MEMORANDUM

To: Orleans County Natural Resources Conservation District | Seymour Lake Association | Echo Lake Protective Association

From: Memphremagog Watershed Association

Re: Watershed Data Library for Echo-Seymour Lakes Watershed Action Plan

Date: July 26, 2023

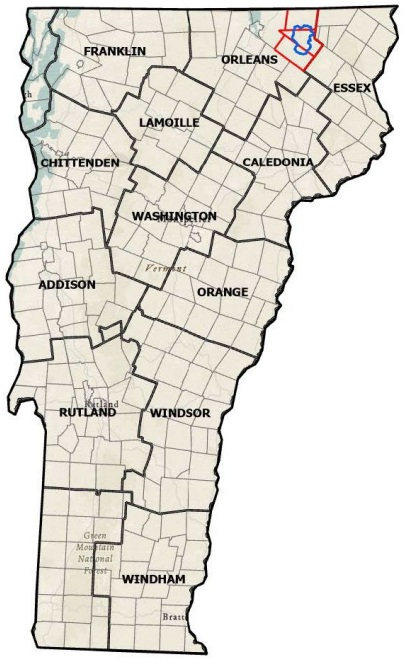

Figure 1. Overview map of the Echo-Seymour Lakes Watershed in relation to Vermont towns and counties.

According to Technical Guidelines developed by Vermont Department of Environmental Conservation (VTDEC, 2023), the goal of an LWAP is to "evaluate water quality conditions and related stressors in a lake and its watershed to identify the greatest threats to the lake ecosystem, including sources of increased stormwater runoff and associated sediment and nutrients as well as other important stressors such as invasive species, habitat loss, erosion, and other threats that may lead to loss or degradation of defined uses under the Vermont Water Quality Standards". The creation of a localized information clearinghouse in the form of a watershed data library is the initial step in the development of the Echo-Seymour Lakes Watershed Action Plan (LWAP). As such, MWA initiated the LWAP process by gathering and reviewing available data, reports, and documentation related to water quality monitoring, stream geomorphic conditions, land use/land cover, LakeWise, stormwater runoff, road networks, and watershed management in the Echo & Seymour Lakes watershed. This memo serves as a summary of the available data and information identified and explored through this process. Information was sourced from publicly available reports, town archives, databases, and previously completed studies. These findings were summarized in a virtual presentation to residents of the town of Morgan and Charleston, the Echo Lake Preservation Association, and the Seymour Lake Association at a virtual meeting on June 14, 2023. A follow-up public meeting held on July 17, 2023 revisited much of this information while discussing target areas for field based assessments of streams, roadways, lakeshores, and developed lands.

WATERSHED STUDY AREA DESCRIPTION

The Echo-Seymour Lakes Watershed is a subbasin of the Lake Memphremagog watershed located in Orleans County, Vermont and spans portions of the Towns of Morgan, Charleston, and Holland (Figure 1). From the outlet of Echo Lake, the contributing drainage area of the watershed (including lakes) is approximately 24.2 miles^2 (15,481 acres). Of this, approximately 20.6 miles^2 (13,224 acres) drains first to Lake Seymour, while the remaining 2,257 acres drains directly to Echo Lake (Figure 2). A substantial

portion of the watershed is dominated by open water; Seymour Lake is a 1,777-acre glacial lake located entirely in the Town of Morgan, while Echo Lake is a 546-acre glacial lake located upstream of the village of East Charleston. Seymour Lake reaches a depth of 167 feet while Echo Lake reaches a depth of 129 feet. Both waterbodies are classified as B(2) waters by the State and characterized as having "good" water quality. Community members at Echo Lake have formally petitioned for reclassification as A(1) "excellent" waters, whereas no such petition has been made for Lake Seymour. Water levels on both lakes are regulated by hydroelectric dams at their respective outlets, owned and operated by the Citizens Utilities Company. Water flows out of Seymour Lake for approximately one-half of a mile before entering Echo Lake, which then drains into the Clyde River in the village of East Charleston. From there, the Clyde River flows approximately 25 miles to its terminus in Newport, VT where it discharges into Lake Memphremagog.

Analyses performed by VTDEC and reported in the Lake Land Cover Maps indicates 70% of the Echo-Seymour Lakes watershed is forested (Figure 3). Other dominant land cover types include grass/shrubs (~16%), open water (~13%), and impervious surfaces (1.4%). Of those impervious areas, bare soil accounts for 28 acres, buildings account for 35 acres, roads account for 111 acres, and parking areas and driveways account for 105 acres (VTDEC, 2022a).

When considering the Seymour Lake drainage area as a sub-catchment of the overall Echo-Seymour Lakes watershed, forested land cover increases to 80% and grass/shrub cover increases to ~18% (Figure 4). Relatively unchanged at this scale is the proportion of impervious surface cover (1.6%). Of the impervious areas within the Lake Seymour sub-catchment, bare soil accounts for 27.3 acres, buildings account for 29.9 acres, roads account for 92.3 acres, and parking areas and driveways account for 87.7 acres.

Land cover data was not readily available from the State for lands that drain directly to Echo Lake without passing through Seymour Lake. However, the relative area of each land cover class for this portion of the study area, referred to as *Echo Lake direct drainages*, can be inferred as the difference between the values from the entire watershed and the values for the Seymour Lake sub-catchment. Using this approach, MWA calculated the Echo Lake direct drainages watershed to be 37% forested, 11% grass/shrubs, 51% open water, and 1% impervious surface.

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 Echo-Seymour Lakes watershed, these land cover types are most concentrated along the periphery of the lakes. When considering only the 250-foot wide shoreland protection area along the periphery of the lakes, forest cover drops to 58% and 63% and impervious cover increases to 9% and 12% for Echo and Seymour Lakes, respectively (Figures 5-6). These changes represent an approximately 20% reduction in forest canopy and ten-fold increase in impervious surfaces in areas of the watershed where the lakes are most vulnerable to water quality stressors.

Table 1. Land cover in the Echo-Seymour Lakes watershed, Echo lake direct drainages, and Seymour Lake sub-catchment based on the VT DEC Lake Land Cover Map.

Land Cover	Acres	% of Watershed Area
Tree Canopy	10,155.4	70%
Grass/Shrubs	2,324.4	16%
Bare Soil	27.1	0%
Open Water (excl. Echo)	1,860.9	13%
Buildings	33.5	0.2%
Roads	81.0	0.6%
Other Paved	92.9	0.6%
Railroads	0.0	0.0%
TOTAL	**14575.2**	**100%**
Supplemental Land Cover*		
Crop	80.7	1%
Hay	1,033.3	7%
Wetlands	235.9	2%
Lake Echo	530	

*supplemental classes may overlap with base classes; percentages may not add up to 100%

Land Cover	Acres	% of Watershed Area
Tree Canopy	1,279.0	37%
Grass/Shrubs	366.1	11%
Bare Soil	0.8	0%
Open Water (excl. Echo)	1,780.5	51%
Buildings	520.0%	0.2%
Roads	1340.0%	0.4%
Other Paved	1480.0%	0.4%
Railroads	0.0%	0.0%
TOTAL	**3459.8**	**100%**
Supplemental Land Cover*		
Crop	0.0	0%
Hay	243.4	7%
Wetlands	19.0	1%
Lake Echo	530	

**Land cover values for Echo Lake direct drainages land cover calculated as difference between Echo-Seymour Lakes watershed and Seymour Lake sub-catchment values

Land Cover	Acres	% of Watershed Area
Tree Canopy	8,876.4	80%
Grass/Shrubs	1,958.3	18%
Bare Soil	26.3	0%
Open Water (excl. Seymour)	80.4	1%
Buildings	2830.0%	0.3%
Roads	6760.0%	0.6%
Other Paved	7810.0%	0.7%
Railroads	0.0%	0.0%
TOTAL	**11115**	**100%**
Supplemental Land Cover*		
Crop	80.7	1%
Hay	789.9	7%
Wetlands	216.9	2%
Lake Seymour	1,777	

Table 2. Land cover along the 250-ft wide shoreland buffer for Echo & Seymour Lakes based on the VT DEC Lake Land Cover Map.

ECHO LAKE SHORELAND		
Land Cover	**Acres**	**% of Watershed Area**
Tree Canopy	74.1	58%
Grass/Shrubs	40.6	32%
Bare Soil	0.3	0%
Open Water (excl. Echo)	2.0	2%
Buildings	2.6	2%
Roads	3.5	3%
Other Paved	4.9	4%
Railroads	0.0	0%
TOTAL	**128**	100%
Supplemental Land Cover*		
Crop	0.0	0%
Hay	11.4	9%
Wetlands	25.6	20%

SEYMOUR LAKE SHORELAND		
Land Cover	**Acres**	**% of Watershed Area**
Tree Canopy	195.1	63%
Grass/Shrubs	73.9	24%
Bare Soil	1.1	0%
Open Water (excl. Echo)	6.1	2%
Buildings	11.2	4%
Roads	8.8	3%
Other Paved	15.9	5%
Railroads	0.0	0%
TOTAL	**312.1**	100%
Supplemental Land Cover*		
Crop	0.0	0%
Hay	2.7	1%
Wetlands	35.3	11%

*supplemental classes may overlap with base classes; percentages may not add up to 100%

Water Quality Monitoring

Long-term monitoring performed by the State in the Echo-Seymour Lakes watershed indicates variable water quality trends that differ between lakes and among seasons. Echo Lake water quality monitoring indicates highly significant increasing trends for summer total phosphorus (TP) concentrations since data collection began in 2005, as depicted in the Echo Lake Score Card (Figure 7; VTDEC 2022a). Fortunately, there are no significant increases in spring TP or summer chlorophyll-α concentrations and no significant decrease in Secchi disk readings (water clarity) since data collection began in 1980. Over this period, spring TP averaged 8.21 µg/L, summer TP averaged 9.8 µg/L, Secchi disk measurements averaged 7.7 meters, and chlorophyll-α averaged 1.8 µg/L.

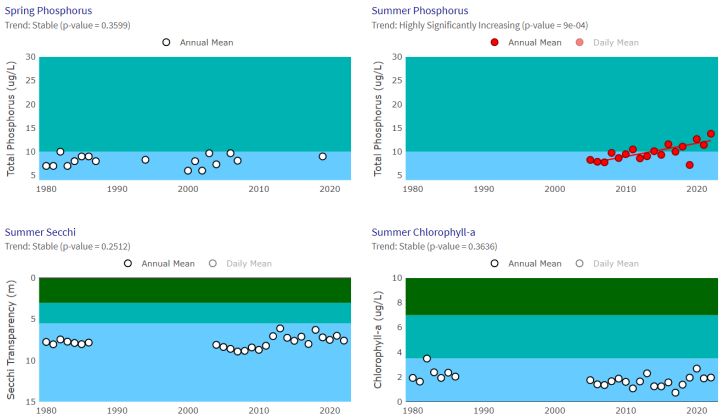

Figure 7. Lake Score Card for Echo Lake.

Seymour Lake monitoring indicates more-or-less stable water quality trends since monitoring began in 1980, as depicted in the Seymour Lake Score Card (Figure 8). The data do not show significantly increasing trends for spring or summer TP concentrations, and these levels typically remain at or below the 10 µg/L threshold for oligotrophic lakes. However, summer Secchi disk readings (water clarity) have decreased significantly since 1980, from approximately 8.5 meters to 7.5 meters. Similarly, and yet somewhat contradictory, summer chlorophyll-α concentrations show significantly decreasing trends over the same time period. Reduced water clarity is typically the result of increased algal populations in the water column or higher levels of turbidity. Given the statistically significant decrease in summer chlorophyll-α concentrations, the reduction in water clarity may be attributed to higher levels of turbidity in the lake water column, however, the available data are not conclusive. Over this period, spring TP averaged 8.7 µg/L, summer TP averaged 8.9 µg/L, Secchi disk measurements averaged 8 meters, and chlorophyll-α averaged 2.2 µg/L.

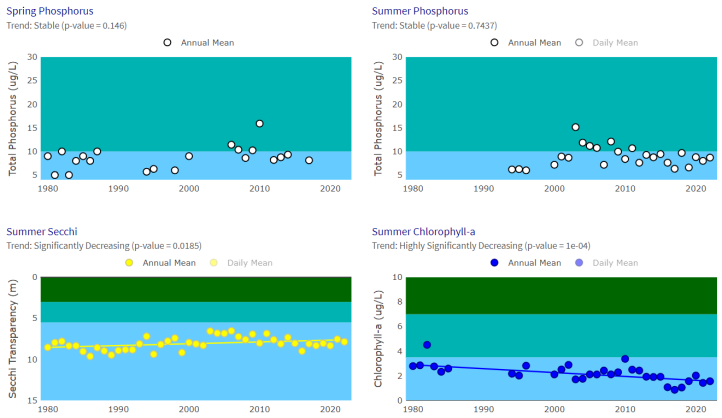

Figure 8. Lake Score Card for Seymour Lake.

Since 2021, the Echo Lake Protective Association has performed routine water quality monitoring of the Seymour outlet/Echo inlet tributary as well as five direct drainages through the LaRosa volunteer monitoring program (Figure 9; VTDEC, 2022b; 2022c). Monitoring focused on evaluating concentrations of TP at all sites as well as chloride and total nitrogen (TN) for select sites and dates. Of the six tributaries sampled, four regularly demonstrated TP concentrations greater than the 14 µg/L typical of oligotrophic lakes in Vermont. Anderson Brook, Bennet Brook, W Echo Lake Road Brook, and Winape Hill Brook averaged 32, 28, 23 and 26 µg/L during the study period, compared to 8 µg/L in the Echo Lake inlet and 16 µg/L in Dickey Brook. At least once throughout the monitoring period, all sites except for the Echo Lake inlet exceeded 60 µg/L; spikes typically occurred in early June and may be associated with summer rainstorms following periods of drought. Chloride monitoring demonstrated tributary levels are well below the Vermont water quality standards for both chronic (230 mg/L) and acute (860 mg/L) exposure. Across all samples, chloride concentration averaged 3.8 mg/L, with a maximum of 11 mg/L (Winape Hill Brook – 6/17/21) and a minimum (and presumed background level) of 2 mg/L. Total nitrogen averaged 0.38 mg/L across all samples, peaked at 1.1 mg/L (Echo Lake inlet – 7/15/22), and was as low as 0.18 mg/L (Echo Lake inlet – 6/10/22). These data shall be used to determine priority waterways for field assessment and project identification efforts.

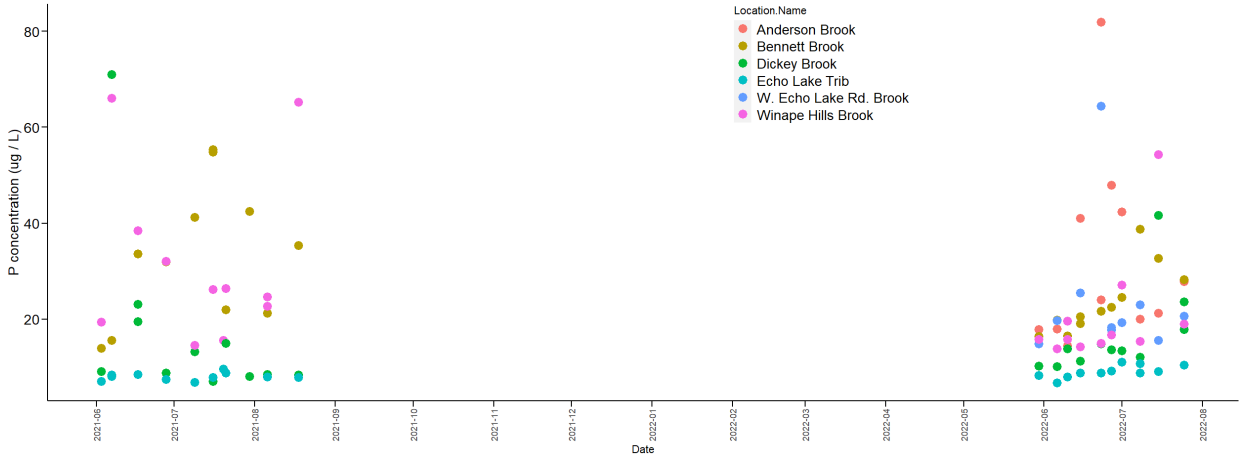

Figure 9. Phosphorus concentrations from LaRosa water quality monitoring efforts in Echo lake, 2021-2022.

Since 2006, the Seymour Lake Association has performed water quality monitoring of up to seven major tributaries to the lake through the LaRosa volunteer monitoring program (Figure 10, VTDEC, 2022c). Monitoring focused on evaluating concentrations of TP at all sites as well as chloride, turbidity, and TN for select sites and dates. Of the seven tributaries sampled, four regularly demonstrated TP concentrations greater than the 14 µg/L typical of oligotrophic lakes in Vermont. The outlet of Sucker Brook, Sucker Brook East, Sucker Brook North (Valley Brook), Mud Pond Tributary, and the South Tributary averaged 27.9, 21.8, 20.8, 20.6, and 20.5 µg/L during the study period, respectively. This is in contrast to the Southeast Tributary and East Side Tributary which averaged 14.1 and 11.6 µg/L, respectively. At least once throughout the monitoring period, all sites except for the Southeast Tributary and East Side Tributary exceeded 60 µg/L. On some occasions, Sucker Brook samples spiked up to 81 and 127 µg/L in June or August, which may be associated with spring runoff or summer rainstorms

following periods of drought. Chloride monitoring demonstrated tributary levels are well below the Vermont water quality standards for both chronic (230 mg/L) and acute (860 mg/L) exposure. Across all samples, chloride concentration averaged 2.3 mg/L, with a maximum of 3.3 mg/L (Sucker Brook – 9/26/06) and a minimum (and presumed background level) of 2 mg/L. Total nitrogen averaged 0.63 mg/L across all samples, peaked at 3.89 mg/L (Southeast Tributary – 9/24/08), and was as low as 0.13 mg/L (Sucker Brook East – 10/2/17). These data shall be used to determine priority waterways for field assessment and project identification efforts.

Figure 10. Phosphorus concentrations from LaRosa water quality monitoring efforts in Seymour Lake, 2006-2018.

Streams & Stream Crossings

Unstable stream channels, eroding streambanks, and incompatible crossing structures can act as significant sources of sediment, phosphorus, and fluvial erosion hazards. According to the Vermont Hydrography Dataset, there are 27.1 miles of mapped perennial streams in the Echo-Seymour watershed (Figure 11). Of these, 16.4 stream miles have undergone Phase 1 Stream Geomorphic Assessments. Phase 2 SGA 'lite' assessments were performed on 1.7 miles of Valley Brook, from the confluence with Sucker Brook at Lake Seymour to upstream of the Valley Brook Streambank Management Area (MWA, 2022). Between Phase 1 and 2 SGA, forestland and streambank erosion assessments were performed by NorthWoods Stewardship Center staff on Sucker and Valley Brook in 2020. In addition to mapped perennial streams, approximately 55 miles of intermittent streams drain higher elevation areas, sub-watersheds less than 0.5 miles^2, and direct drainages to the lakes. Compared to the Willoughby watershed, the Echo-Seymour watershed has a much higher proportion of intermittent compared to perennial streams. MWA believes the mapped perennial streams are not truly representative of all perennial streams in the watershed based on recent field assessments where streams classified as intermittent appear to demonstrate perennial flow. Hydrography data, coupled with tributary water quality monitoring data, informed stream reach selection and assessment prioritization.

Between 2006 and 2019, 413 culverts and 7 bridges were inventoried within the Echo-Seymour Lakes watershed (Figures 12, 12a). Culvert inventory results, including location data and overall structure condition, are available through VT Culverts (VAPDA, 2022).

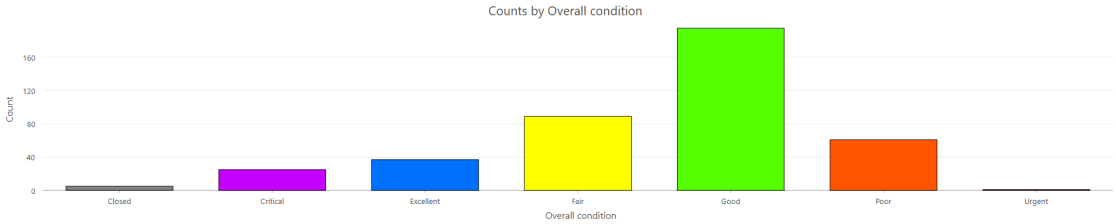

Figure 12a. Summary of overall condition for 413 culvert crossings in the Echo-Seymour Lakes watershed.

Of the 413 inventoried crossings, 26 crossings were evaluated for geomorphic compatibility and aquatic organism passage (AOP) in 2017 (Figures 12, 12b). AOP assessments identified only 1 crossing with full AOP, 9 crossings with reduced AOP, and 16 crossings with no AOP for all aquatic organisms including adult salmonids.

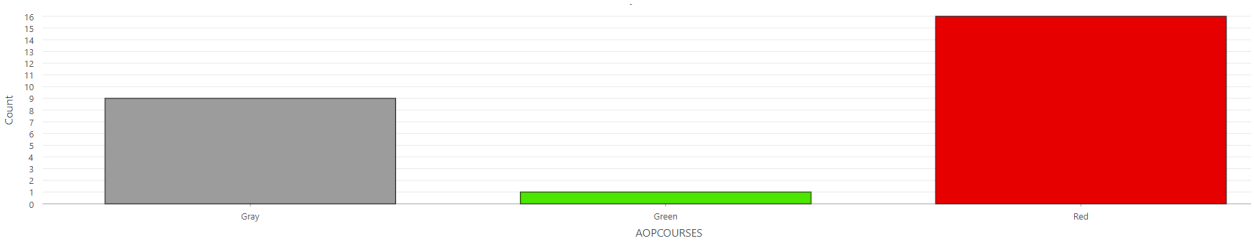

Figure 12b. Bar graph illustrating the number of culverts determined to have full (green), reduced (grey), or no (red) aquatic organism passage.

Of the same 26 culverts, only 4 structures were found to be mostly geomorphically compatible (teal), while 7 were partially compatible (yellow) and 15 were mostly incompatible (orange)(Figures 12, 12c). None were found to be fully geomorphically compatible.

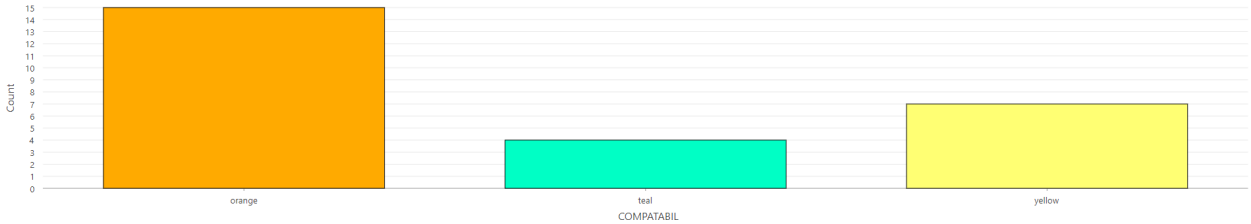

Figure 12c. Bar graph illustrating the number of culverts determined to be mostly compatible (teal), partially compatible (yellow), or most incompatible (orange).

Roadways

Within the lake's contributing drainage area are 52.3 linear miles of roads, based on the VT Agency of Transportation's (VTrans) Road Centerline dataset (Figure 13; VTrans, 2022). Of these, the majority are Town roads (53%, 27.4 miles), followed by Private roads (35%, 18.5 miles), and State Highways (12%, 6.4 miles). In addition to roadways, mapped private drives contribute another 31.8 miles of impervious parking and roadway surfaces to the watershed.

Public Roads

Roadways can act as efficient conveyors of stormwater runoff and associated pollutants when hydrologically connected to waterways. VTDEC maintains a statewide database of hydrologically connected road segments to support watershed and transportation stormwater planning. From this database, MWA extracted 26.1 miles of municipally owned road segments located within the Echo-Seymour Lakes watershed. Of the 441 municipal road segment assessments within the watershed, 154 are listed as hydrologically connected, while 287 are not. This translates to approximately 9.2 miles of hydrologically connected roads compared to 16.9 miles deemed *not connected*. These road segments were screened by DEC for proximity to mapped surface waters and river corridors, and evaluated based on road slope, adjacent hill slope, and soil erodibility to produce a preliminary road erosion risk ranking (Low, Moderate, High). Preliminary road erosion risk rankings identified 2 'High Risk' road segments, 20 'Moderate Risk' road segments, and 202 'Low Risk' road segments. Ranking was not performed on 217 road segments and were, therefore, reported as 'No Measured Risk' (Figures 14, 14a).

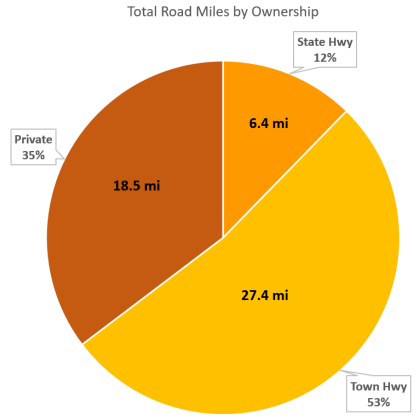

Figure 3. Proportion of total roads and length of roads by State (orange), Town (yellow) and Private (rust) ownership.

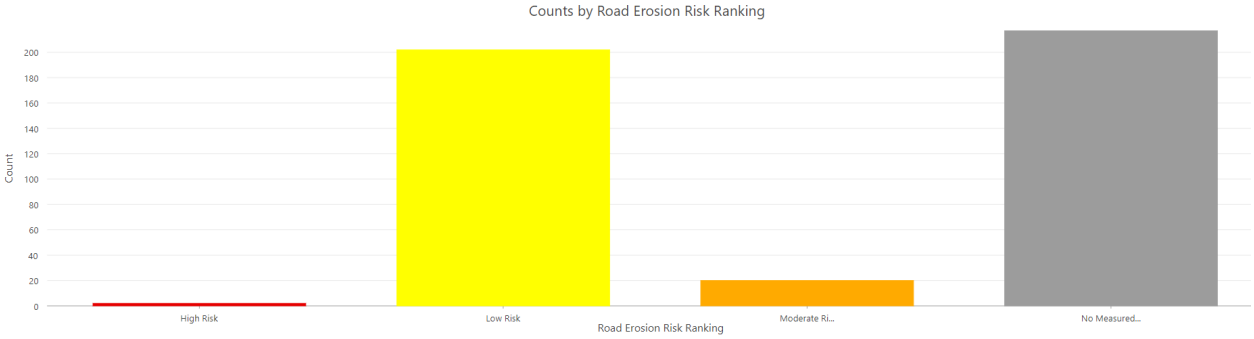

Figure 14a. Bar graph illustrating the number of road segments classed as demonstrating high (red), moderate (orange), low (yellow), and unmeasured (grey) road erosion risk.

Following this preliminary risk ranking, a Road Erosion Inventory (REI) is conducted by municipalities for all road segments as they work to fulfill the requirements of the Municipal General Roads Permit (MRGP). REI's are performed to establish baseline conditions and evaluate progress of implementation

efforts related to transportation stormwater management. REI data are used to evaluate municipal road segment conditions and classify them according to whether they meet MRGP requirements. Approximately 170 of the 441 road segments within the Echo-Seymour Lakes watershed were evaluated through the REI process. Of this subset, 2 segments are classed as having 'Incomplete Data'; 111 segments fully meet standards; 18 segments partially meet standards; and 39 segments do not meet standards (Figures 15, 15a). Road segments that do not meet MRGP requirements are widely dispersed and tend to be located on steeper roads in the headwaters of the watershed or alongside the lakeshore. For instance, a series of non-compliant road segments can be found on East and West Echo Lake Road as well as Sunset Drive.

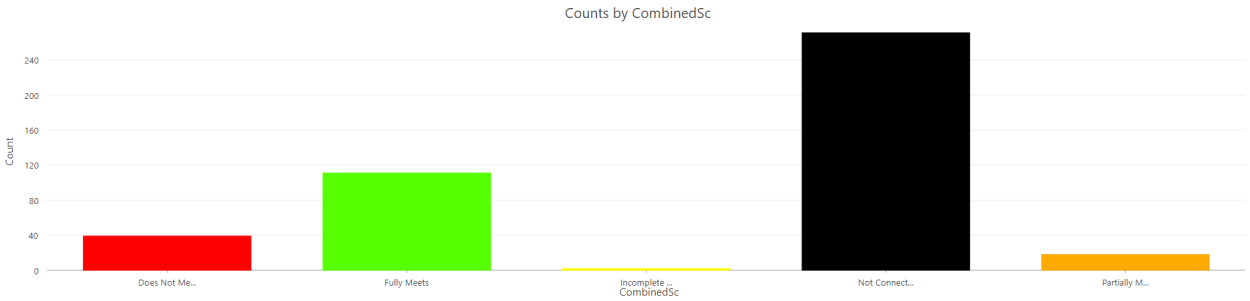

Figure 15a. Bar graph illustrating the number of road segments classed as fully compliant (green), partially compliant (orange), incomplete data (yellow), not hydrologically connected (black), and fully incompliant (red).

Based on the degree of non-compliance with MRGP requirements and additional factors such as erosion risk, slope, and proximity to waterways, road segments were then prioritized by DEC to aid planning and implementation work (Figure 15b). This final step identified 2 very high priority, 17 high priority, 24 moderate priority, and 14 low priority road segments. A list of the highest priority road segments can be found in Table 1.

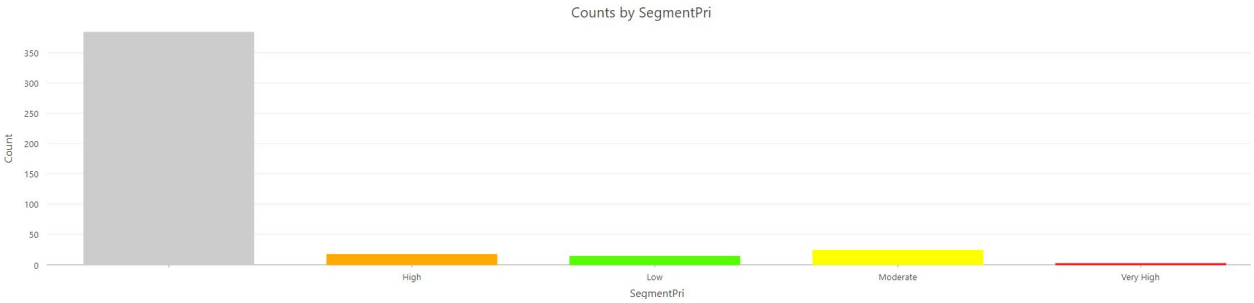

Figure 15b. Bar graph illustrating the number of road segments classed as very high (red), high (orange), moderate (yellow), low (green) priority as well as not prioritized (grey).

Collectively, these roadway data will be used to identify target road segments for field assessments, project identification, and development efforts.

Table 3. List of high-priority municipal road segments for future upgrades to meet MRGP requirements.

Segment ID	Town	Road	Priority
174982	Morgan	SUNSET DR	Very High
174983	Morgan	SUNSET DR	Very High
17826	Charleston	CAMP WINAPE RD	High
191948	Charleston	W ECHO LAKE RD	High
191958	Charleston	W ECHO LAKE RD	High
191959	Charleston	W ECHO LAKE RD	High
191961	Charleston	W ECHO LAKE RD	High
92560	Charleston	E ECHO LAKE RD	High
92562	Charleston	E ECHO LAKE RD	High
132154	Holland	MEAD HILL RD	High
109780	Morgan	HATTON HTS	High
174979	Morgan	SUNSET DR	High
174980	Morgan	SUNSET DR	High
174981	Morgan	SUNSET DR	High
174984	Morgan	SUNSET DR	High
174985	Morgan	SUNSET DR	High
174986	Morgan	SUNSET DR	High
189528	Morgan	UPLAND ACRES	High
68677.1	Morgan	VALLEY RD	High

Private Drives

As mentioned above, the Echo-Seymour Lakes watershed contains nearly 32 miles of private drives and driveways, most of which are in close proximity to streams and lakeshores (Figure 16). Many of these private drives provide access to the many small camp properties, some of which are shared, owned, or maintained by multiple landowners through formal (e.g., road association) or informal arrangements. Based on the large footprint of these roads, their unregulated status, and their potential to act as direct sources of water quality stressors, efforts were made to classify and prioritize private driveway segments.

MWA applied an approach using protocols akin to VTDEC's Hydrologically Connected Road Segments to identify priority driveway segments for field assessments. First, 445 private driveway centerlines were segmented into 100-meter lengths for a total of 765 segments. Next, all segments within 100 feet of a mapped stream (intermittent and perennial), adjoining hydrologically connected road segment, wetland, or waterbody were selected and considered to be hydrologically connected. Finally, maximum and average segment slope was determined for each hydrologically connected private road segment using a raster DEM of the watershed. MWA will review the subset of 274 private road segments considered to be hydrologically connected to identify a priority list of segments for field assessments (Figure 17).

Potentially Erosive Features Data

High-resolution LiDAR data was used by the UVM Spatial Analysis Lab and Watershed Consulting Associates to identify potentially erosive features on forested landscapes in the Champlain and Memphremagog basins (UVMSAL & Watershed Consulting Assoc., 2021). Potentially erosive features were remotely sensed using DEM raster data while considering distance to mapped streams, soils, contributing drainage areas, gully morphology, stream power index, and other physical characteristics. MWA extracted potentially erosive features located within the Echo-Seymour Lakes watershed, amounting to 1,900 individual features (Figure 18). Many of these are natural features such as the steep gullies on Elan Mountain and Bear Hill. However, other potential erosive features appear to stem from roadside ditches, incised ephemeral channels, logging roads, and other non-natural sources. Many of these potentially erosive features align with intermittent streams (<0.5 mi^2 drainage areas) and may be acting as erosive gullies. These data will be used alongside soil erodibility to identify areas of interest (AOIs) for follow-up assessments, project identification, and development efforts.

Stormwater & Wastewater Infrastructure

MWA did not identify any existing stormwater or wastewater infrastructure within the Echo-Seymour Lakes watershed based on available data from the State. It is assumed the residences and businesses within the watershed are all on septic systems with no centralized storm or wastewater treatment facilities.

Significant Natural Communities | Rare, Threatened, & Uncommon Species

MWA communicated with the Vermont Natural Heritage Coordinator at ANR to fulfill a Data Usage Agreement and discuss significant natural communities and known rare, threatened, or uncommon species in the watershed (Figure 19; VTDEC, 2022c). The Vermont Atlas BioFinder allows a user to view all mapped significant natural communities that occur within the watershed, as well as identify coarse areas of rare, threatened, or uncommon species.

Natural communities are used to better understand and prioritize conservation initiatives at local, state, and regional levels. The only mapped significant natural community in the watershed is a Northern White Cedar Swamp located at the north end of Mud Pond. It is the opinion of MWA that significant natural communities exist elsewhere in the watershed but have not been mapped as comprehensively as other catchments such as the Willoughby Lake watershed. One outcome of this LWAP may be to recommend closer evaluation of biological resources in the watershed to identify additional significant natural communities that are not currently mapped as such.

Due to privacy and conservation policy requirements, locations of rare, threatened, or uncommon plants and animals cannot be shared publicly through this document or planning process (E. Marshall, *personal communication*). One rare animal species was listed in the BioFinder inventory, and public vegetation inventories show an uncommon plant species, American Shoregrass (*Littorella americana*), as having been observed in Lake Seymour. MWA and OCNRCD shall use this information to better inform project identification, prioritization, and development on lake shoreland projects. These data are useful in designing and implementing water quality and habitat restoration projects that give consideration to vulnerable species and may also provide co-benefits and funding incentives if habitat restoration benefits the species of concern.

WATERSHED PLANNING

Tactical Basin Plan

The draft 2023 Memphremagog Watershed Basin 17 Tactical Basin Plan (TBP) summarizes existing conditions for surface waters throughout the Memphremagog watershed and nearby basins (VTDEC, 2017a). The TBP provides an assessment of the health of the basin through the lens of the phosphorus Total Maximum Daily Load (TMDL) for Lake Memphremagog and other watershed health initiatives. The TBP "provides a detailed description of current watershed conditions and identifies water quality focused strategies to protect and restore the Basin's surface waters". In the TBP, Echo Lake is identified as a surface water of 'good quality', but notes that it is subject to several stressors that threaten its status as an oligotrophic waterbody. These stressors include increasing nutrient trends, elevated mercury levels, and loss of shoreland habitat. Similarly, Seymour Lake is identified as surface waters of good quality but notes the lake is subject to stressors including increasing nutrient trends, high mercury, and poor shoreland habitat quality. The Lake Score Cards for both lakes are summarized in Table 3 of the TBP and Figures 7 & 8 above.

The TBP provides several strategies to address water quality stressors in Echo & Seymour Lakes. In the regulatory realm, reclassification of both lakes as A(1) excellent surface waters would protect the watersheds 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 (Strategy #49). In 2021, the Echo Lake Protective Association submitted a petition to the State requesting reclassification to A(1) status. No such petition has been filed for Seymour Lake as of 2023. In addition to reclassification, both lakes are listed as ideal candidates for host Septic Socials to bring attention and awareness to the influence numerous small-scale residential septic systems can have on lake water quality. Lastly, another strategy recommends Echo Lake continue to implement chemical monitoring of tributaries through the LaRosa program to better locate primary sources of increasing nutrient trends (TBP Table 17).

Beyond monitoring and regulatory protections, the TBP recommends addressing water quality stressors in Echo and Seymour Lakes by assessing, identifying, and implementing water quality projects in several works sectors. Specifically, this includes implementing agricultural BMPs through the Agricultural Conservation Planning Framework and other initiatives (Strategies #2, 4, 6, 8, 9, 10, 11), performing private road REIs and installing BMPs (Strategy #23), promoting septic system outreach and upgrades (Strategy #28), continuing LakeWise assessments and implementation of shoreland restoration projects (Strategies #43, 44, 45, 46), upgrading stream crossings for enhanced AOP and geomorphic compatibility (Strategies #40, 41), and implementing riparian and process-based restoration projects on streams (Strategies #33, 34, 36).

As of 2023, Seymour Lake has received 46 Lake Wise awards, 33 certificates of recognition, and 5 completed lake shoreland restoration projects. Approximately 29 properties were not eligible for awards based on Lake Wise assessments. On Echo Lake, awards have been given out to 24 properties, as well as 8 certificates of recognition and 1 completed lake shoreland project; 11 properties were not eligible for an award or certificate. Overall, both lakes have an impressive number of Lake Wise awards and assessments compared to other area lakes. However, there still remains many opportunities to further improve lake shoreland habitat and reduce runoff from developed lakeshore properties.

In addition to nutrients, other watershed health stressors include invasive species and aquatic organism passage (AOP) restrictions. Across both lakes, self-sustaining populations of brook trout, rainbow trout, landlocked Atlantic salmon, brown trout, rainbow smelt, white sucker may benefit from AOP improvements. Table 11 of the 2017 Basin 17 Lake Memphremagog, Tomifobia and Coaticook TBP identifies the Twin Culverts at the Seymour north beach as a priority for improving spawning habitat access for rainbow smelt. In recent years, Seymour Lake successfully warded off infestations of invasive Eurasian watermilfoil. Both lake associations maintain robust Aquatic Invasive Species Greeter and Volunteer Invasive Patroller programs that are critical to preventing invasive species at public boat ramps and act as early detectors for populations that may establish in the lakes.

Total Maximum Daily Load

The 2017 Lake Memphremagog Phosphorus Total Maximum Daily Load provides a quantitative approach for modeling phosphorus loading from the Memphremagog basin which includes all sub-catchments of the Echo-Seymour Lakes watershed (VTDEC, 2017b). This model used literature-based phosphorus export values to calculate loading rates for different land uses and septic systems while estimating retention in lakes larger than 4 hectares. Modeled data were calibrated to measured loads delivered to Lake Memphremagog from the four contributing river basins and smaller direct drainages. While the TMDL report did not specifically address P export dynamics in the Echo-Seymour Lakes watershed, output data from the model runs are available for these sub-catchments in the TMDL documentation and are discussed further below.

During development of the Memphremagog TMDL, the Echo-Seymour Lakes watershed was divided into 7 sub-catchments to parse loading rates based on drainage areas and dominant land cover types. In total, the six catchments export approximately 2,234 kg P/year across approximately 69.6 km^2. Model output data for the Echo-Seymour Lakes watershed indicate the greatest areal P export rates are located in sub-catchments downstream and upstream of Mud Pond, Echo Lake direct drainages, Seymour Lake direct drainages, and Valley Brook. Listed from largest export rates to smallest, these five drainages all contribute more than 27 kg P per km^2 per year with the highest loading rate in the lower Mud Pond sub-catchment (47 kg P/km^2/year). These four sub-catchments also demonstrate the greatest proportions of developed (3 – 9%) and agricultural (9 – 33%) land cover.

In general, the majority of P loads for each of the 7 sub-catchments originate from forested, developed, pastured, and hayed lands. In the sub-catchments with the greatest overall P export rates, forested lands contributed between 9 – 68%; developed lands contributed between 8 – 10%; pasture/hay contributed between 7 – 28%; hay contributed between 8 – 22%. Other noteworthy sources include dirt roads (low, moderate and high erosion risk) that contribute anywhere from 8 – 17% of P loads per sub-catchment. Table 4 provides a summary of proportional P export rates by land cover type for each of the 7 sub-catchments.

Retention of phosphorus inputs to Echo Lake was estimated to be between 37 – 51%, likely due to the relatively short residence time of 1.1 years for surface water passing through the lake. Seymour Lake P retention was slightly higher, estimated to be between 57 – 68%, likely due to the substantially longer residence time of 4.5 years. Longer residence time in Seymour Lake is the result of significantly larger storage volume compared to Echo Lake.

It is worth noting that the TMDL provides a very coarse evaluation of phosphorus export dynamics in the Echo-Seymour Lakes watershed. The streams in this watershed were often too small to estimate internal

stream loading, so there is no estimated loading data available for this sector. In addition, there was no attempt to quantify septic loading rates for any of the sub-catchments. Moreover, the "land use [data] used in this model may underestimate the amount of developed lands around the lake and may not accurately reflect the higher intensity of shoreland development and proximity to surface waters, [meaning the] model [may] underestimate the level of loading from shoreland development and private roads to some degree" (B. Copans, *personal communications*). Thus, it is important to be conservative when interpreting the TMDL output results for the Echo & Seymour Lakes watershed and instead focus on overall trends rather than empirical phosphorus export rates.

Table 4. Summary of total P export by sub-catchment and percent of P load contributed by various land cover types within each sub-catchment.

			% of P Load Contributed from Various Land Cover Types by Sub-catchment																				
Sub-catchment	ID #	Total P export (kg/yr)	Water	Developed	Developed Pervious	Developed Impervious	Barren land	Forest	Road Paved	Dirt road	Dirt Road Low Erosion	Dirt Road mod Erosion	Dirt Road high Erosion	Shrub/ herb	Farm-stead	Pasture /Hay	Hay	Pasture	Wetland	Cultivated A soils	Cultivated B soils	Cultivated C soils	Cultivated D soils	Cultivated unknown soils
Mud Pond up	12	201.583	1%	5%	2%	3%	0%	11%	0%	5%	8%	0%	0%	1%	6%	23%	18%	5%	1%	0%	0%	11%	0%	0%
Mud Pond down	24	115.002	0%	9%	4%	5%	0%	9%	1%	2%	5%	2%	0%	0%	2%	28%	22%	7%	1%	0%	0%	0%	0%	0%
Valley Brook	11	283.823	0%	5%	2%	4%	0%	22%	2%	1%	4%	2%	0%	2%	12%	20%	16%	5%	1%	0%	0%	0%	0%	0%
Sucker E up	287	17.152	1%	8%	4%	1%	0%	68%	0%	0%	4%	0%	0%	2%	0%	1%	1%	0%	10%	0%	0%	0%	0%	0%
Sucker E down	23	101.669	0%	10%	5%	3%	0%	36%	0%	6%	17%	0%	1%	1%	0%	7%	5%	2%	2%	0%	0%	0%	0%	0%
Seymour direct	20	1079.96	7%	10%	5%	4%	0%	14%	1%	3%	5%	1%	0%	1%	4%	10%	8%	2%	2%	0%	2%	5%	1%	0%
Echo direct	39	435.164	5%	8%	4%	3%	0%	9%	0%	4%	9%	1%	0%	0%	5%	20%	15%	5%	1%	0%	0%	0%	0%	0%

International Joint Commission

The Study of Nutrient Loading and Impacts in Lake Memphremagog, produced for the International Join Commission, outlined current conditions in the watershed, reviewed ongoing management efforts, and recommended initiatives and policy efforts to address nutrient loading and algae blooms in Lake Memphremagog (IJC, 2019). This report did not specifically address the dynamics controlling phosphorus export in the Echo-Seymour Lakes watershed. However, it does provide general recommendations that can be applied to the basin, including:

- Adopt widespread on-farm BMPs supported by resources for implementation and direct service providers
- Adopt BMPs and stormwater regulations for new development projects and increased implementation of retrofit projects for existing development
- Identify priority conservation areas that protect essential ecological services provided by natural lands in the watershed and implement programs and provide incentives to conserve and restore these lands
- Incorporate climate change impacts into all decision-making in order to ensure nutrient loading targets are met and investments in BMPs are long-term and that finite resources are used effectively

TOWN PLANNING & PERMITTING

Morgan Town Plan

The Morgan Town Plan, last amended on December 17, 2012, is a non-regulatory planning document that outlines the general vision, direction for future development, and local needs and desires of the community. The document is intended to provide actions and priorities to be addressed by the Town Selectboard, Zoning Administrator, Clerk, Planning Commission and others in the execution of their duties. Arguably the most important section of the document, Section VII, lists the proposed implementation projects or initiatives that will steer decision-making of development and conservation policies in Morgan. This section of the Plan is a summary of proposed goals and projects with clear and actionable statements that include limiting density of development on forested lands, balancing the pressures of recreational access and natural resource protection, conserving prime agricultural lands for production, boosting commerce and non-polluting industries, regulating transporting projects, and a Preservation Plan for rare and irreplaceable natural areas. This document sets a foundation for regulating development and balancing natural resources integrity with access to the Lake and other valuable resources. The LWAP process recommends the Town and Selectboard revise the Town Plan to elaborate on specific initiatives and projects while increasing the specificity of development restrictions and sensitive areas that need protection.

The Morgan Zoning Bylaws were adopted on the same day as the Town Plan and is, therefore, similarly outdated. While requirements are set in the zoning plan for development density, lakeshore access, landscaping for stormwater management, and other activities that may influence water quality, the bylaws offer little to protect the integrity of Lake Seymour. It is recommended that the Zoning Bylaws be updated to reflect new information about sensitive areas and conservation/restoration initiatives in

Morgan. For instance, Morgan should consider establishing specific Conditional Use Permits (see Westmore Town Plan & Zoning Bylaws) for activities like upgrading driveway culverts and stream crossings, vegetation clearing along streams, shorelines, wetlands, and other areas to protect waterways from excess runoff.

Charleston Town Plans

The Charleston Town Plan, last amended on December 13, 2018, is a non-regulatory planning document that outlines the general vision, direction for future development, and local needs and desires of the community. The Objectives and Interpretation section outlines clear guidelines around the 'proper scale' of development that is allowable in Charleston, such as a maximum of 5 acres of contiguous disturbance. These guidelines are only as effective if oversight and enforcement is appropriate. As mentioned above, Charleston should consider establishing specific Conditional Use Permits (see Westmore Town Plan & Zoning Bylaws) for activities like upgrading driveway culverts and stream crossings, vegetation clearing along streams, shorelines, wetlands, and other areas to protect waterways from excess runoff, particularly in the Echo Lake community.

The Town of Charleston, Vermont All-Hazards Mitigation Plan Update was adopted by the Town selectboard on April 8, 2021. This planning tool works to identify specific hazards that may threaten the town, prioritize hazards for mitigation planning, recommends town-level goals and strategies to reduce losses, and establishes a coordinated process to implement goals and strategies by utilizing available resources and creating actionable steps forward. Echo Lake is listed in the Mitigation Plan as a potential flood zone based on FEMA studies. However, the document emphasizes that the majority of specifically identified hazards are located outside the Echo Lake watershed and primarily along the Clyde River floodplain.

LWAP Kick-Off Meeting

OCNRCD & MWA led a virtual kick-off meeting on June 14, 2023 as well as an in person meeting on July 17, 2023 at the Morgan Community House as part of the LWAP process. The meeting began with members of the Echo and Seymour Lake associations and greater communities sharing their relationship with and knowledge about the lakes. Discussions focused on understanding their vision for the future of the watersheds and the trends that have been observed over the past decades. OCNRCD provided an overview of the intent and purpose of an LWAP, the process by which the LWAP will be developed, opportunities for public engagement and assistance, and a tentative schedule. MWA presented on current available data highlighted in this report and briefed the attendees about priority assessment areas. Each participant was given a map printout of the watershed and asked to mark and label areas they know of that may be contributing to water quality and habitat degradation. These maps were collected and used to developed a plan for the proposed field assessments.

DATA GAPS

MWA was not able to identify significant water, sewer, or stormwater infrastructure for the town of Morgan or Charleston. Moreover, there is a lack of long-term data for the tributary streams flowing into Echo Lake. Other data limitations were the land use P export rates from TMDL, which are probably too coarse and outdated to provide meaningful data at this scale. MWA encourages the Seymuor Lake Association and Echo Lake Protective Association to continue and perhaps expand tributary water quality monitoring to better characterize P loading trends from select tributaries. Lastly, there were no data available for hydrologically connected road segments or road erosion inventories for privately

owned roads. These data will be developed during the prioritization of core assessment areas, covered further in a separate memo.

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