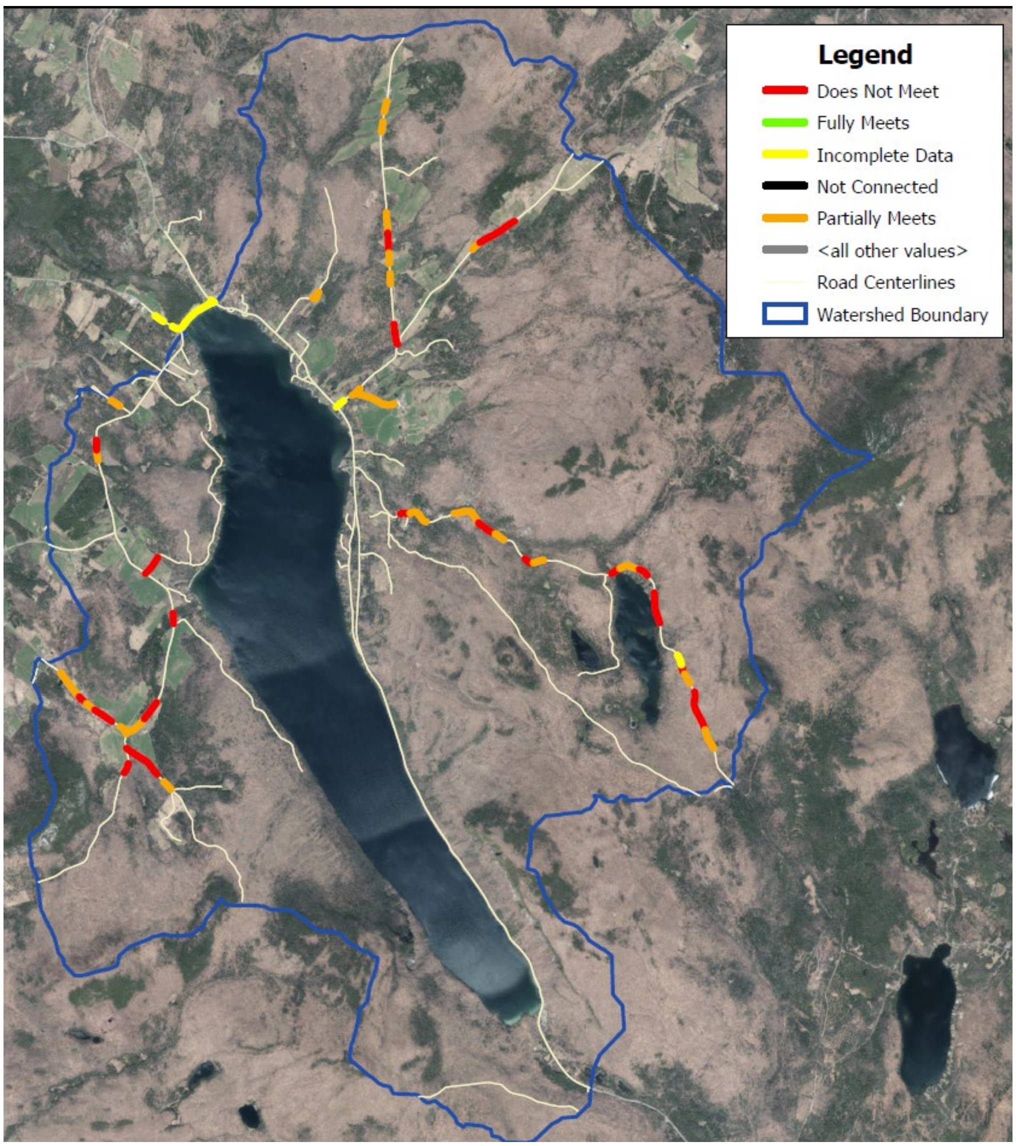

Figure 8. Town road segments that were identified and proposed for field assessments.

Private roads and driveways were not included in the state REI database, so additional efforts were taken to identify priority segments for field assessments. Of the 9.2 miles (145 segments) of private road within the Willoughby watershed, 3.3 miles (54 segments) were identified as having potential need for field assessments. These segments were selected using protocols akin to the Hydrologically Connected Road Segments. Private road centerlines were segmented into 100-meter lengths and all segments within 100 feet of a stream (intermittent and perennial), wetland or waterbody were selected for field assessment. Slopes greater than 10% were explored as additional filters for Private Road segments, but most private road segments in the watershed have average slopes approaching or greater than 10%. Private road segments proposed for field assessments are illustrated in Figure 9.

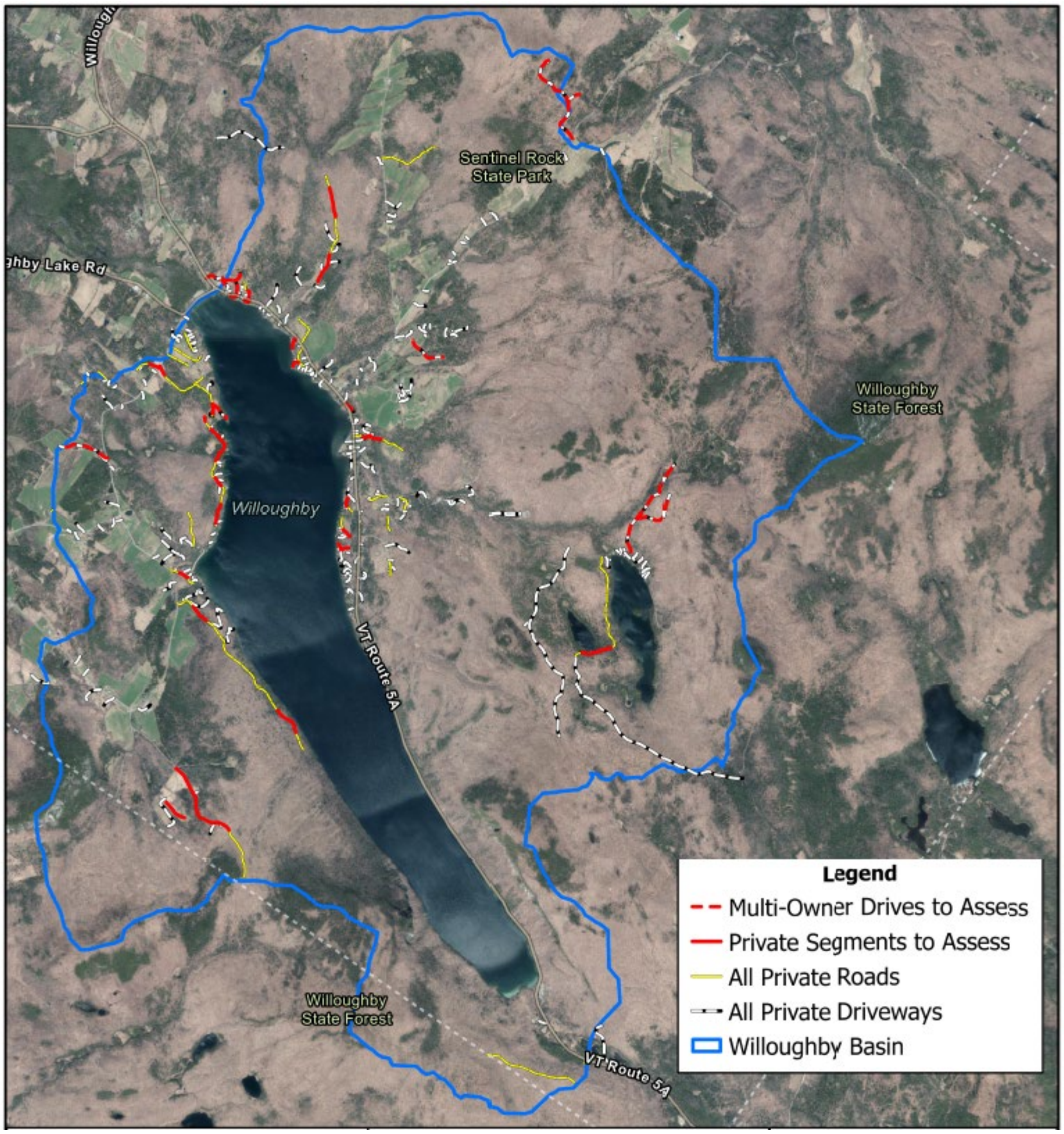

Figure 9. Private roads and driveways that were proposed for field assessment.

4.2.2 Findings from Road Assessments

MWA identified 27 discrete road/stormwater inputs to streams and over 60 opportunities to install or improve road erosion BMPs for managing runoff (Figure 10). Stormwater inputs from roadways were concentrated along the Rt 5A corridor, Long Pond Road, and Hinton Hill Road. Both Long Pond Road and

Hinton Hill Road are particularly steep and run alongside major tributaries for most of their length. The lower portion of Hinton Hill Road is paved and includes a small storm drain system, which discharges directly to Wells Brook and the Lake without treatment. As of 2022, upper Hinton Hill Road was undergoing road erosion BMP installation. Assessments identified some existing road erosion BMPs installed along Long Pond Road, but many of the road segments remain hydrologically connected and untreated. In some cases, road segments listed as not hydrologically connected were, in fact, hydrologically connected upon closer inspection. On both roads, sediment loading appears to be high, cross-culverts were partially plugged with sediment, and un-armored outfalls were contributing to scour, erosion, and gully formation. **It is recommended that all segments of Long Pond Rd be prioritized by the Town for MRGP re-evaluation, road erosion BMP maintenance, and installation of additional BMPs such as sediment forebays, culvert outfall splash aprons, grader berm removal, stone lined ditches, and turn-outs.**

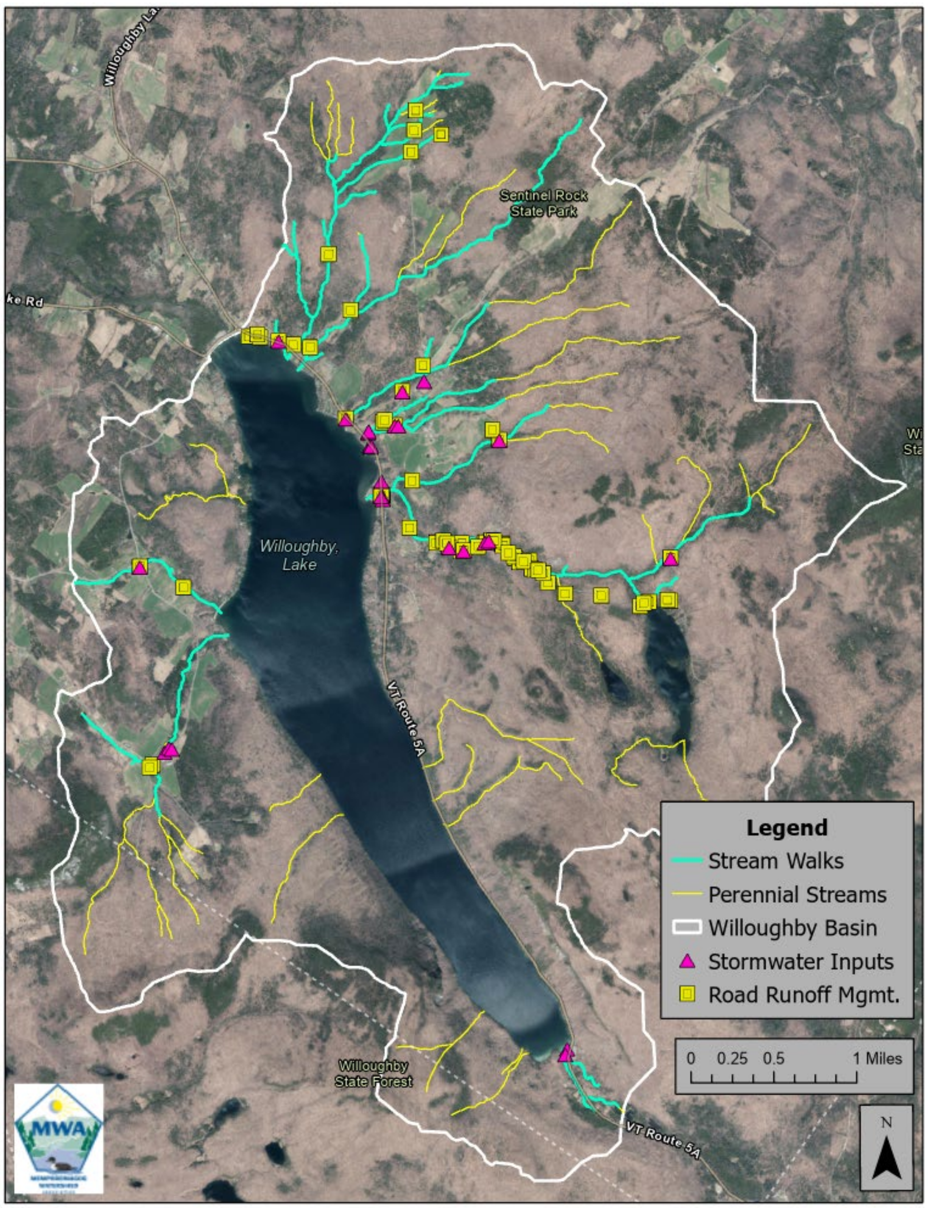

Figure 10. Recorded observations of various stormwater and road runoff inputs to waterways.

Other sources of stormwater inputs to waterways were related to residential development, farm, or forest road runoff. While impervious surfaces are relatively low in the watershed, dense development along the shoreline emphasizes the importance of managing stormwater from roofs, driveways, and parking areas on-site. For instance, we identified four (4) steep, private driveways with visible signs of erosion and direct hydrologic connection to streams.

Using information from the REI reports and stakeholder input, MWA proposed to assess 3.3 miles of public roads, 2.9 miles of private roads, and 3 miles of private driveways. In total, the LWAP Team evaluated 3.9 miles of public roads, 2.8 miles of private roads, and 3.2 miles of private driveways (Figure 11). Road assessments were completed opportunistically in September 2022 in conjunction with stream walks and more comprehensively in June 2023 after coordination with the Town Road Foreman. State Route 5A was excluded from field screening due to the existing TS4 regulatory requirements for managing stormwater runoff from State Highways. However, potential State Highway projects were identified where field assessments encountered problematic culverts, erosion, sedimentation, or other issues associated with Route 5A. **From this work, the LWAP Team identified 21 potential road erosion reduction projects and three (3) potential stormwater management projects.**

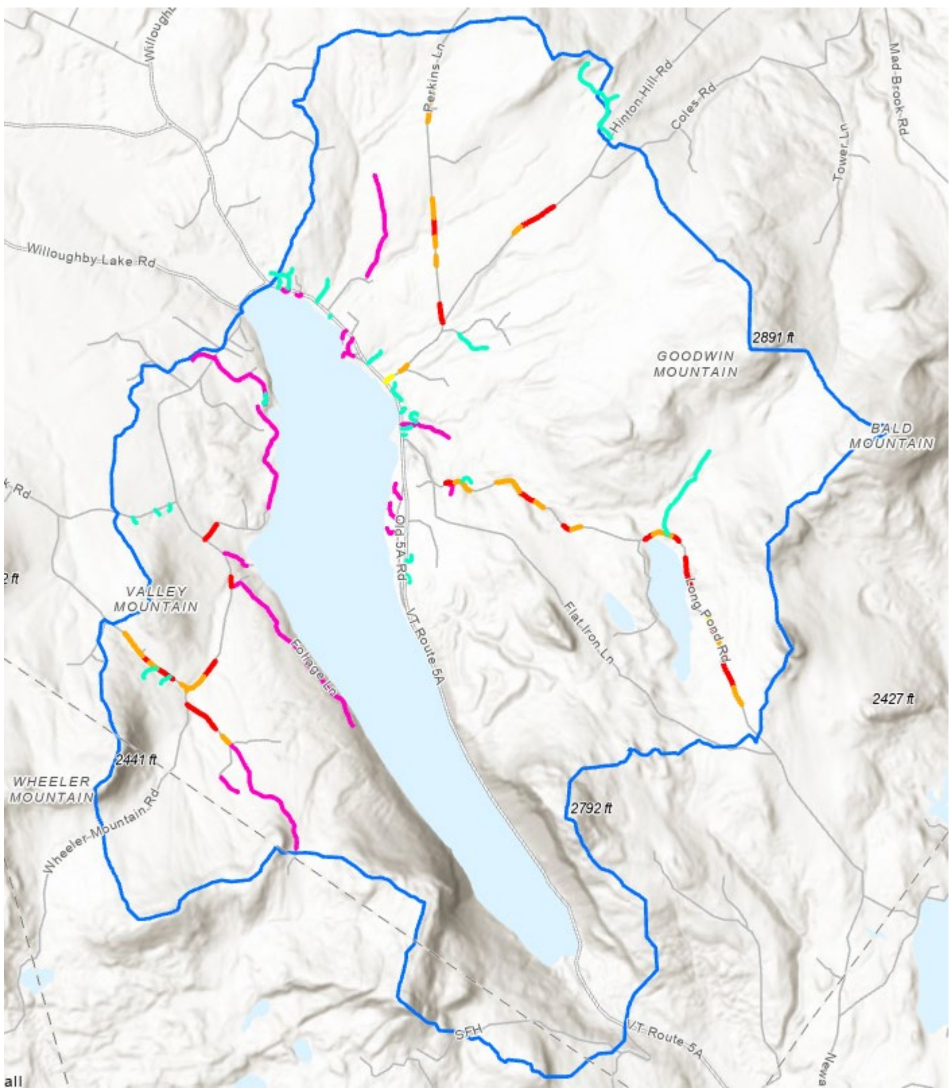

Figure 11. Field assessments performed on public roads (orange, red, yellow) private roads (magenta) and private driveways (cyan).

4.3 Lake Shorelands

4.3.1 Shoreland / Lake Wise Assessments Planning & Approach

The LWAP Team performed two lake shoreland assessments, one in July 2022 and another in June 2023. The first boat tour focused on the northern half of the lake, while the second boat tour circumnavigated the lakeshore (~12 miles). These boat tours identified 14 potential properties for Lake Wise assessments including: the North beach, four (4) lakeshore resorts with significant shoreline frontage, and seven (7) camp parcels adjacent to stream outlets. OCNRCD then conducted outreach to engage landowners and schedule Lake Wise assessments (Figure 12).

Ultimately, nine (9) Lake Wise assessments were conducted on private properties. Three new Lake Wise awards were issued, but we were not able to obtain landowner invitations to do assessments on most of the more critical properties.

Of the four (4) Lake Wise assessments conducted in 2022, no viable projects were identified, but one (1) award was issued. Following the 2023 boat tour, seven (7) additional lakeshore properties were targeted for outreach and offered Lake Wise assessments. Subsequently, five (5) assessments performed in 2023, in which 2 properties were issued awards and 1 project was identified for 30% conceptual designs. **From this work and other assessments focused on tributary outlets to the Lake, the LWAP Team identified ten potential lake shoreland projects, five of which were chosen for prioritization efforts.**

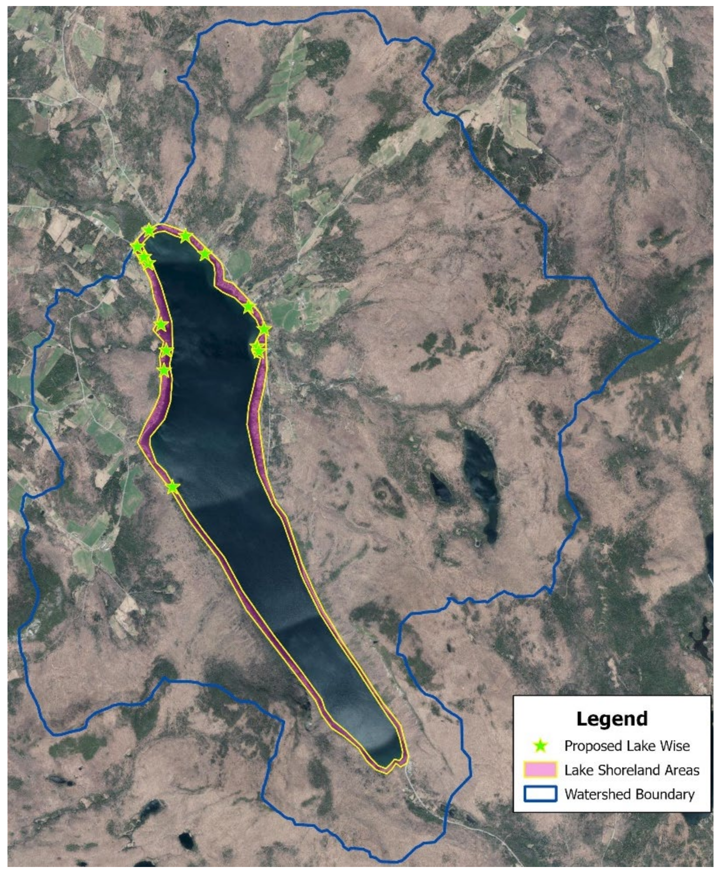

Figure 12. Lake Wise assessments (green stars) that were proposed following the Shoreland Assessments (purple polygon).

4.4 Agricultural, Developed & Forested Lands

4.4.1 Planning & Approach for Large Land Ownerships

During planning for field assessments, MWA identified five (5) large land ownerships and recommended they be screened for water quality project opportunities. These properties were selected because of the simplicity of working with a single landowner, the cumulative effects of large-scale agricultural, forestry, and development activities, and the tendency for these properties to have multiple waterways running through them. The LWAP Team performed outreach to landowners to gain access to the properties beyond what could be assessed via public access to navigable waters. MWA and OCNRCD met with landowners – sometimes on multiple occasions – to walk properties and discuss opportunities to protect and improve water quality and habitat.

4.4.2 Findings from Farm Assessments

Stream assessments led MWA and OCNRCD to evaluate several larger agricultural parcels for opportunities to improve water quality. Two operational farms and one retired farm comprise the majority of agricultural lands in the watershed. Both operational farms, one located off Perkins Lane and the other off Lakeview Road (Wheeler Mountain Road), have opportunities to improve riparian buffer quality and quantity as well as reduce barnyard and heavy use area runoff. The non-operational farm, located on Lacross Ln, has opportunities to restore stream habitat, create and enhance riparian buffers, reduce agricultural ditch drainage capacities, and stabilize headcuts and gullies.

Several sources of farm-related stormwater runoff (Perkins Lane, Lacross Lane, Lakeview Road) should be considered priorities for project development work. Runoff from manure pits, silage bunkers, and barnyard operations are nutrient and bacterial loading concerns. **To address these concerns, the Lakeview Road farm is already engaged with OCNRCD to implement buffer plantings, cattle fencing, and farmstead stormwater management to restore sections of Roaring (Lightning) Brook.** Continued planning efforts are being taken to capture and treat barnyard area runoff and agricultural waste (e.g., manure, grain, road grit) along Lakeview Road to prevent discharge to the brook. In addition, a tributary stream near the intersection of Wheeler Mountain Road and Lakeview Road is currently being planned for a suitable buffer and wetland enhancement actions, cattle fencing, and farm road stabilization practices to reduce sediment and nutrient loading to Roaring Brook.

On Lacross Lane, the Willoughby Grand View Farm is now undergoing a phase of transition away from primarily dairy production and more toward recreational, tourism, and scenic uses. The farm drains to both Wells and Ministers/Mill Brook. The fields were heavily ditched in the past, resulting in rapid conveyance of runoff to nearby brooks, particularly Ministers Brook. The ditches terminate into dramatic forested gullies subject to mass wasting and headcuts. Two ditch termini were used as dumping areas and are littered with trash. Across the farm are two major tributaries of Wells Brook. The northern tributary shows opportunities for riparian buffer inter-plantings, stream crossing and headcut stabilization, and wet meadow enhancement. The southern brook is heavily altered; flow was diverted from the historic channel during construction of a farm pond. The active channel was excavated and diverted streamflow to the northern tributary, with severe erosion and mass wasting occurring throughout the channelized reach. The farm pond collects runoff from the barnyard area, appears eutrophic, and is a water quality and flood risk concern. **MWA and OCNRCD are working with NRCS and the landowner to decommission manure pits and ponds, reduce drainage ditch runoff and erosion, enhance floodplains and wetlands, and re-establish woody buffers.**

The Perkins Lane farm is primarily a haying operation with approximately 30 head of cattle. Five (5) perennial streams flow through this farm and eventually drain into a major tributary of the lake. Each stream has opportunities for riparian buffer enhancement/creation, stream crossing stabilization, cattle fencing, and culvert upgrades. MWA spoke with the farmer on several occasions but was unable to obtain support to develop riparian buffer projects at this time.

While a small portion of the assessment work was dedicated to forested lands, nonetheless MWA identified several opportunities to improve forest roads, trails, and stream crossings. **A large portion of the upper watershed is traversed by historic and contemporary logging roads; these roads**

should be evaluated for opportunities to stabilize erosive gullies or improve stream crossings where undersized or damaged culverts are present. As a result of these findings, MWA began working with a large forest landowner through a project development grant to identify, design and implement forest road and stream crossing BMPs to reduce erosion and sediment loading.

In total, six (6) large parcels were thoroughly assessed by evaluating stream drainages, ditch networks, roadways, forest trails, and agricultural fields. **From this work, the LWAP Team identified one (1) potential pollution mitigation project, two (2) potential forestry projects, and two (2) potential agricultural projects.**

5.0 Project Evaluation & Prioritization

5.1 Field & Desktop Analysis

Data collected from the field included key characteristics for each discrete problem area that was identified as a potential project opportunity. This may have included field measurements and estimations that would be critical for later prioritization and phosphorus (P) reduction calculations. For instance, gully dimensions such as length, width and depth were collected to inform P loading rate and reduction estimates. Key characteristics from the field were then coupled with geospatial datasets to further refine project scopes and potential water quality benefits. Geospatial datasets included:

- Contributing Drainage Area - Each discrete project's contributing drainage area was delineated using manual methods from 1-foot topographic contours, or where possible, using GIS tools such as USGS StreamStats, VT Atlas, or watershed tools in ArcGIS.
- Land Use/Land Cover - Where relevant, contributing drainage area polygons were uploaded to VT Atlas and utilized to classify land use/land cover for individual projects.
- Aerial Imagery - Each project area was thoroughly evaluated using contemporary aerial imagery (2016 – 2023); in certain cases, imagery dating as far back as 1962 and 1940 were reviewed to better characterize historic conditions and past disturbances.
- Stream Crossing Structures - Bridge and culvert data collected by the Northeastern Vermont Development Association and Vermont Fish & Wildlife were thoroughly reviewed to provide context related to geomorphic compatibility, structural condition, and potential barriers to aquatic organism passage.
- Soils - Used to review soil erodibility, hydric soil classification, hydrologic soil group classification, and prime farmland status.
- Potentially Erosive Features – Used to review upland and forested contributing drainage areas to inspect for remotely sensed gullies and other erosive features.
- Road Erosion Inventory – Used to identify known road segments that are not in compliance with MRGP standards.
- Parcel Data – Used to approximate parcel boundaries, road rights-of-way, and ownerships as they relate to a project area.

Field assessments identified 75 potential project opportunities across the landscape that varied from Agricultural, Road Erosion and Stormwater BMPs to Floodplain/Stream/Wetland and Lakeshore Restoration (Figure 13). These potential projects were summarized in a Batch Import File (BIF) and will be uploaded to DEC's Watershed Projects Database for future project partners to develop, design, and implement. During the development of the BIF, the LWAP Team ranked each project (HIGH-MEDIUM-LOW) based on our best professional judgment. Our Team evaluated each potential project and assigned a ranking that reflects the assumed potential water quality benefits. From this list of 75 projects, the LWAP Team selected 30 HIGH and/or MEDIUM priority projects for more in-depth prioritization based on the methodology we developed in partnership with DEC and Westmore stakeholders.

Figure 13. Project locator map of 75 potential water quality and habitat improvement projects that were summarized into a Batch Import File for uploading to the VT Watershed Projects Database.

5.2 Prioritization Criteria & Cost Estimating

The LWAP Team developed a prioritization methodology that effectively compared multiple project types amongst each other to aid in the selection of projects for 30% concept designs. The prioritization methodology was heavily influenced by the criteria developed during the completion of the Lake Elmore Watershed Action Plan (Fitzgerald Environmental Associates, 2020). The LWAP Team solicited input from the community and DEC at public meetings and incorporated this feedback into the *Willoughby LWAP Prioritization Criteria & Methods* memo, available in Appendix C. Each potential project was evaluated through field and desktop analyses and points were assigned to each criterion based on quantitative and qualitative measures. The maximum possible score was 32 points. The *Prioritization Table* for high-priority projects is available in Appendix D. In summary, prioritization efforts ranked potential projects based on the following criteria:

Water Quality Benefits (15 points total):

- **Phosphorus (P) Load Reduction (0 – 4 points):** Represents the magnitude of potential P load reduction achieved through project implementation. Values were chosen to represent relative P removal efficiency and/or P removal capacity. All P loading reductions were quantified using DEC's "Interim Phosphorus Calculator Tool_V1.0" or Stormwater Treatment Practice calculator.
    - 0 points – No P source and/or no increased treatment (0 lb/yr)
    - 1 point – Minor P source and/or minor increase in treatment (0 – 1 lb/yr)
    - 2 points – Moderate P source with some increase in treatment (1 – 2 lb/yr)
    - 3 points – Moderate P source with significant increase in treatment (2 – 5 lb/yr)
    - 4 points – Major P source with significant increase in treatment (> 5 lb/yr)
- **Sediment Retention (0 – 4 points):** Represents the magnitude of potential sediment load reduction or retention achieved through project implementation. Values may be chosen to represent existing sediment loading rates, reductions through stabilization, and/or retention through treatment capacity.
    - 0 points – No meaningful sediment source and/or no treatment (e.g., rooftop runoff infiltration)
    - 1 point – Minor sediment source and/or minor increase in treatment (e.g., lawns, grass swales)
    - 2 points – Moderate sediment source with some increase in treatment (e.g., parking areas, unvegetated riparian buffers)
    - 3 points – Moderate sediment source with significant increase in treatment (e.g., unpaved road BMPs, bank stabilization)
    - 4 points – Major sediment source with significant increase in treatment (e.g., stabilize mass wasting, stormwater treatment practice)
- **Drainage Area (0 or 1 point):** Approximate drainage area to site is greater than 2 acres.
- **Percent Impervious or Agricultural Land Cover (0 – 3 points):** Score based on percentage of impervious surfaces in the contributing drainage area.

  - 0 points – Percent impervious surface or agricultural lands <25%
  - 1 point – Percent impervious surface or agricultural lands 25-50%
  - 2 points – Percent impervious surface or agricultural lands 50-75%
  - 3 points – Percent impervious surface or agricultural lands >75%

- **Connectivity to Surface Waters (0 – 3):** Represents the direct hydrologic connectivity to perennial or ephemeral waterways.
  - 0 points – All runoff infiltrates on site or is treated through natural or artificial means
  - 1 point – Moderate treatment of runoff before discharge to receiving waters (e.g., mature riparian buffer)
  - 2 points – Minor treatment of runoff via conveyance or drainage infrastructure prior to discharge to receiving waters (e.g., stone lined ditch, lawn)
  - 3 points – No treatment of runoff prior to discharge to receiving waters (e.g., storm drain outfall)
- **Landowner Support (0 – 2 points):** Represents the degree to which landowners have expressed support for the project being designed and/or implemented.
  - 0 points – Landowner support not obtained or expressed
  - 1 point – Landowner expressed initial support for the project
  - 2 points – Public land; landowner has expressed full support of the project
- **Cost & Feasibility (0 – 6 points):** Cost and feasibility represents both the lifetime project cost and planning and design constraints that may influence implementation of the project. Lifetime project costs include planning, design, engineering, permitting, implementation, and operations and maintenance (O&M).
  - 1 point – >$100,000
  - 2 points – $50,000 – 100,000
  - 3 points – $25,000 – 50,000
  - 4 points – $10,000 – 25,000
  - 5 points – $2,500 – 10,000
  - 6 points – <$2,500
- **O&M and Project Longevity (0 – 2 points):** Projects with minimal and/or inexpensive operations & maintenance requirements should be prioritized over those that have expensive or intensive O&M requirements.
  - 0 points – expensive & intensive labor requirements
  - 1 point – moderate expense & labor requirements
  - 2 points – low expense & labor requirements

- **Co-Benefits (1 point each; up to 7 points):** Clean Water Projects often provide co-benefits beyond P reduction and sediment retention capacities. The following co-benefits were selected by the Willoughby LWAP Team and reflect specific concerns of the watershed and the community of Westmore.
    - Chronic Problem Area
    - Reduces Flood Risk, Peak Flows, or Seasonal Flooding
    - Educational
    - High Visibility or Potential to Influence Community
    - Agricultural Land Use Compatibility
    - Improves Existing BMPs
    - Enhances Lakeshore Natural Communities

Since reduction of phosphorus and sediment loads are the priority of the LWAP process, these two metrics comprised up to 25% of each potential project's total possible score. The P reduction rate was determined using the "Interim Phosphorus Reduction Calculator Tool_V1.0" or the "Stormwater Treatment Practice Calculator" (depending on most relevant project types), both developed by DEC. P removal rates were coupled with cost estimates to determine the approximate project efficiency score ($ / lb. of P reduction). Cost estimates for each project were generated through several approaches. For typical Clean Water Project types (e.g., riparian buffers, lakeshore stabilization, floodplain/stream restoration, road erosion BMPs, etc.), the LWAP Team applied average unit costs taken from DEC's *Water Quality Restoration Formula Grant Target and Fund Allocation Methodology* (VTDEC, 2022b). In these instances, proposed project scopes (e.g., linear feet of stream restoration, acres of floodplain restoration, linear feet of road BMPs, acres of riparian buffer plantings) were multiplied by the average unit cost reported by DEC. On occasion, potential project constraints such as existing infrastructure or technical complexity were taken into account and cost estimates were adjusted based on best professional judgment. Where average unit costs were not available or deemed appropriate, the LWAP Team estimated project costs by collecting cost data from similar projects completed in the region within the last 5 years. This approach was particularly useful for stream crossing structures and stormwater infrastructure. The LWAP Team compared project cost estimates to the Vermont Agency of Transportation 2- and 5-year Averaged Price Lists from the 2018 specifications for relative accuracy and adjusted cost estimates to account for discrepancies as well as recent inflation.

5.3 Project Summary Sheets

Of the 75 potential projects included in the BIF and uploaded to the Watershed Projects Database, 30 HIGH- and MEDIUM-ranking projects were selected for evaluation through the Prioritization Criteria using the methods described above. These 30 priority projects were also described in further detail in *Potential Project Summary Sheets*, provided in Appendix E. Project Summary Sheets provide critical information for each priority project, including:

- Project Name, Identification Number & Clean Water Project Type
- Location (lat/long), Ownership, & Locator Map
- Description of Problem Area & Photo(s) of Water Quality Issues/Project Opportunities

- Description of proposed BMP & anticipated Co-Benefits
- Table of Prioritization Criteria Scores
- Notes/Comments relevant to landowner support, anticipated permitting, cost estimates, and potential constraints/technical complexities.

5.4 Water Quality Stressors by Sector

The LWAP Team utilized outputs from the P load reduction calculations to estimate the relative contribution of nutrients to Lake Willoughby from each of the five Clean Water Project sectors. P removal rate outputs for each potential project were taken from the Interim P or STP Calculator and grouped by their respective work sectors, acting as a proxy for excess P loading rates from agriculture, streams/wetlands, roads, shorelands, and stormwater runoff. Based on this analysis, agricultural lands and roads each contribute approximately one-third of the overall excess P that is discharged to Lake Willoughby (Figure 14). Waterways contribute approximately one-quarter of the excess P, while lakeshore erosion and stormwater contribute 7% and 6%, respectively.

Given the rocky and naturally armored shoreline of Lake Willoughby, the LWAP Team was not surprised by the small proportion that shoreland erosion contributes to excess P loading. Similarly, the Willoughby watershed is 80% forested and only approximately 1% impervious, therefore, stormwater runoff from developed lands was not anticipated to be a major contributor to excess sediment and P loading. However, that does not suggest that meaningful water quality benefits cannot be obtained through improved stormwater management and shoreland BMPs along the most heavily developed sections of the lakeshore.

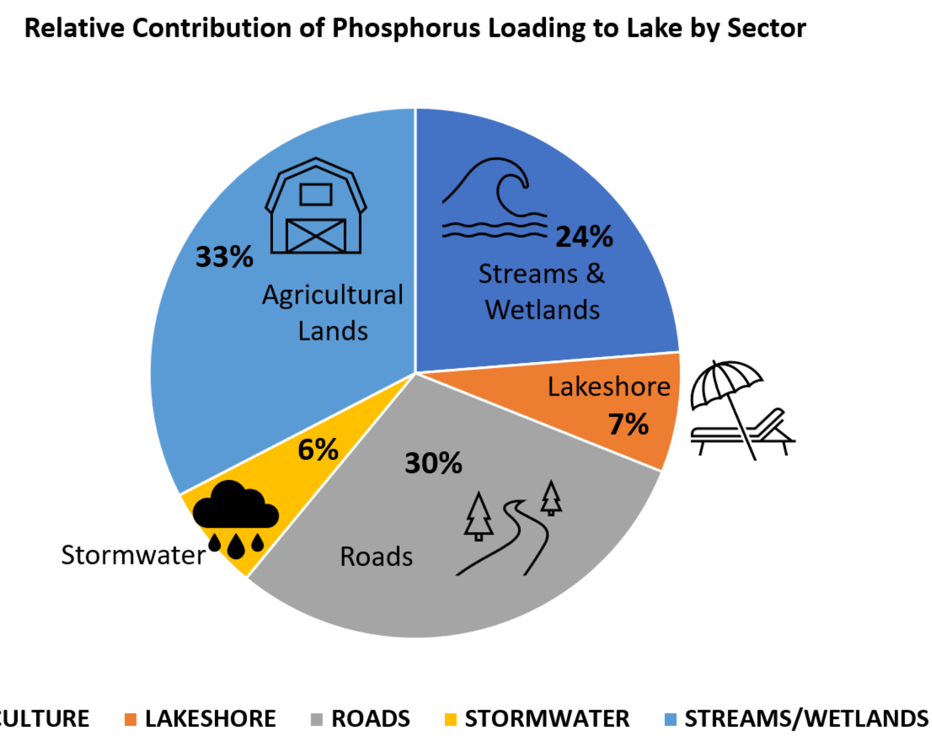

Figure 14. Relative contributions of phosphorus loading to Lake Willoughby by project work sector based on the 30 prioritized projects.

Based on field assessments and visual indicators of erosion, scour, runoff, channel migration, and farming activities, the LWAP Team agrees with the relative contributions of excess P to the Lake by roadways, agricultural runoff, and stream instability. Large deltas of recently deposited sediments were observed at the outlets of all major tributaries to the Lake. These sediments are believed to be primarily originating from 1) road & ditch erosion, 2) streambank erosion/mass wasting, 3) farm drainage ditches, and 4) geomorphically incompatible culverts. Agricultural runoff was evident downgradient of several farms where field assessments identified manure-laden drainage ditch outflows, filamentous algae, and 'froth' that resembles organic-rich pollution. Unpaved roads throughout the watershed are typically very steep, run alongside perennial streams, and are narrowly confined by hillslopes, thus limiting the potential for roadside BMPs. Lastly, the lower reaches of most of the major tributaries are exhibiting substantial channel migration and bank erosion; this trend is believed to be the result of steep-gradient headwater systems, artificially armored banks (field stone and boulder riprap), confined floodplains (from existing development), and a climatically driven increase in the frequency and intensity of rainstorms.

5.5 Priority Project Selections

During the July 6, 2023 public meeting, the LWAP Team presented fifteen high-priority projects as recommendations for the Town to pursue further. These 15 projects ranged from shoreland and floodplain restoration to stormwater runoff and road erosion management.

1. North Beach Shoreland Restoration*
2. Lake Shoreland BMPs at Mill Brook outlet (north campground)
3. Lake shoreland BMPs at Mill Brook outlet (south campground)
4. Hinton Hill Rd Stormwater Improvements*
5. WhiteCaps Campground Stormwater BMPs*
6. Grand View Farm drainage improvements*
7. Stabilize mass wasting on Hinton Hill Rd brook
8. Buffer Restoration on farm tributaries off Perkins Ln
9. Farm pond dam removal and stream reconnection off Lacross Ln
10. Wheeler Mountain Rd wetland enhancement
11. Lond Pond Rd erosion BMPs*
12. Lacross Ln road erosion BMPs
13. Lakeview Rd erosion BMPs
14. Perkins Ln road erosion BMPs
15. Big Valley Rd erosion BMPs

Of these fifteen projects, five were selected and proposed for 30% design development (* denotes original five recommended projects). These five projects included the North Beach shoreland restoration and the Hinton Hill Rd stormwater improvements, both of which stimulated much discussion and public comment. Several residents voiced strong opposition toward any proposed changes at North Beach. Others from the Westmore Community Church requested additional public meetings to discuss how the Hinton Hill Rd project would affect Church property. Based on this feedback, the LWAP Team worked with residents and town officials to select the final list of projects that would be developed into 30% conceptual designs.

6.0 30% Preliminary Designs

MWA developed 30% preliminary designs for five of the highest-priority projects that were identified and prioritized during the LWAP process. These projects were selected for their potential water quality benefits as well as strong landowner support and multiple co-benefits. The *30% Design Plan Sets* are included in Appendix F and include the following components:

- Existing Conditions Site Plan
    - Above-ground utilities and building footprints
    - Parcel boundaries
    - Mapped streams and wetlands
    - LiDAR-derived 1-ft contour lines
- Proposed Best Management Practices and/or Treatment Areas
- Longitudinal profiles, cross-sections, and contributing drainage areas
- Stream geomorphic parameters (e.g., bankfull width, floodprone width, incision ratio, entrenchment ratio, etc.)
- Typical details for proposed practices
- Preliminary cost opinion

The five projects selected for 30% design development included:

1. **Grand View Farm Drainage Improvements** – Extensive network of drainage ditches and forested gullies convey significant volumes of runoff and high sediment loads to both Minister's & Mill Brooks. The designs call for earth and stone check dams, woody ditch plugs, gully stabilization, turn-out swales, and woody buffers to increase infiltration, arrest erosion, reduce runoff and sediment loading, and reverse incision of the drainage ditches and gullies. Several alternatives are presented.
2. **Wells Brook Outlet Restoration** – Heavily armored banks narrowly confine a highly entrenched stream channel with no riparian buffer at the mouth of Wells (Church) Brook. The banks are on the verge of collapse and present a hazard to Route 5A. High sediment loads pass through this reach with minimal floodplain access. A geomorphically incompatible 4-ft CMP culvert with failing headers and abutments acts as a velocity barrier preventing AOP. The designs call for a new, properly sized and aligned 14-ft box culvert, stream channel realignment, and creation of an inset floodplain with woody riparian and lakeshore buffers.
3. **Lakeview Road Erosion BMPs -** Lakeview Road contains multiple segments that are classified under "Does Not Meet" MRGP standards according to the REI. Runoff from these steep road segments carries sediment directly to Roaring (Lightning) Brook. Designs call for removal of grader berms on the road shoulders, re-grading the crown of the roads, lining existing or proposed ditches with stone, and installing several engineered turnouts to redirect runoff from streams.

4. **Big Valley Road Erosion BMPs –** Big Valley Road contain multiple segments that are classified under "Does Not Meet" MRGP standards according to the REI. Runoff from these steep road segments carries sediment directly to Roaring (Lightning) Brook. Designs call for removal of grader berms on the road shoulders, re-grading the crown of the roads, lining existing or proposed ditches with stone, and installing engineered turnouts where possible to redirect runoff from streams.
5. **Hinton Hill Road Stormwater Improvements –** As the only road in Westmore with an underground storm drain system, runoff from steep paved segments of the road discharges directly to Wells Brook without treatment. This results in high sediment loading and potential hydromodification of this stream reach. Designs call for diverting storm flows from existing and proposed storm drain infrastructure to discrete treatment areas on the Westmore Community Church property.

7.0 Next Steps

As urgent water quality issues were identified and willing landowners were brought on board, the LWAP Team initiated 'Next Steps' even before the LWAP process was complete. For instance, following some of the forested lands and stream assessments, MWA applied for and was awarded a *Forested Headwaters Project Development Grant* by Watersheds United Vermont to work with large landowners in the Willoughby and Mad Brook drainages. This grant has allowed MWA to further investigate water quality improvement project opportunities that will benefit Lake Willoughby once implemented. On the Willoughby Grand View Farm off Lacross Lane, OCNRCD and MWA are working closely with the new owner to develop a more holistic approach to managing runoff and improving water quality in Mill, Ministers and Wells Brooks. For this work, OCNRCD applied for and was awarded a grant to conduct a feasibility study that will evaluate how to remove a eutrophic farm pond dam and return critical flows to a stream that was dewatered through diversions decades ago. At the outlet of Wells Brook, OCNRCD and MWA are working with the owners of two abutting properties and VTrans to restore stream habitat, floodplain function, and fish passage below the Route 5A crossing.

Following the close of the Willoughby LWAP process, the LWAP Team will continue to work with interested landowners to develop, design, and implement water quality improvement projects. This includes seeking grant funding to finalize designs, engineering and permitting for the five high-priority projects that were developed as part of our LWAP work. OCNRCD will continue to work with landowners and DEC to perform Lake Wise assessments and make recommendations for shoreland and stormwater BMPs to manage runoff for lakeshore properties. MWA will continue to work with OCNRCD and the Town of Westmore to develop designs and permit applications to implement the work that landowners and other partners' support.

8.0 Broader Recommendations

The LWAP Team identified numerous opportunities to improve water quality, manage stormwater runoff, enhance aquatic organism passage, and reduce fluvial erosion and flood risk hazards in the Willoughby watershed. In general, findings indicate the best opportunities for improving water quality and habitat to protect the health of the lake lie in restoring riparian and lakeshore buffers, promoting geomorphic stability in streams, and reducing runoff from developed and agricultural lands. The following are broader recommendations from the LWAP Team that can be adopted by the Westmore Association, the Town, and its residents.

8.1 Functioning Floodplains & the Role of Woody Debris in Stable Streams

The majority of stream miles in the Willoughby watershed flow through steep, confined valleys. Towards the bottom of the drainages, most streams have a brief opportunity to access floodplains before discharging to the lake due to the shallower slope, flatter topography, and wider valleys. However, this is also where the densest development and infrastructure lie, particularly along the Route 5A corridor. When in a natural state, floodplains act to absorb floodwaters, reduce peak flow velocities, trap sediment, retain and cycle nutrients, and provide refuge for fish and other aquatic organisms. Over the last century, the limited floodplain areas in the Lake Willoughby watershed have been encroached upon by houses, camps, driveways, and lawns, resulting in an apparently drastic reduction in available and functioning floodplain areas. Furthermore, channels have been degraded by the installation of hydraulically undersized culverts that are often both geomorphically and biologically incompatible. As a result, there is a large deficit in the availability of natural, functioning floodplains in the watershed. **The LWAP Team strongly encourages the Town of Westmore, VTrans, and private landowners to work together to restore floodplain areas where possible.** Greater access to floodplains will reduce fluvial erosion and flood hazard risks while improving water quality, primarily by reducing stream power and promoting sediment deposition. This can be achieved by removing berms and streambank armoring, replacing incompatible culverts and stream crossings, re-establishing natural woody buffers, and reducing channel incision through means such as grade control structures and strategic wood additions, where appropriate.

In forested stream settings, natural inputs of large wood help to stabilize the channel and regulate sediment fluxes. In general, MWA observed less bank erosion and geomorphic instability where large wood and natural debris jams were present, even though these were typically on steep, high energy reaches. In some cases, MWA estimated natural wood debris jams were retaining 1-2 tons of sediment (Figure 15) and providing significant in-stream habitat for fish by creating scour pools and bars, sorting sediment by size class, and trapping leaf litter and organic detritus. When comparing the locations of bank erosion and mass wasting observations with the apparent distribution of large wood in Willoughby watershed streams, a disconnect appears to occur on the lower reaches of many of the east side drainages. A lack of natural woody vegetation, active removal of large wood (per conversations multiple landowners), bank armoring, and other stream alterations appear to coincide with signs of channel and bank instability. Additionally, MWA observed an abundance of bank armoring – typically in the form of field stone piles – in the lower reaches of these streams (Figure 16). It is possible that over the last century, the lowest reaches of Willoughby's east side tributary streams were cleared of large wood and armored with field stone to reduce flooding and channel migration. While these alterations were put in place to protect development and infrastructure, they ultimately fail over time, require expensive maintenance, and act to transfer stream energy and flood damages downstream. This can result in accelerated bank erosion rates, reduced sediment retention capacities, and lower quality aquatic habitat. **Therefore, the LWAP Team recommends replenishing large wood stocks in both steep and shallow stream reaches where risks of entrainment and downstream impacts are low.**

Figure 15. Natural log jams retain sediment and provide diverse aquatic habitat on Stoney Brook.

Many stream crossings beneath Route 5A are listed as causing reduced aquatic organism passage (AOP). MWA also observed several of these structures as being undersized and geomorphically incompatible. These structures should be replaced over time to promote free movement of aquatic organisms and reduce fluvial erosion hazard risks. It is worth noting that potential natural passage barriers in the form of ledge outcrops and waterfalls are abundant in many of the streams draining to the lake. As such, replacement of structures that currently provide *Reduced AOP* or *No AOP* may not result in improved access to headwater habitat. Close inspection of AOP issues and selection of projects that will guarantee improved AOP to upper reaches of the streams is paramount to the prioritization effort. **The LWAP Team recommends several structures as priorities for further evaluation and replacement:**

1. The double culvert where Roaring (Lightning) Brook crosses Lakeview Road is partially plugged, perched, and appears to be vulnerable to flood-related damage.
2. The culvert where Wells (Church) Brook crosses Route 5A is the subject of a proposed replacement project and is included as one of the 30% designs.
3. Upstream from there, the Wells Brook crossing beneath Lacross Lane has already been engineered and should be prioritized for immediate replacement. It is worth noting that both of these Wells Brook reaches do not appear to have natural fish passage barriers.
4. Finally, the culvert on Beavers Brook where it crosses Old Cottage Lane should also be evaluated for opportunities to improve passage.

Large scale bioengineered streambank stabilization is not a common practice in the Northeast Kingdom as it does not always incorporate natural channel adjustment processes and may prevent rivers from reaching a state of dynamic equilibrium. However, many of the instances of accelerated bank erosion and mass wasting observed in the Willoughby watershed are in close proximity to development and pose a potential risk to infrastructure if allowed to progress unabated. **Therefore, where existing development conflicts with stream processes and channel management is unavoidable, MWA recommends that bioengineering techniques should be considered before installing or replacing traditional stabilization methods (e.g. riprap).** These practices work to absorb stream energy, reduce sediment and phosphorus loading from channel and bank erosion, and provide functional habitat and flood resilience.

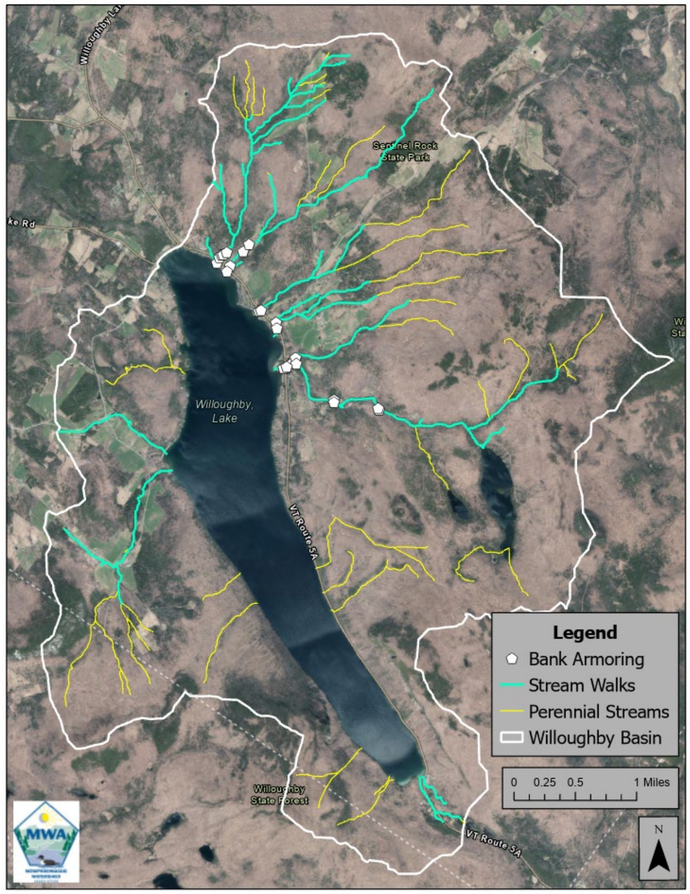

Figure 16. Bank armoring was observed in many locations along the lowest reaches of tributaries to Lake Willoughby.

The LWAP Team also recommends the Town of Westmore adopt the River Corridor Bylaws to provide greater protection to riparian areas, streambank encroachment, and development in flood hazard areas and river corridors. An example of standard flood hazard bylaws is available from DEC for Towns to review and adopt.

8.2 Town Roads & Private Drives

Many public roads in the Town of Westmore are unpaved, steep, confined by hillsides or valley walls, and adjacent to waterways. The roads which present the greatest level of erosion risk and therefore opportunities to reduce sediment loading include Long Pond Road, Lakeview Road, Old Cottage Lane, Hinton Hill Road, and Perkins Lane. **Therefore, the LWAP Team recommends the Town of Westmore Roads Department continue working with OCNRCD and MWA to bring segments of these roads up to MRGP standards while also addressing eroding culverts, ditches, and travel lanes**.

Private roads and driveways are numerous in the Willoughby watershed, amounting to 24% of the overall road mileage (8.9 miles). These are often steep, unpaved, and lack road erosion BMPs. **As such, we recommend that private road associations and individual landowners work with OCNRCD and MWA to design and implement Best Management Practices that manage runoff and reduce road erosion**. This may include regrading private road surfaces, lining ditches with stone, adding drainage culverts and stabilized outfalls, and other simple modifications. **The LWAP Team also recommends that private driveways be improved with practices such as water bars and open-top culverts that direct runoff to stable vegetated areas rather than piping this water directly to waterways or the lake.** The Westmore Association is a great advocate for this type of work on private property and could partner with OCNRCD or MWA to increase awareness and adoption of these strategies.

8.3 Promoting Lake Wise & Restoring Lakeshore Buffers

While more than half of the Lake Willoughby shoreland is forested, there are nonetheless numerous opportunities to improve natural lakeshore habitat that would also provide water quality benefits. The northern half of the lake is subject to intense redevelopment as historically small camps are converted to larger, permanent residences. As this trend continues, it is even more important that the Town, Westmore Association, landowners, and neighbors willingly adopt Best Management Practices for their lakeshores. **As such, the LWAP Team encourages the Westmore Association to continue to promote and pursue Lake Wise program participation from lakeshore property owners by contracting professional outreach and technical services that will recruit greater adoption of this critical program**.

The existing vegetative buffer disturbance permit is a great start to prevent further loss of lakeshore buffers, however, it is not clear that this requirement is enforced or well-known to residents (Town of Westmore, 2020a; 2020b; 2020c). **The LWAP Team recommends that the Town of Westmore work to increase the awareness of the vegetative buffer disturbance rules and actively discourage the removal of shoreland or riparian vegetation unless absolutely necessary for public health and safety (e.g., hazard trees). The vegetative buffer disturbance permit should also clearly state that removal of any vegetation within 250 feet of the shoreline also requires a VT Shoreland Permit.** This may include mailings to all residents along with Town Meeting Day information or targeted mailings to new residents or homeowners when properties change hands. While the VT Shoreland Permit dictates how much vegetation can be removed from within 250 feet of the shoreline, Town Bylaws can go above and beyond the standards set by the State.

8.4 Septic System Upgrades & Stricter Requirements

While the contributions of nutrient loads to the Lake from septic systems is not part of the LWAP process, our Team strongly believes that aging septic systems play an important role in the phosphorus loading to Lake Willoughby. This is because 1) many of the septic systems in place are likely well past their initial design lifespan, 2) septic systems are subject to much greater usage as summer camps transition to permanent residences, and 3) many properties are seeing increases in the number of bedrooms and occupancy rates. **The Town should encourage new development or redevelopment projects to utilize septic tanks and pump-out services as being preferred over typical leach fields, as this would result in wastewater being treated at approved facilities.** Other options may include separation of greywater vs. blackwater or stricter performance requirements for septic system upgrades.

"Septic Socials", or wastewater workshops – popular in other regional lake communities – are informal workshops hosted by Lake Associations where landowners learn about septic system maintenance, problem identification, design options, upgrades, funding opportunities, and more. The **Westmore Association should launch an educational campaign and organize and invite all lakeshore landowners to attend a Septic Social or wastewater workshop to learn how they can manage wastewater to protect the Lake.**

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10.0 APPENDICES

A. Watershed Data Library
B. Proposed Assessment Areas
C. Prioritization Criteria
D. Prioritization Table
E. Project Summary Sheets
F. 30% Design Plans
G. Photographs of Example Project Types