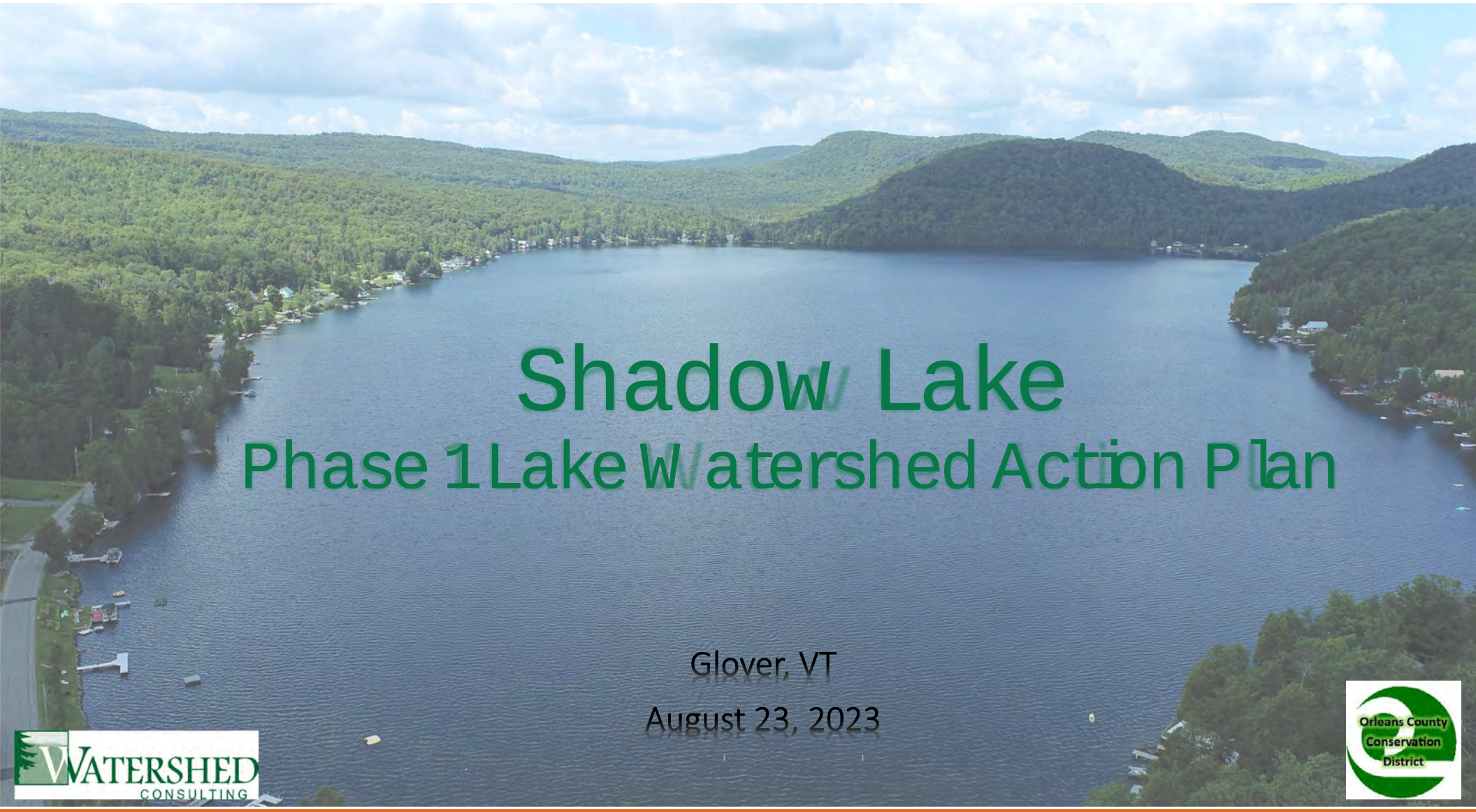


Shadow Lake

Phase 1 Lake Watershed Action Plan

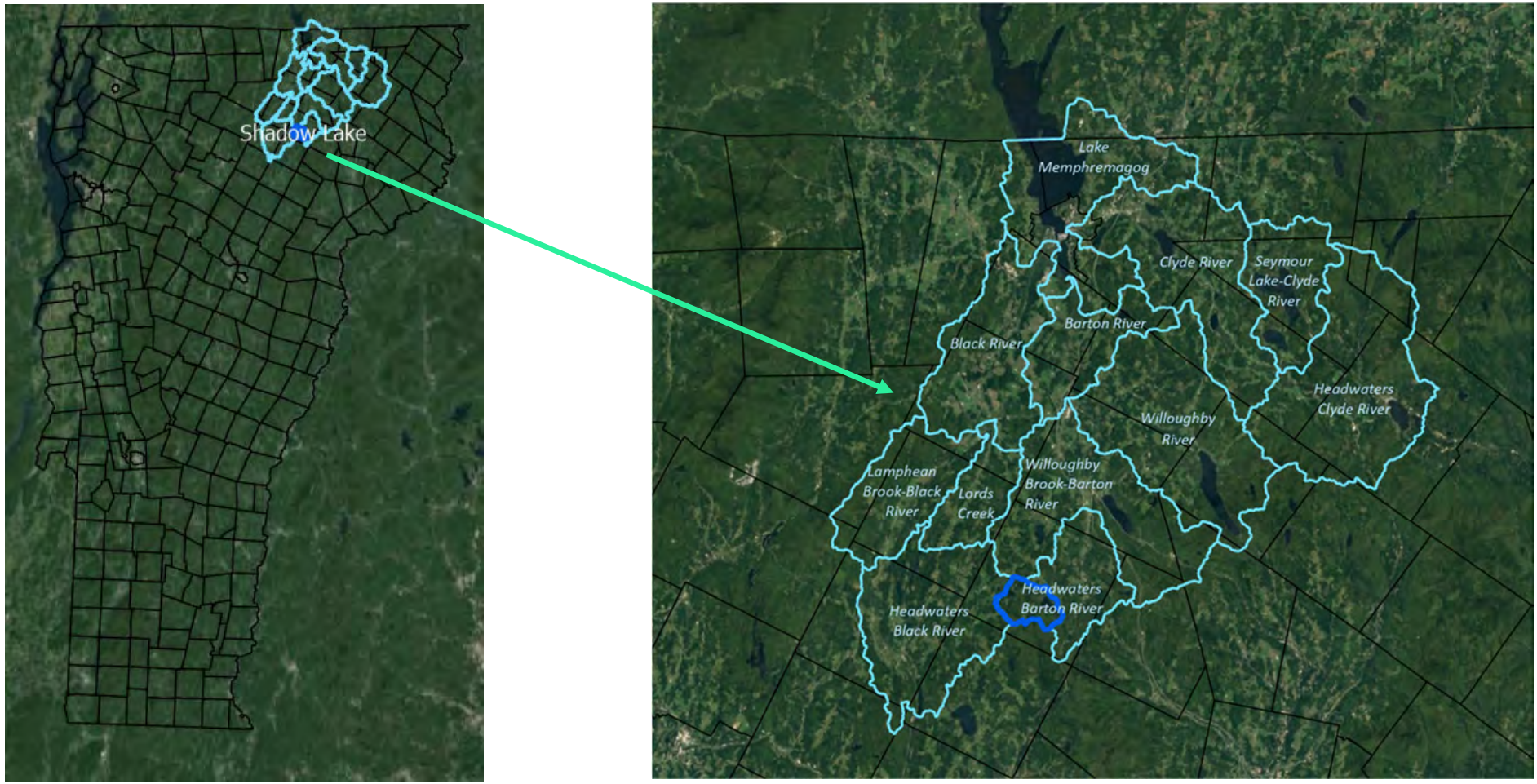
Glover, VT

August 23, 2023

WATERSHED CONSULTING

Orleans County Conservation District

Shadow Lake



Shadow Lake is within the Lake Memphremagog watershed

Shadow Lake Phase 1 LWAP

Completed tasks:

- Data Review
- Lakeshore Assessments
- Terrestrial Assessments
- Road Assessments
- Drone Flights

Remaining tasks:

- Lakewise Assessments
- Final Recommendations
- Final Plan

WATERSHED CONSULTING

Shadow Lake

217-acre lake area

3,413-acre drainage area (dark blue line)

5 tributaries (light blue lines)
9.46 miles of tributaries

Daniels Pond flows to Shadow Lake

Residence Time: 1.758 years

Lake Volume: 115.5 acre-feet

WATERSHED CONSULTING

Shadow Lake

217-acre lake area

3,413-acre drainage area

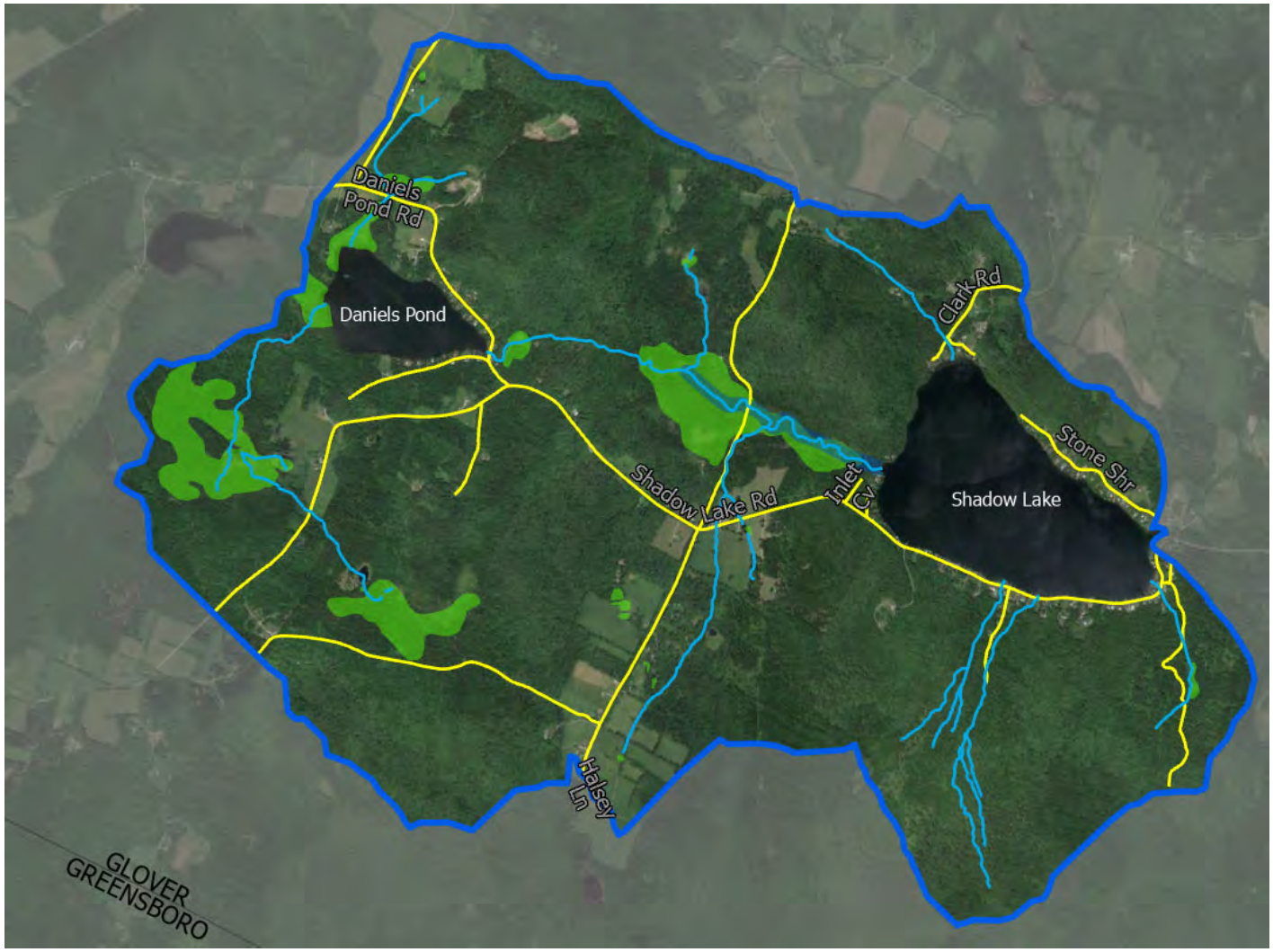
Main roads shown in yellow

WATERSHED CONSULTING

Shadow Lake

217-acre lake area

178 acres of mapped wetlands (green)



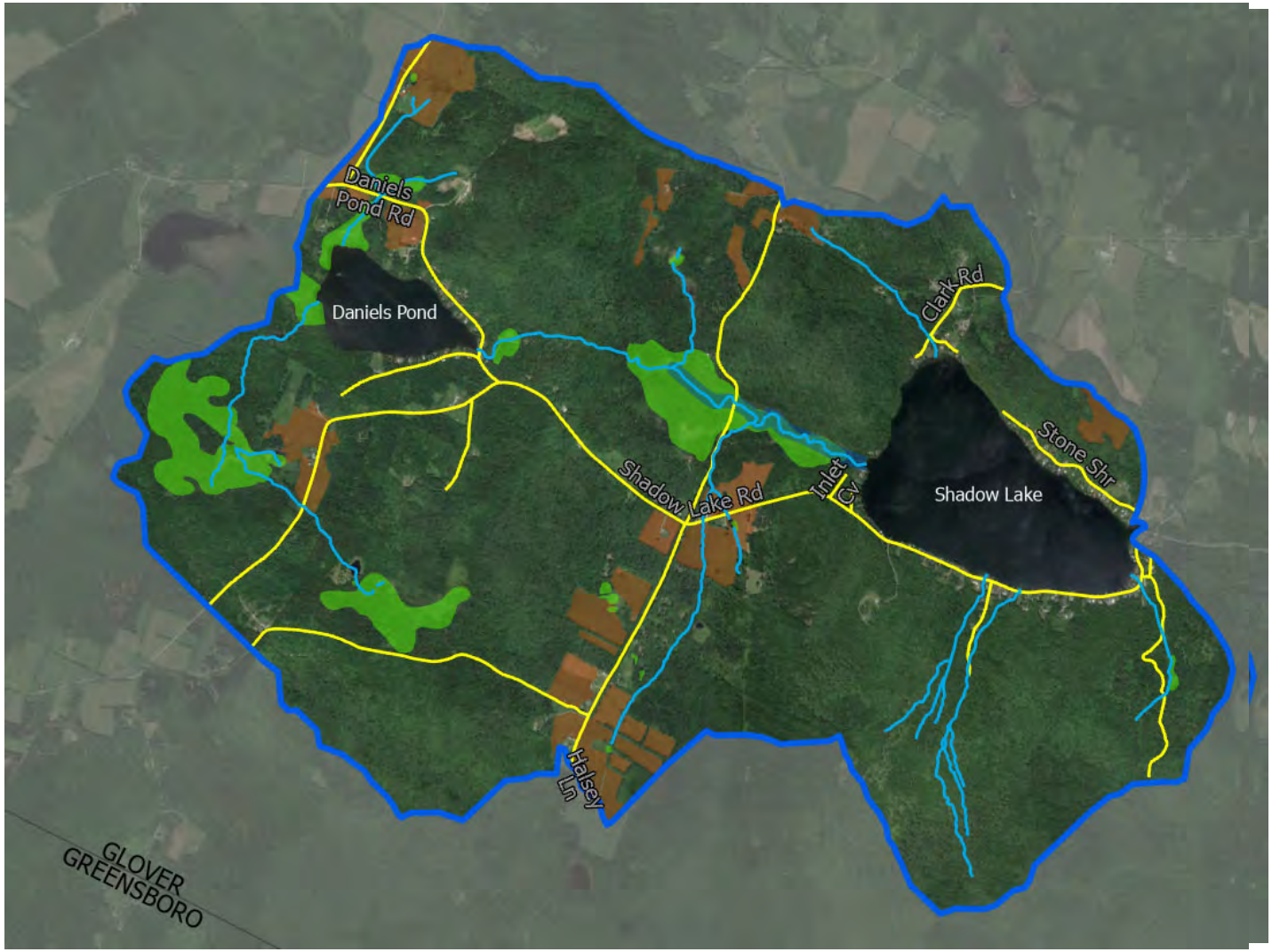
WATERSHED CONSULTING

Shadow Lake

217-acre lake area

178 acres of mapped wetlands (green)

200 acres of agricultural lands (brown)



WATERSHED CONSULTING

Shadow Lake

217-acre lake area

178 acres of mapped wetlands

200 acres of agricultural lands (brown)

121 mapped culverts, conveying water across roads or driveways (red dots)

WATERSHED CONSULTING

Shadow Lake

10 mapped stream crossing culverts, scored for Aquatic Organism Passage (AOP)

Red = No AOP for all aquatic organisms including adult salmonids
Grey = Reduced AOP for all aquatic organisms

See the Vermont Culvert Aquatic Passage Screening Tool for more info

VERMONT WATERSHED CONSULTING

Shadow Lake

10 mapped stream crossing culverts, scored for Geomorphic Compatibility

Teal = Mostly Compatible
Yellow = Partially Compatible
Orange= Mostly Incompatible
Red = Fully Incompatible

- Structure fully incompatible with channel and high risk of failure.
- Re-design and replacement performed ASAP

See the Vermont Culvert Geomorphic Compatibility Screening Tool for more info

WATERSHED CONSULTING

Shadow Lake

Parcel boundaries in white

106 lakeshore properties (red property boundary lines) along Shadow Lake

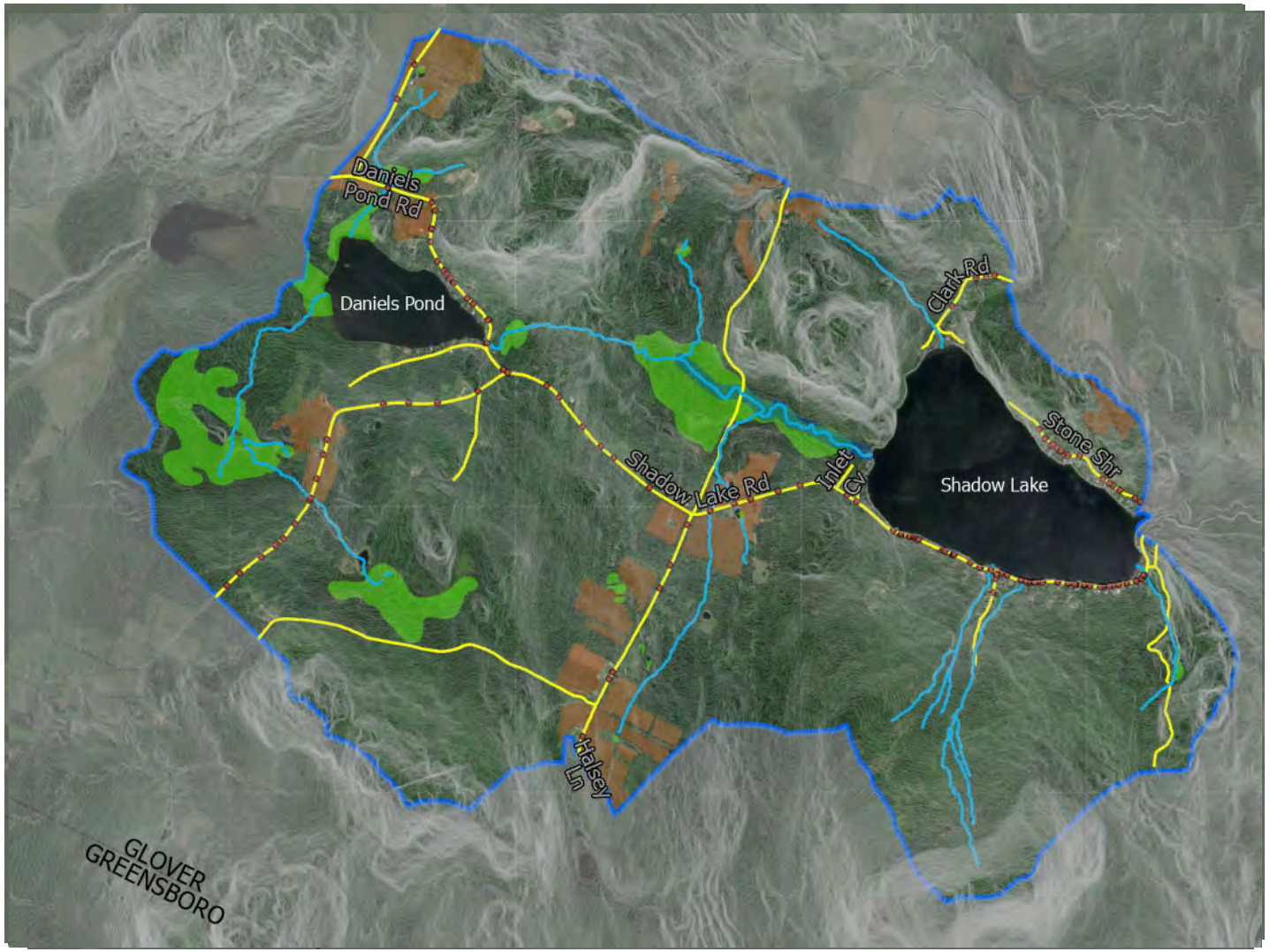
WATERSHED CONSULTING

Shadow Lake

Shadow Lake is in a low point, steeper to the northwest

Grey lines show contours

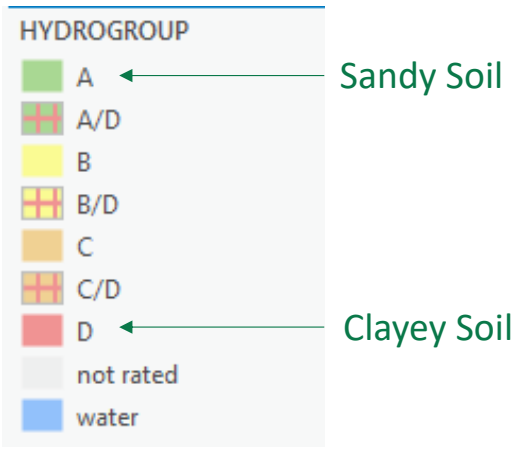
Closer together = steeper slopes



WATERSHED CONSULTING

Shadow Lake

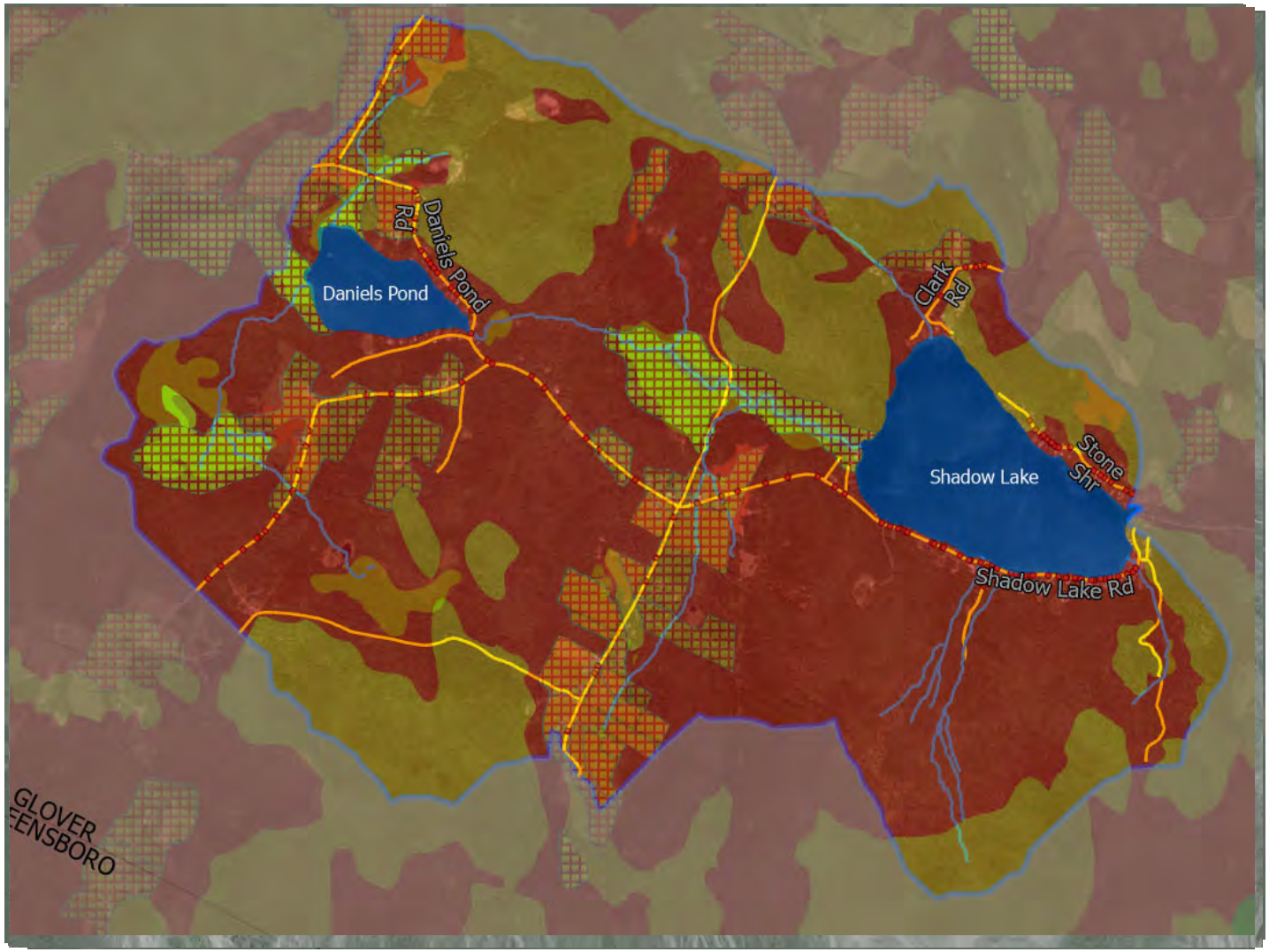
178 acres of mapped wetlands



Sandy Soil

Clayey Soil

More D (Clay Soil) = more runoff



WATERSHED CONSULTING

Shadow Lake

34.8-acre Significant Natural Community (green)

- **Northern White Cedar Swamp**

WATERSHED CONSULTING

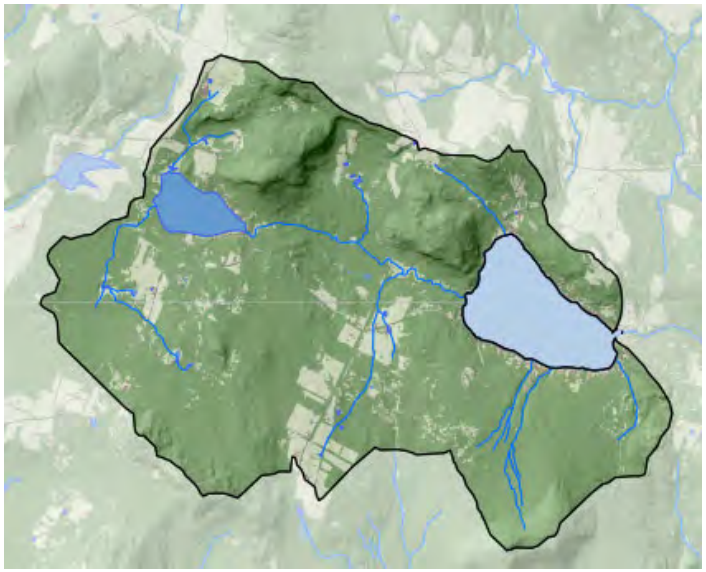
Shadow Lake

393 Potentially Erosive Features (red) totaling 6 acres

Data generated by UVM Spatial Analysis lab

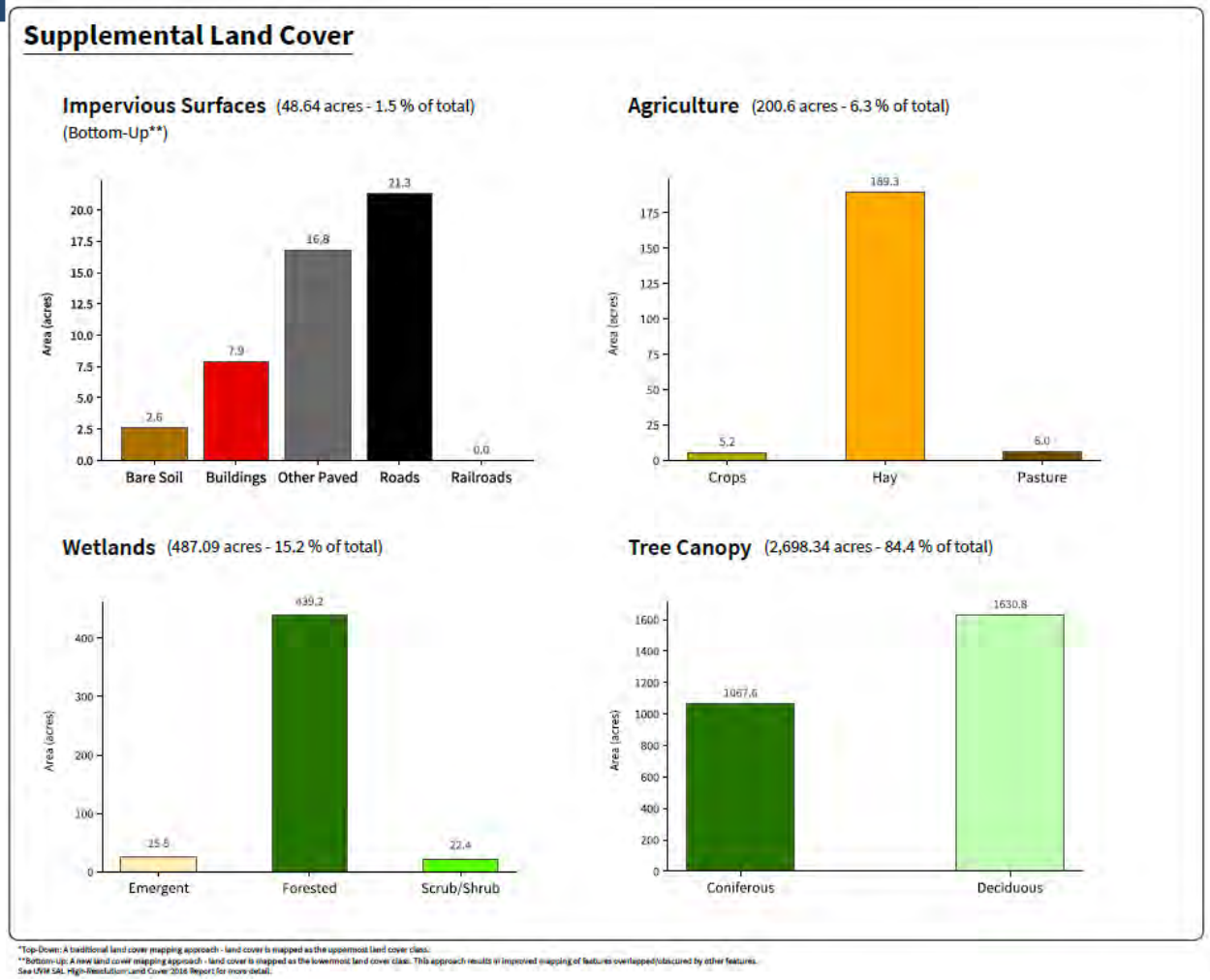
VWATERSHED CONSULTING

Land Cover: Watershed



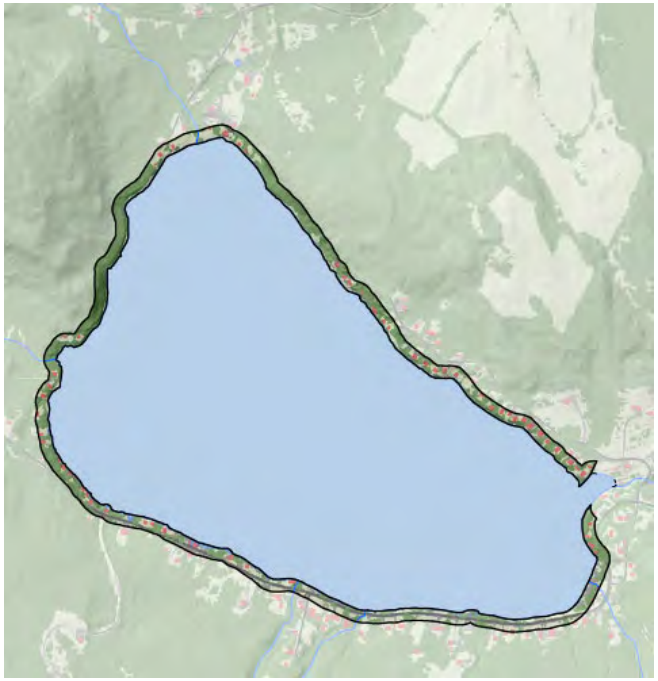
- 85% of the watershed is forested
- 15% is wetlands
- 1.5% impervious
- Agriculture is 6.3%

- See UVM SAL High-Resolution Land Cover 2016 Report for more detailed explanation of methodologies

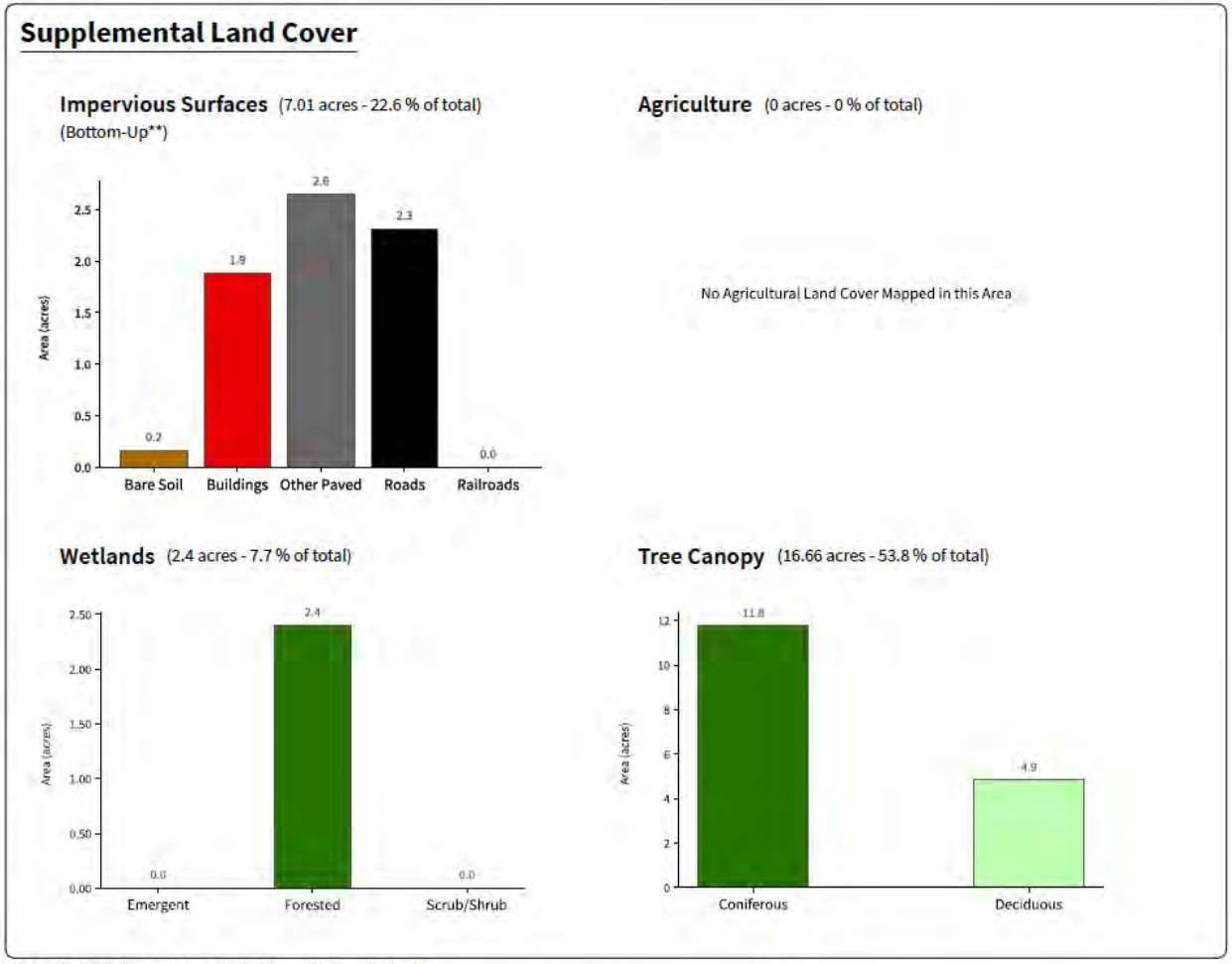


VERSHED CONSULTING

Land Cover: Lake 100ft buffer



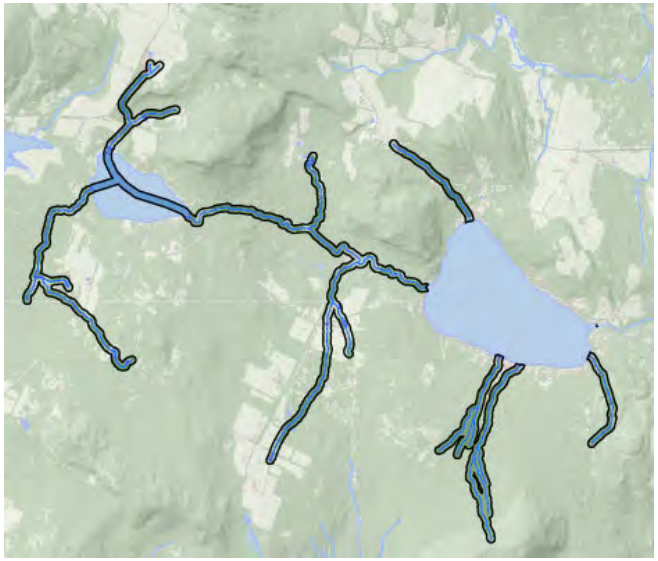
Greater percentage of impervious surface within the 100 ft buffer than in the entire watershed



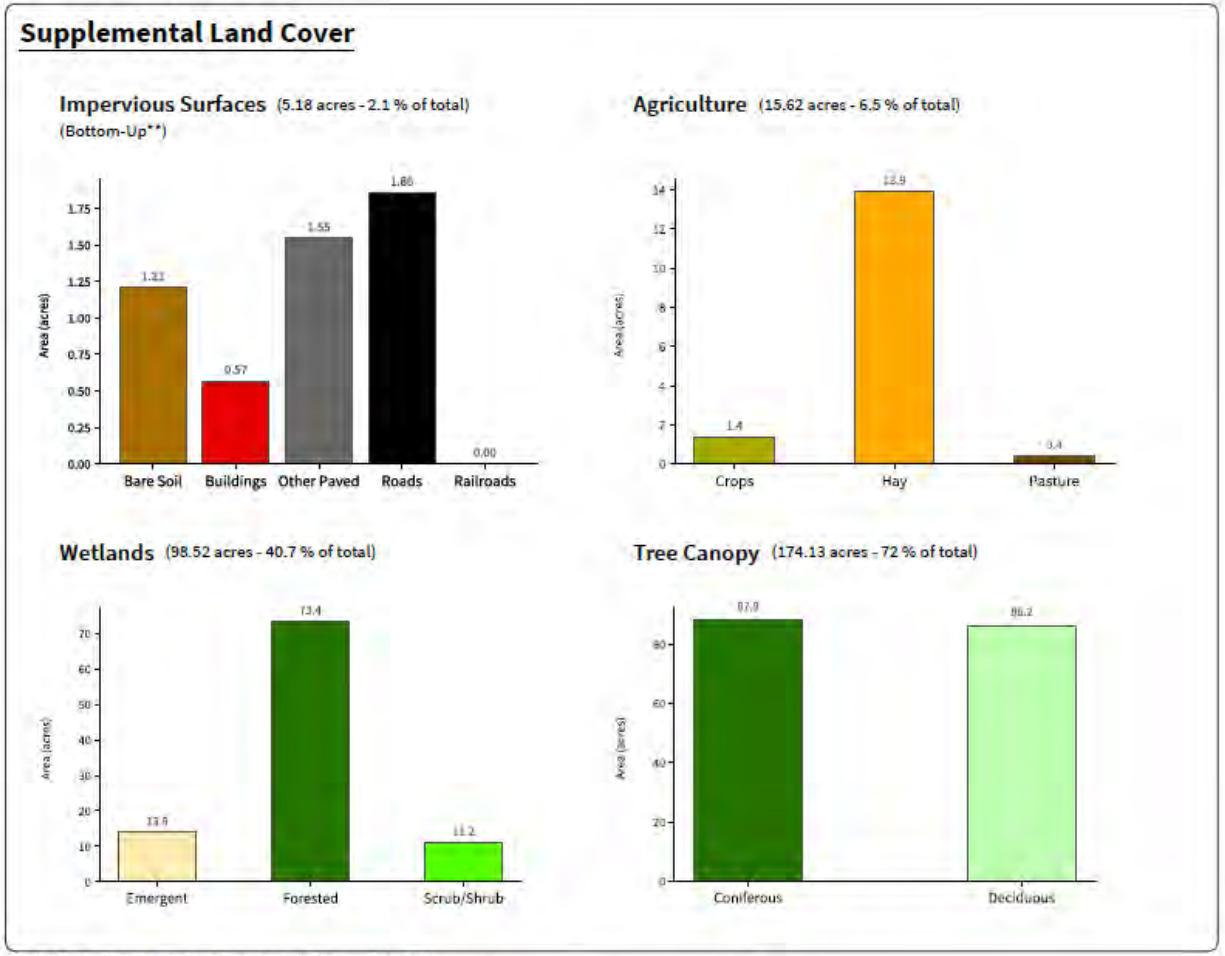
*Top-Down: A traditional land cover mapping approach - land cover is mapped as the uppermost land cover class.
**Bottom-Up: A new land cover mapping approach - land cover is mapped as the lowermost land cover class. This approach results in improved mapping of features overlapped/obscured by other features.
See UVM SAL High-Resolution Land Cover 2016 Report for more detail.

WATERSHED CONSULTING

Land Cover: Tributary 100ft buffer



The impervious and agricultural percentages are slightly higher within 100ft of the tributaries than in the overall lake's watershed



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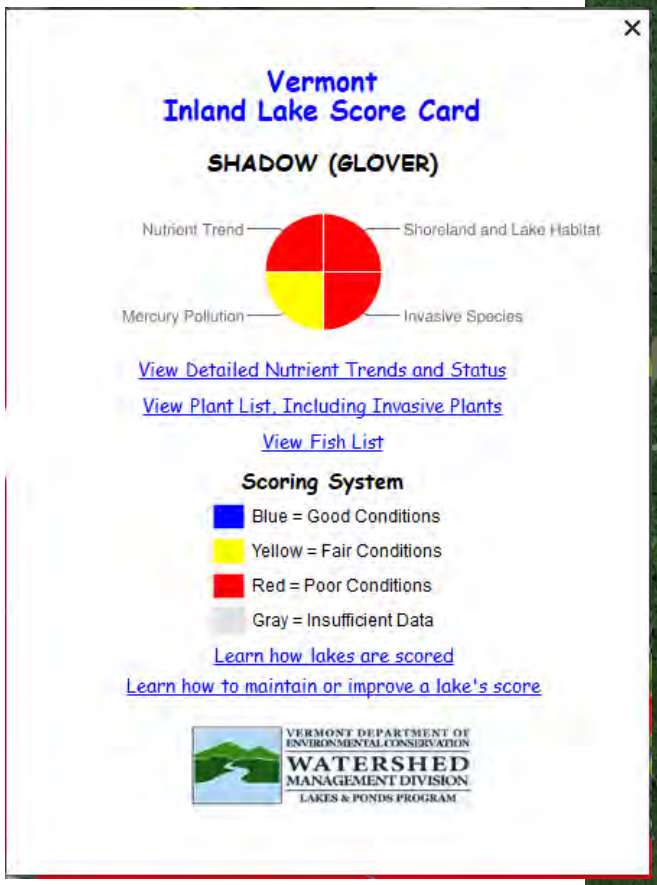
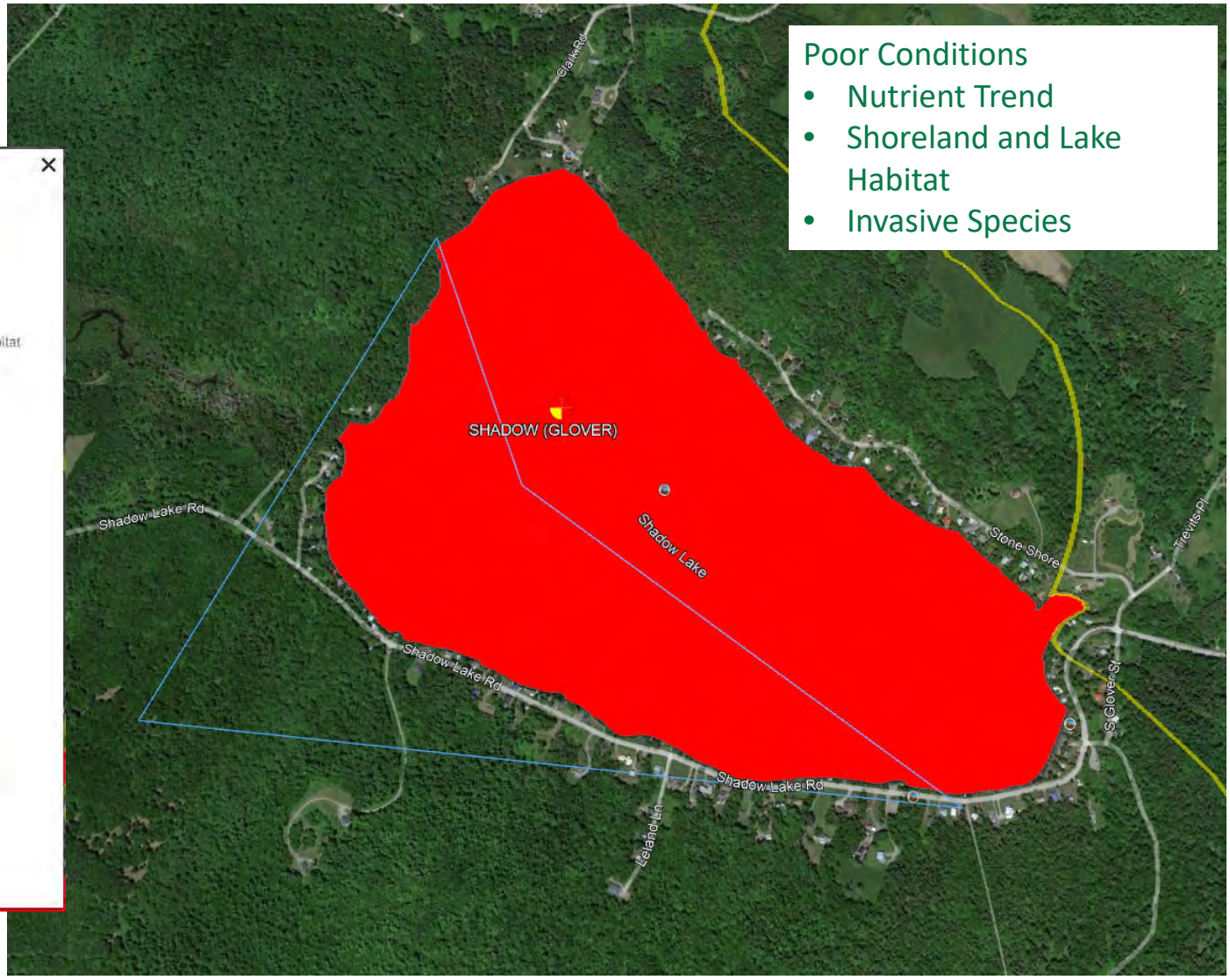
WATERSHED CONSULTING

Lake Scorecard





Poor Conditions
- Nutrient Trend
- Shoreland and Lake Habitat
- Invasive Species

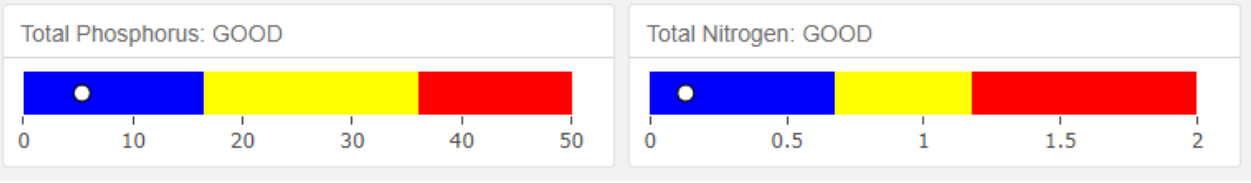
WATERSHED CONSULTING

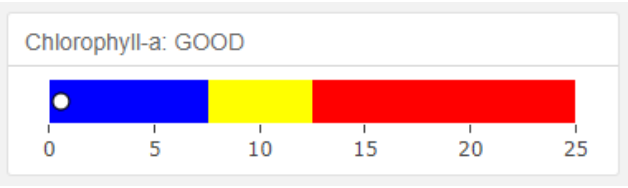
Lake Assessment

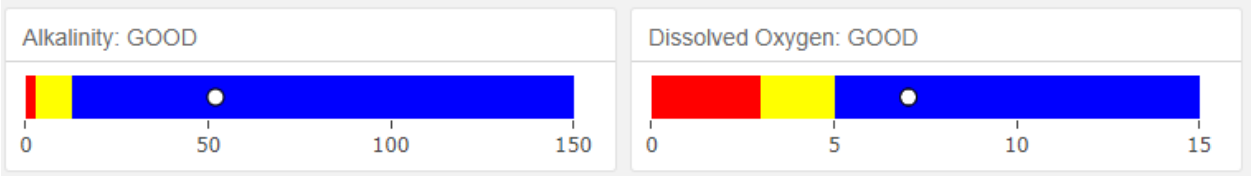
Assessment Report Card

Total Phosphorus	GOOD
Total Nitrogen	GOOD
Chlorophyll-a	GOOD
Alkalinity	GOOD
Dissolved Oxygen	GOOD
Lakeshore Disturbance	POOR
Lakeshore Habitat	POOR
Shallow Water Habitat	FAIR
Physical Complexity of Habitat	POOR

Condition Assessments

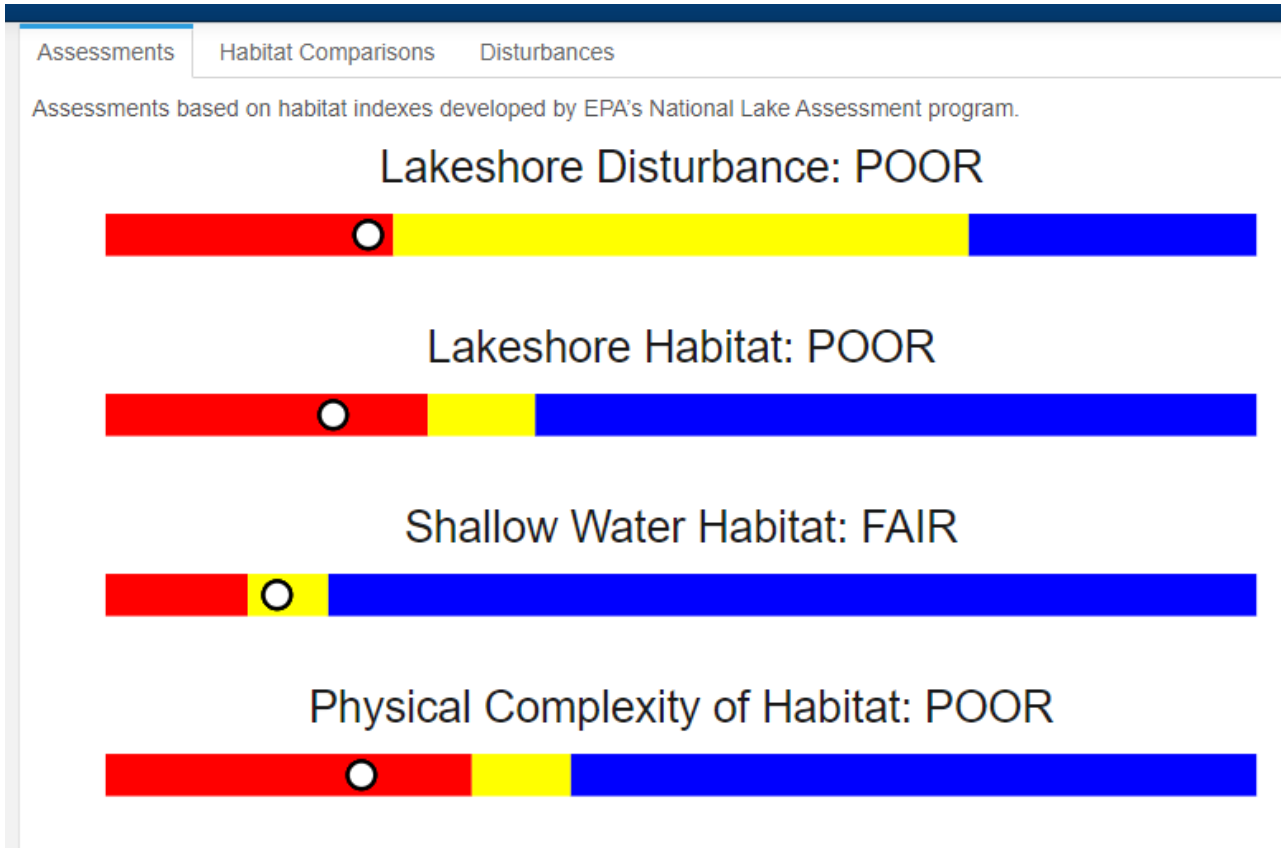






Some parameters were ranked well, including nutrients (Phosphorus and Nitrogen) but are trending higher (see later slides)

Lake Assessment



Other parameters were classified as fair (yellow) or poor (red)

Lake Scorecard

SHADOW (GLOVER) - data through 2020

Learn How Lakes Are Scored

Lake Area:
217.3 acres

Basin Lake Area Ratio:
16

Max Depth:
42.4 meters

Mean Spring TP:
8.3 ug/L

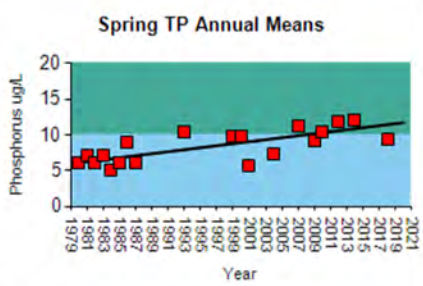
Mean Summer TP:
8.9 ug/L

Mean Summer Chla:
2.3 ug/L

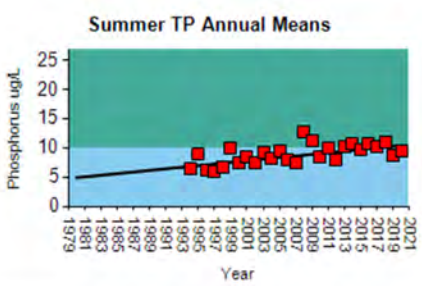
Mean Summer Secchi:
7.9 meters

Hypereutrophic
Eutrophic
Mesotrophic
Oligotrophic

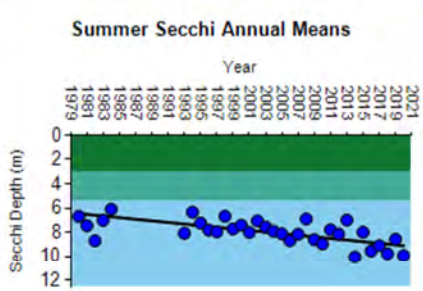
Spring TP Trend: p = 0.0024 | CV = 27
Highly significantly increasing



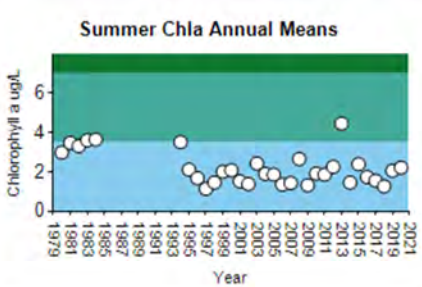
Summer TP Trend: p = 0.0015 | CV = 19
Highly significantly increasing



Summer Secchi Trend: p = 0 | CV = 13
Highly significantly increasing



Summer Chla Trend: p = 0.0717 | CV = 39
Stable



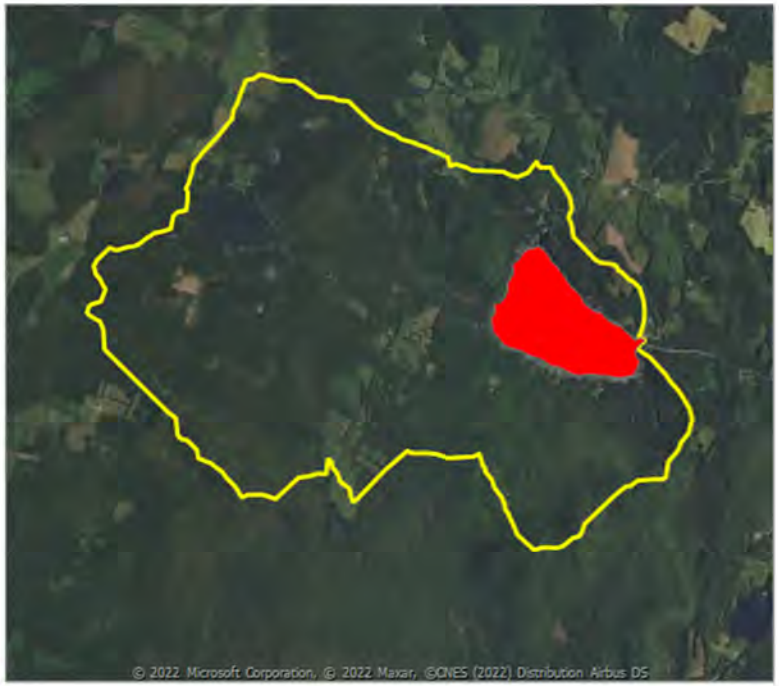
Stresses / Impairments

Altered -- Flow alteration

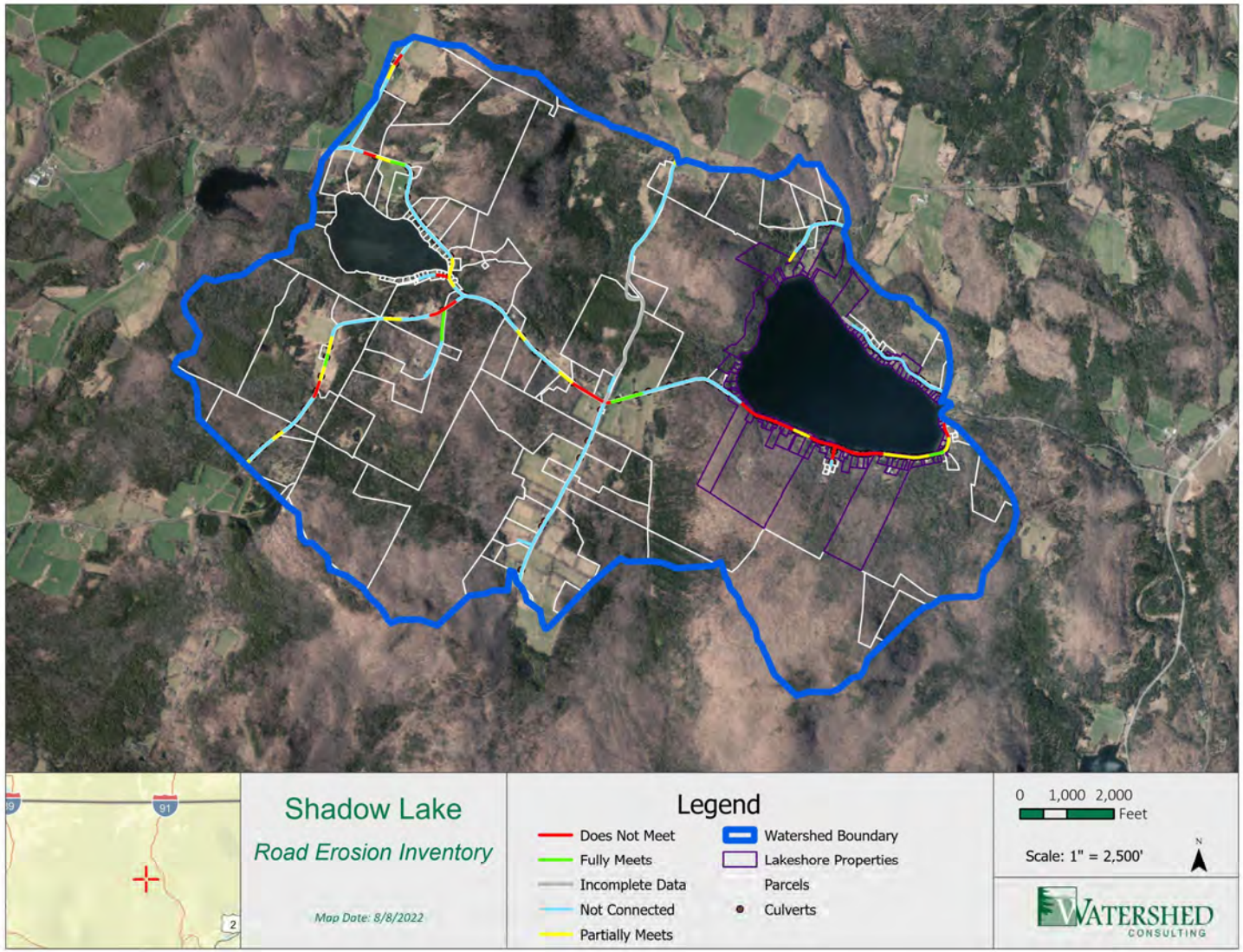
Trend Score: Poor

WQ Standards Status: Altered

Watershed Score: Moderately Disturbed

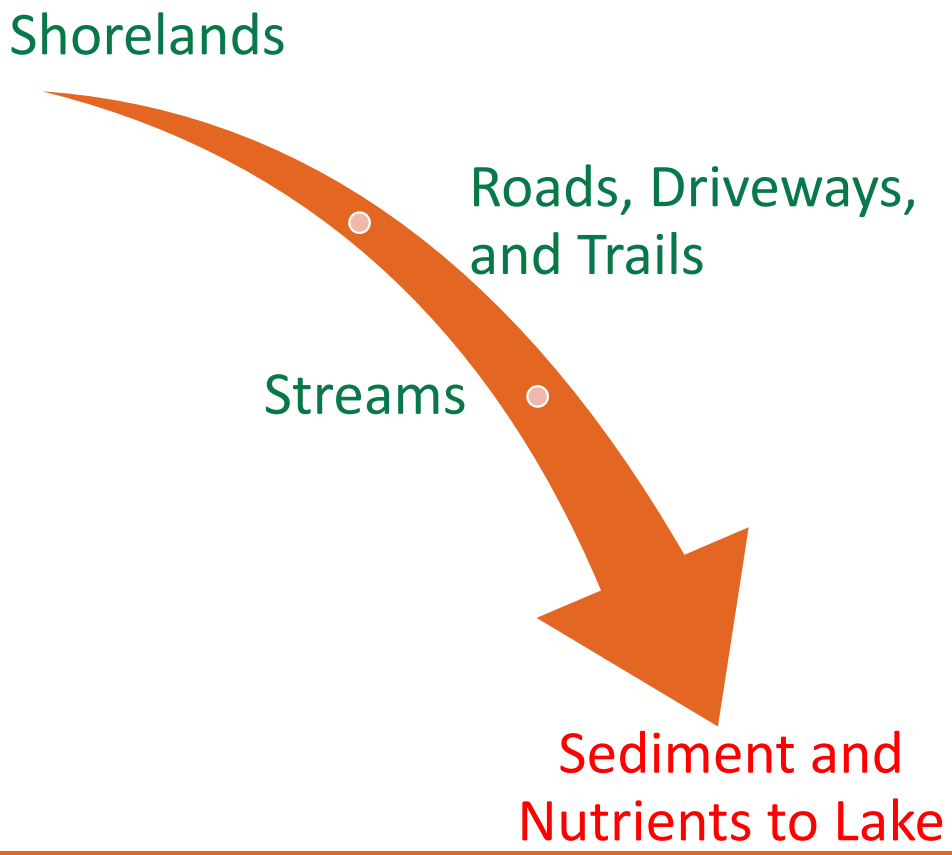


While TP is still classified as good, the trends are showing increasing TP for annual means for spring and summer. These trends are pushing the lake out of oligotrophic status and into mesotrophic conditions.



WATERSHED CONSULTING

Issues and Sources



Shoreland

Assessed via boat.
Identified issues along lake segments.

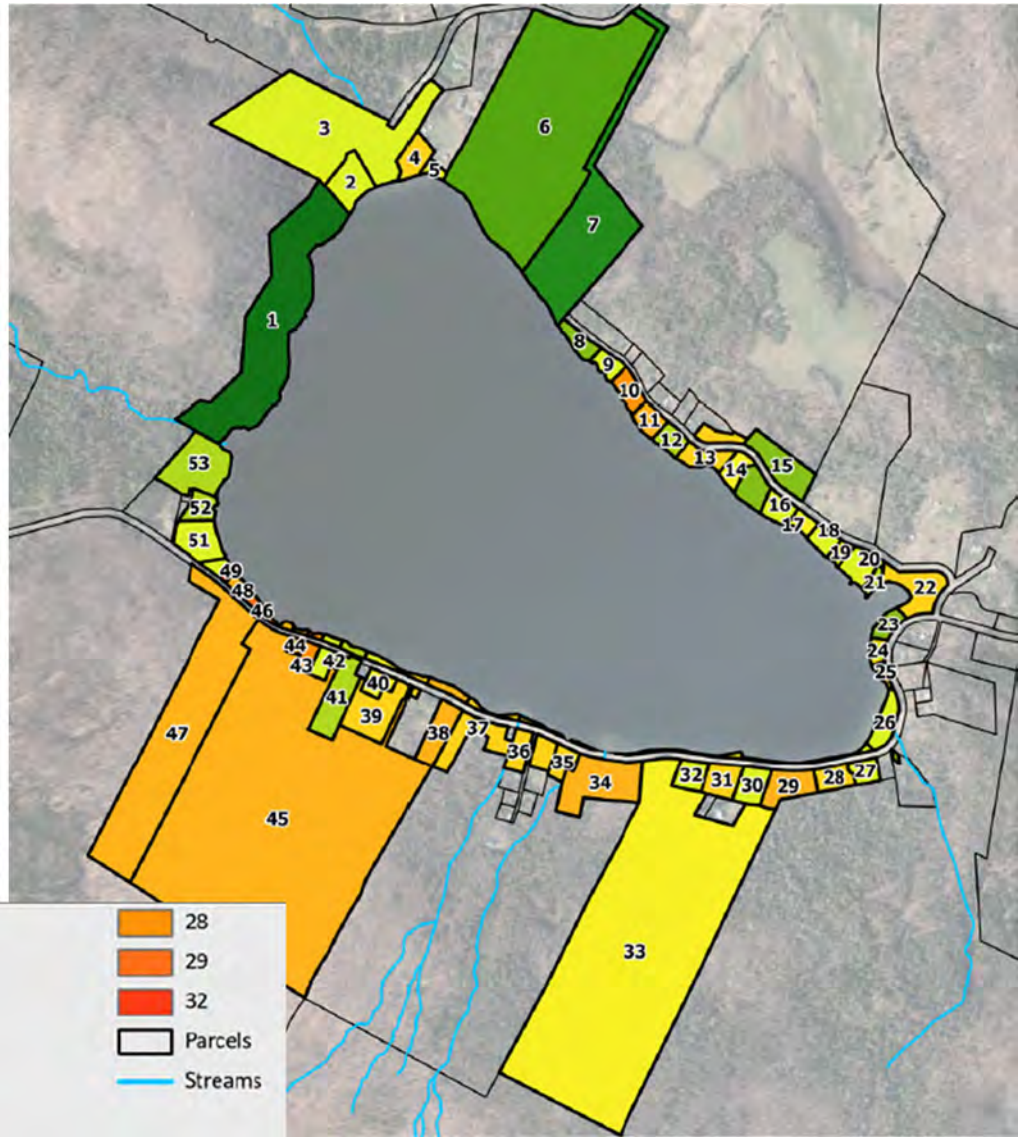
Segments are defined as areas they have similar characteristics.

Segments were scored for indicators of potential water quality issues.

53 scored segments

Used to guide outreach and prioritization for Lakewise assessments

- Shoreline Natural Condition:
- Shoreline Stability:
- Shoreline Vegetation Width:
- Shoreline Erosion:
- Stormwater Flow Type:
- Percent Lawn/Cleared Area:
- Lake Access Stability:
- Slope to Lake:
- Bedrock Controls:
- Constructed Stabilization:



VATERSHED CONSULTING

Shoreland Issues

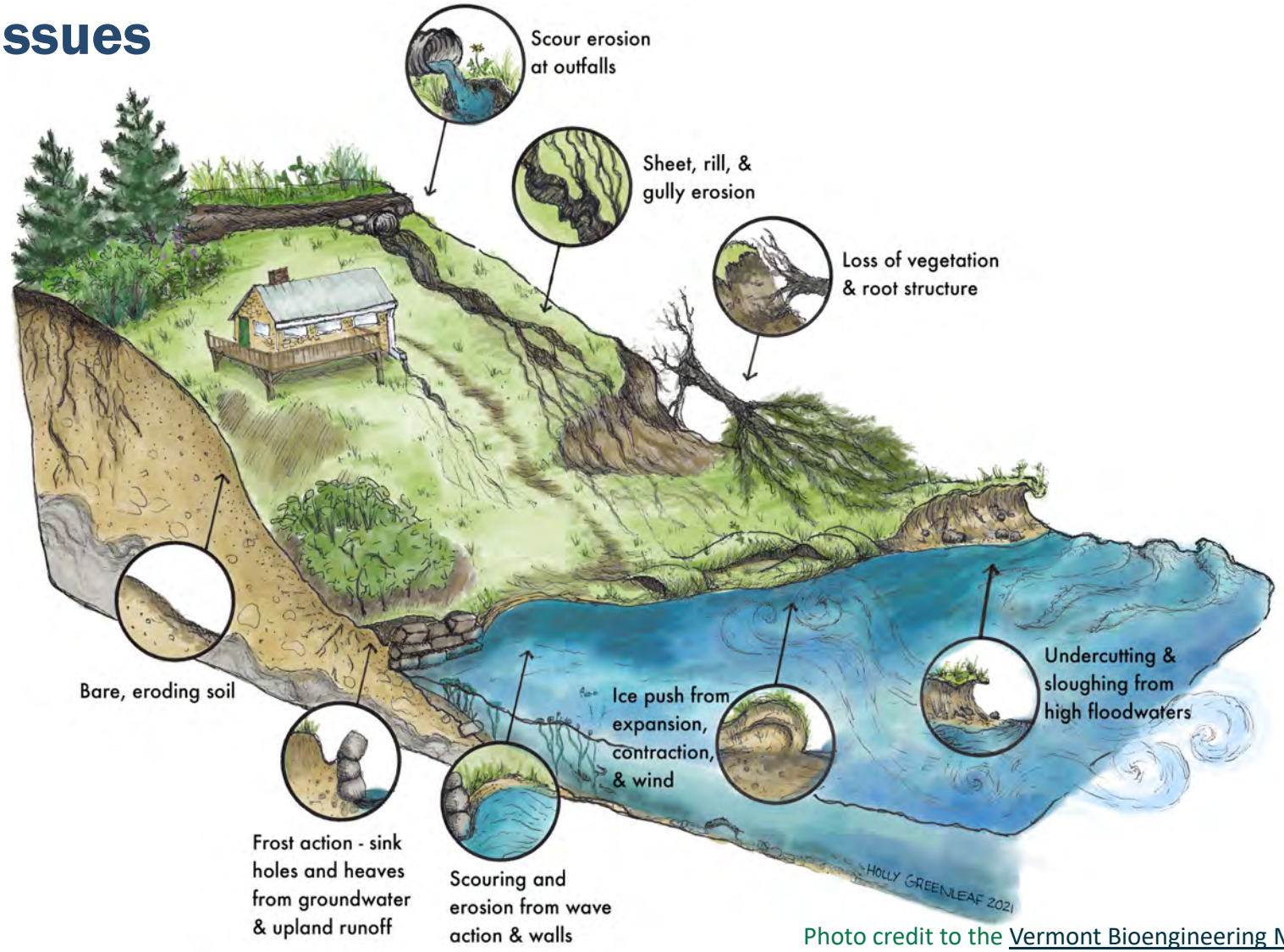


Photo credit to the Vermont Bioengineering Manual, 2022

Shoreland - Lacking Buffers

Lakeshores lacking robust native buffers can contribute higher nutrient loads. Shorelines can become unstable.

Turf grass has very shallow roots that does not stabilize the shoreline.

WATERSHED CONSULTING

Shoreland - Erosion

Lakeshores lacking robust native buffers can contribute higher nutrient loads. Shorelines can become unstable.

Bare soils, especially on a slope, are very prone to erosion.

WATERSHED CONSULTING

Roadways (including driveways, roads, other travel areas)

Issues observed:

- Unstable ditches and uncompacted ditch slopes leading to sediment transport
- Undersized, absent, or clogged culverts
- Improper grading, grader berms, piled loose materials near culverts and streams

WATERSHED CONSULTING

Roadways

Unstable ditches and uncompacted ditch slopes leading to sediment transport

WATERSHED CONSULTING

Roadways

Undersized, absent, or clogged culverts

VATERSHED CONSULTING

Roadways

Improper grading, grader berms, piled loose materials near culverts and streams

WATERSHED CONSULTING

Roadways

VATERSHED CONSULTING

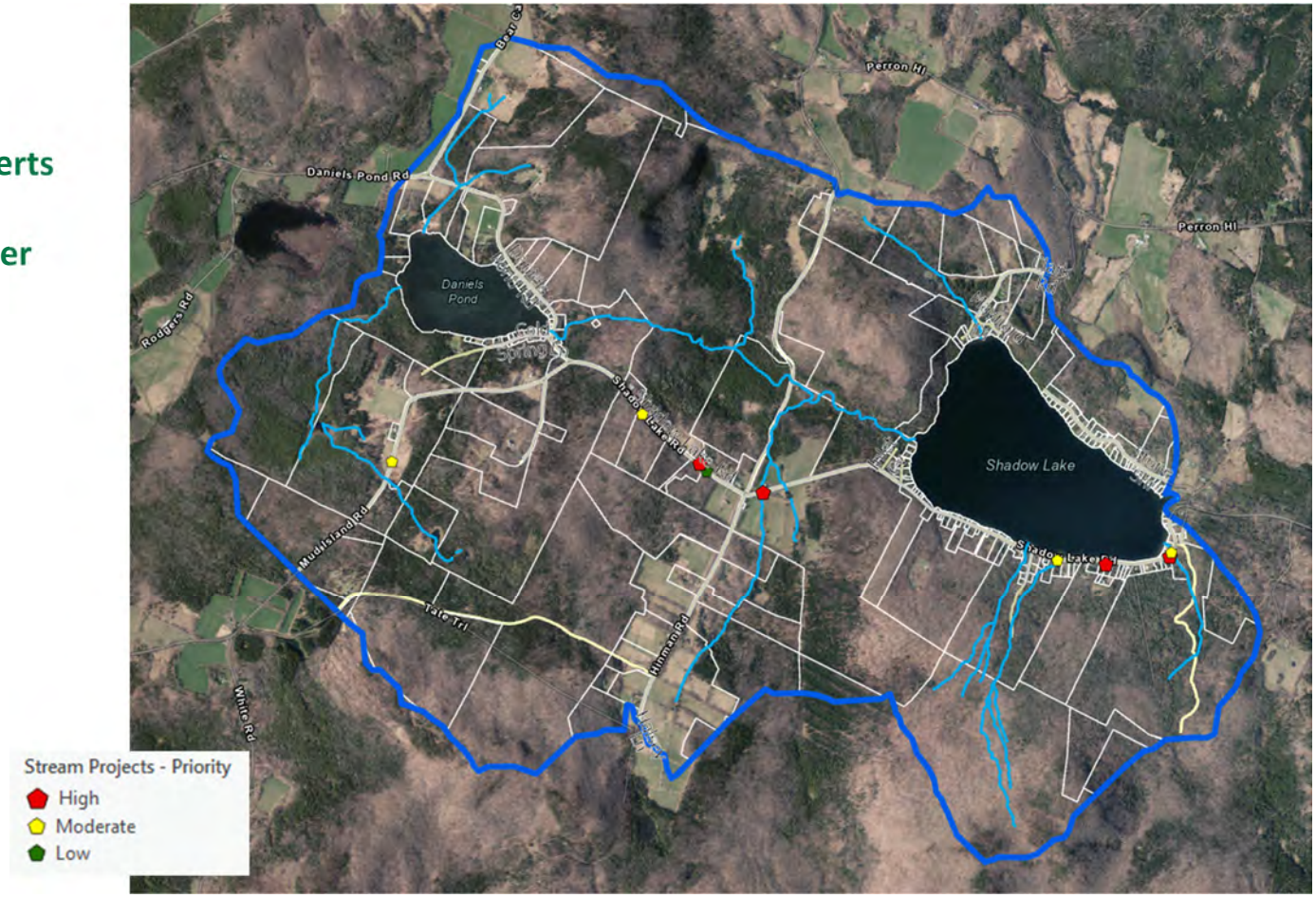
Roadways

VATERSHED CONSULTING

Streams

Issues observed:

- **Unstable streambanks**
- **Scour / erosion near stream culverts**
- **Lack of robust vegetated buffer**
- **Unfiltered channelized stormwater inputs into streams**



WATERSHED CONSULTING

Streams

Issues observed:

- **Unstable streambanks**
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WATERSHED CONSULTING

Streams

Issues observed:

- **Unstable streambanks**
- **Scour / erosion near stream culverts**
- **Lack of robust vegetated buffer**
- **Unfiltered channelized stormwater inputs into streams**

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Sediment Transport

WATERSHED CONSULTING

WATERSHED CONSULTING

WATERSHED CONSULTING

WATERSHED CONSULTING

WATERSHED CONSULTING

WATERSHED CONSULTING

Water Quality Stressors

Roads including:

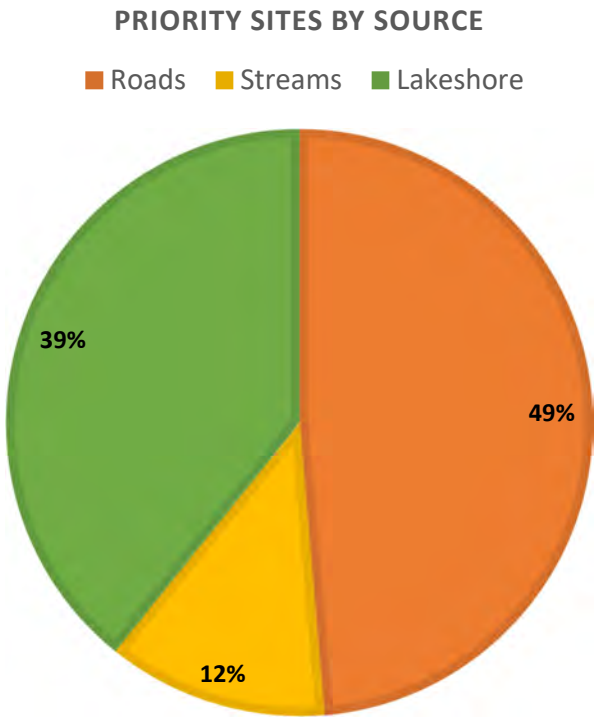
- Roadway runoff
- Development
- Off Road vehicle use
- Deicing chemicals
- Winter sand
- Undersized or absent culverts
- Clogged culverts
- Unstable ditches
- Poor grading / grader berms

Streams including:

- Stream erosion / channelization
- Lack of buffers
- Lack of floodplain access

Lakeshore including:

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



Recommendations:

- Reassess road segments post-July storm and plan for safe passage of larger storm events
- Implement site-specific BMPs to capture and filter sediment and provide detention
- Apply unpaved driveway BMPs
- Preserve and protect large undeveloped parcels
- Illicit discharge survey
- Stabilize trails and prevent future damage from ATVs
- Complete Lakewise assessments and implement site-specific recommendations
- Improve lake buffers
- Stabilize roadside ditches and ensure they are cleaned out regularly

WATERSHED CONSULTING

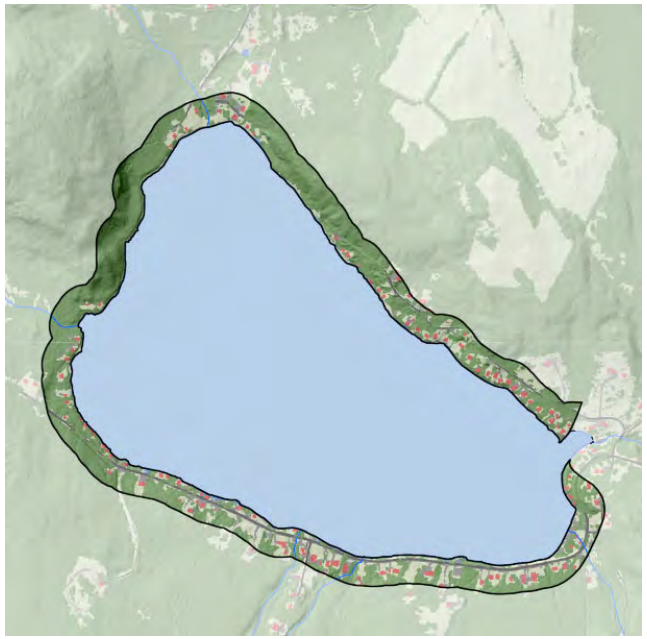
Thank you for your attention!

Contact:

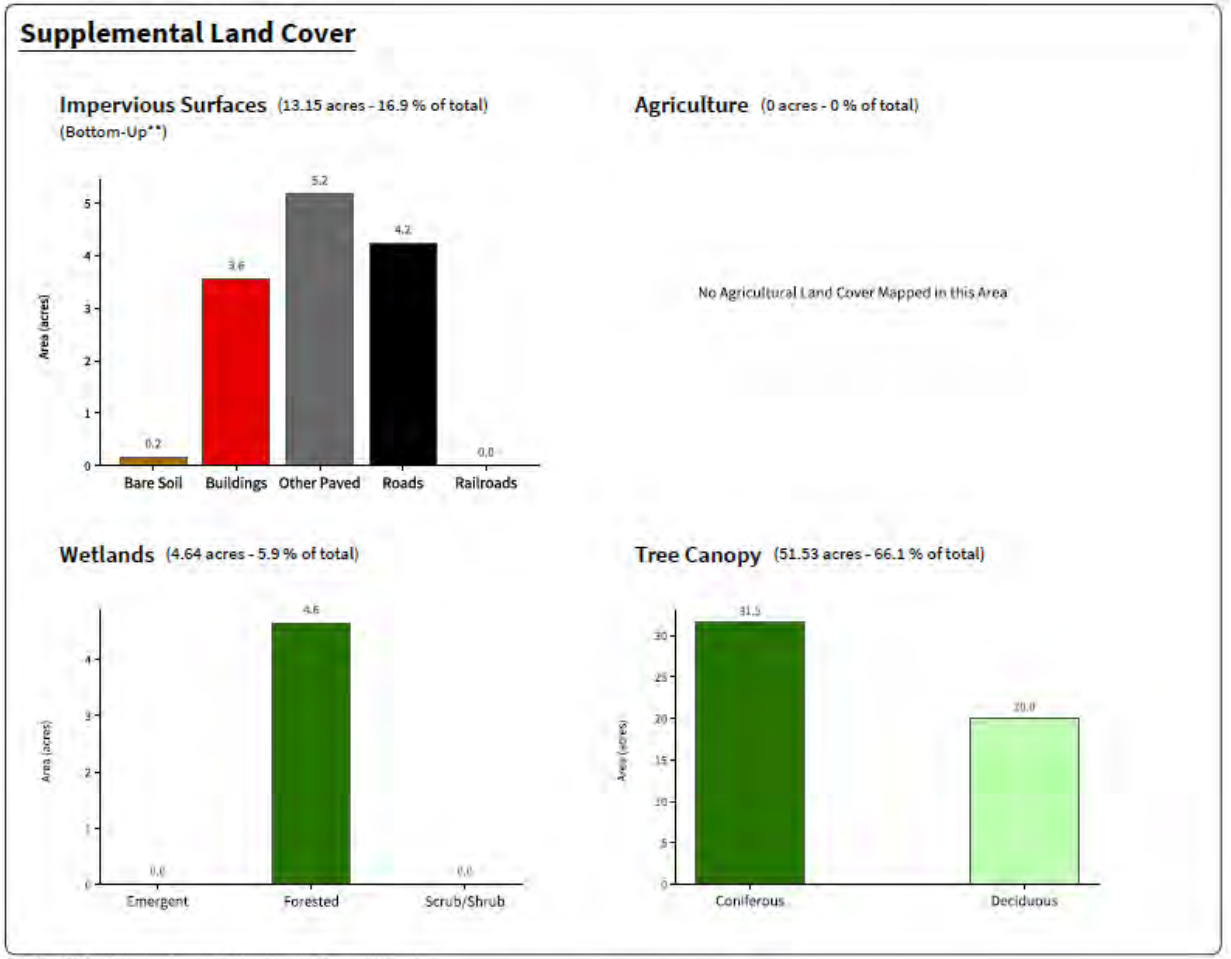
Kerrie@watershedca.com

WATERSHED CONSULTING

Land Cover: Lake 250ft buffer



More forested percentage of land cover within 250 ft of Shadow Lake than 100 ft, but still much higher percent impervious than overall watershed



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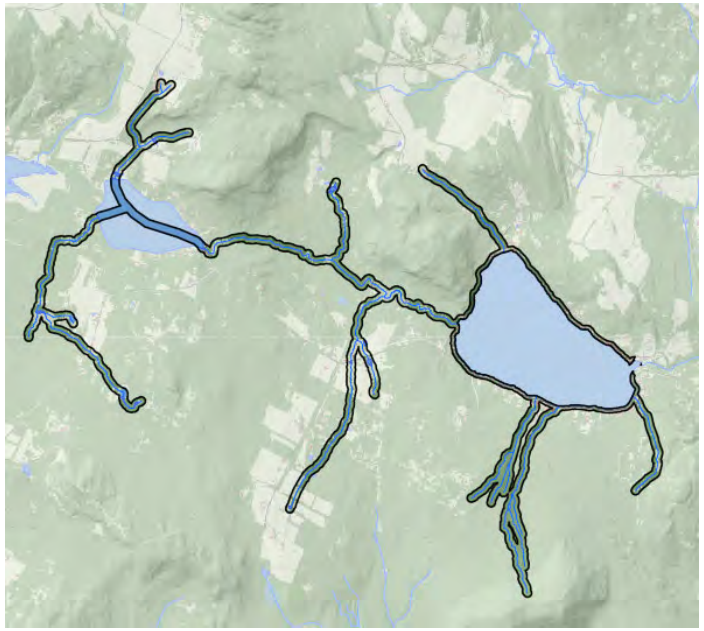
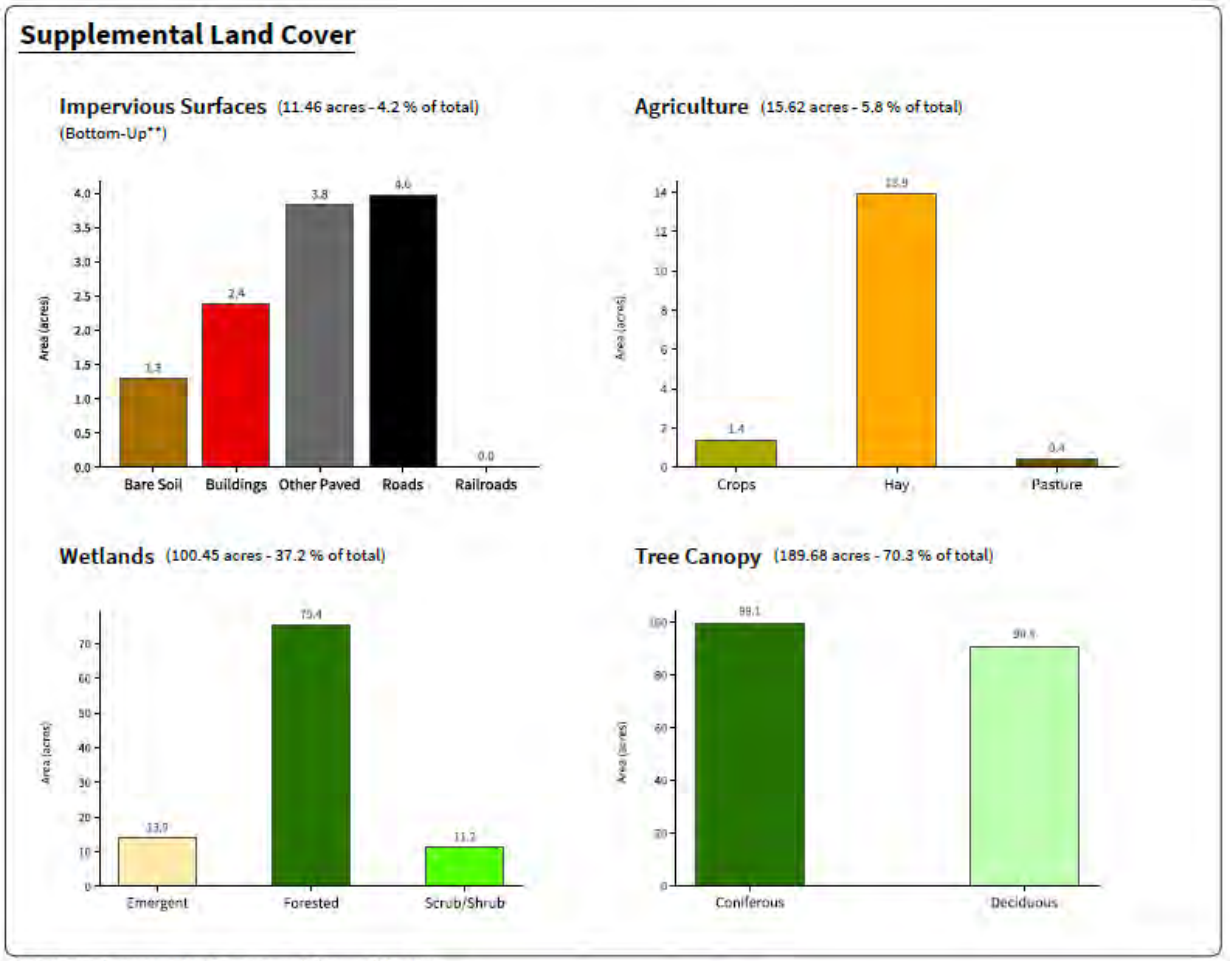
**Bottom-Up: A new land cover mapping approach - land cover is mapped at the lowermost land cover class. This approach results in improved mapping of features overlapped/obscured by other features.
See UVM SAL High-Resolution Land Cover 2016 Report for more detail.

WATERSHED CONSULTING

Land Cover: Lake and Tributary 100ft buffer



The impervious percentages are higher within 100ft of the tributaries and lake than in the overall lake's watershed



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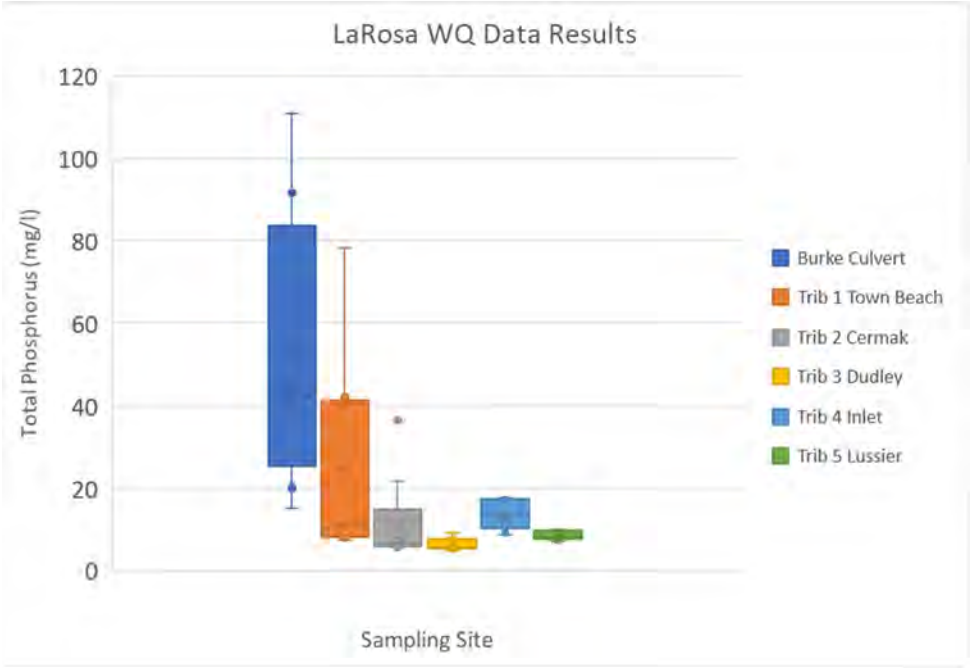
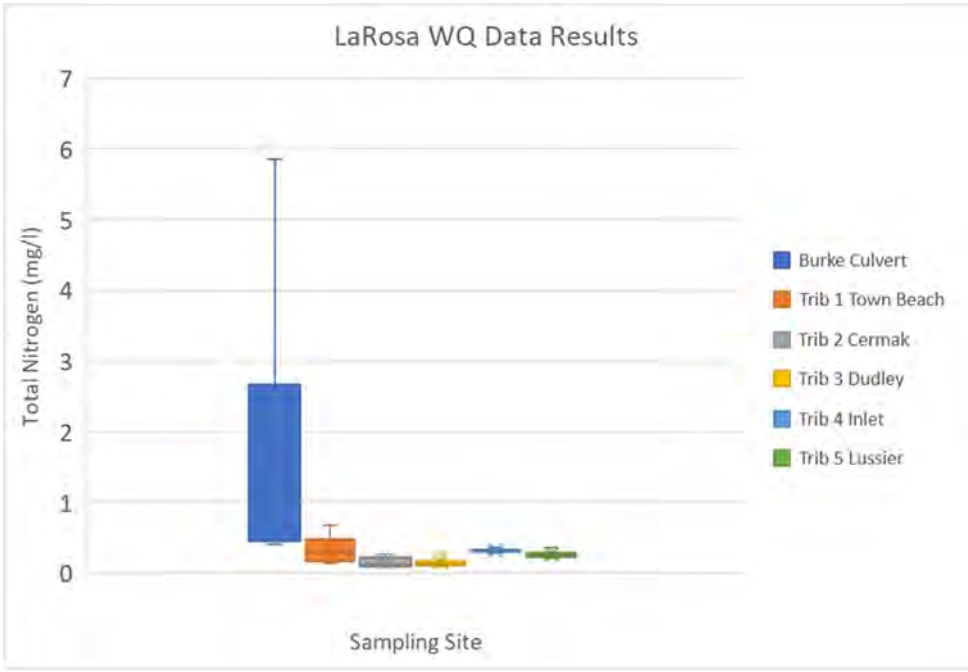
See LWA SAL High-Resolution Land Cover 2016 Report for more detail.

WATERSHED CONSULTING

Water Quality Data





WATERSHED CONSULTING