Lake Nipmuc Baseline Assessment Study

Final Presentation

Key Findings and Recommendations

ESS Group, Inc.

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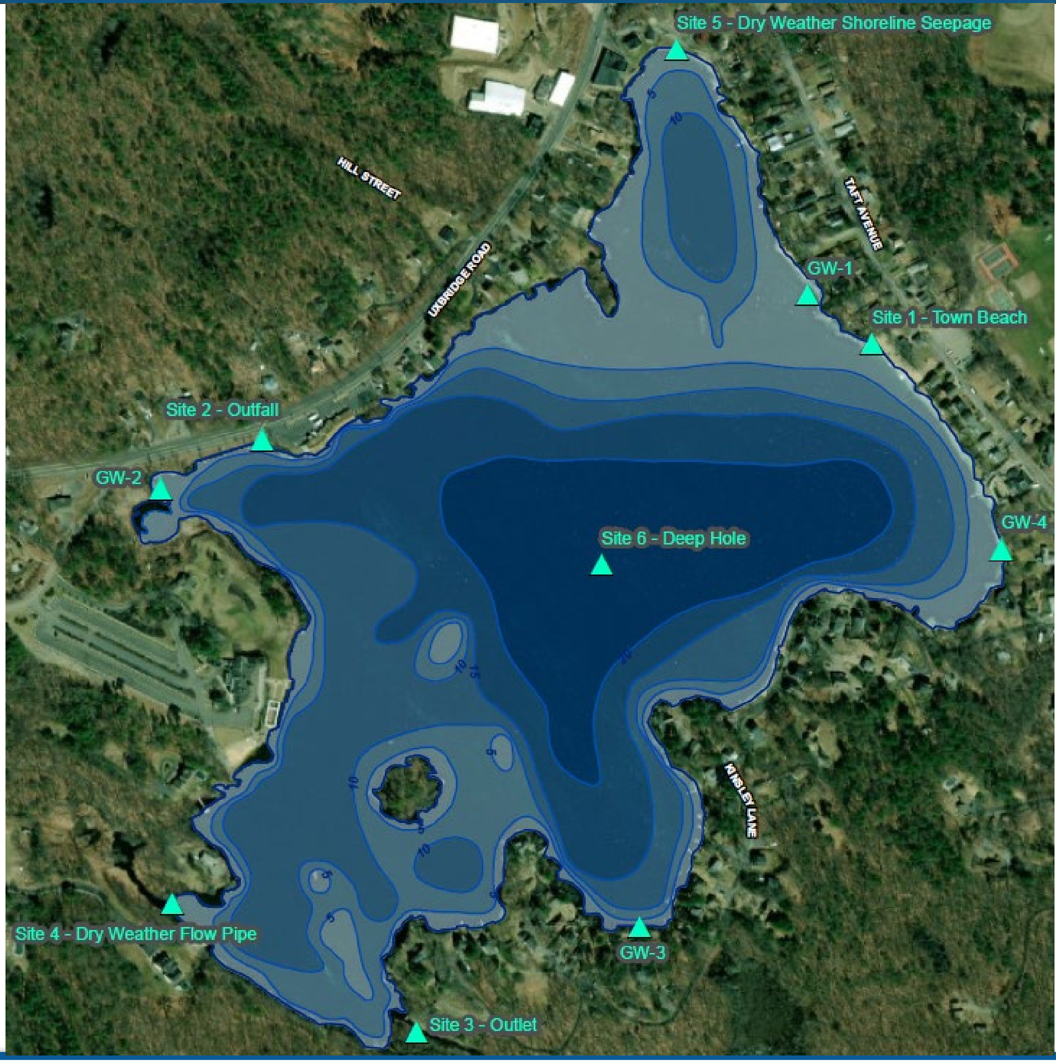
Background & Project Scope

- Task 1 – Project Kick-off and Existing Data Review
  - Held remotely on May 12
- Task 2 – Surface Water Sampling
  - Collected June 25 (dry) and July 12 (wet)
- Task 3 – Groundwater Seepage Survey
  - Collected September 13
- Task 4 – In-Lake Sampling and Mapping
  - Multiple visits – April 28, June 8, and September 13
- Task 5 – Watershed Assessment Report and Presentation
  - Presentation tonight with report to follow

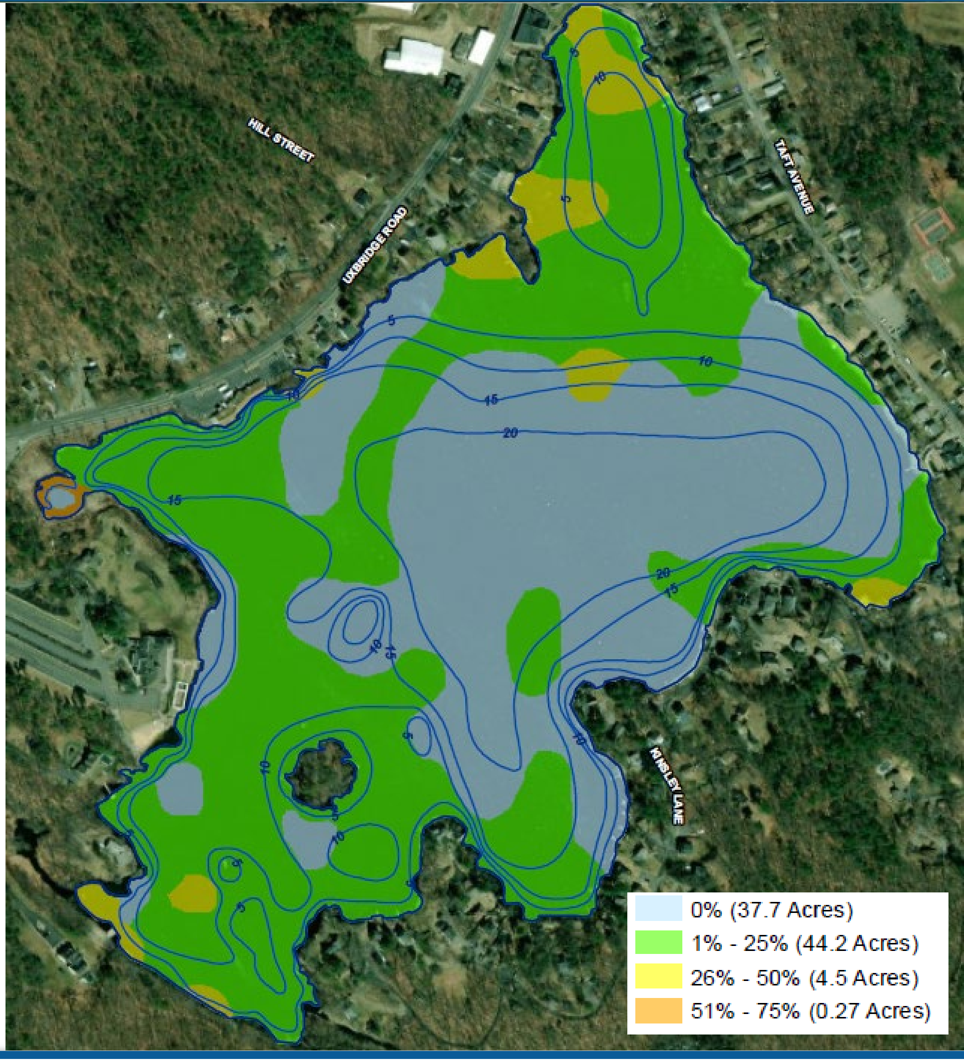
Mapping – Bathymetry

- Setting
  - 87-acre Great Pond in small watershed (~0.5 sq miles)
  - Underlain by till/bedrock
  - No perennial tributaries
  - Outlet is Meadow Brook (to Blackstone)
- Bathymetry
  - Large central basin with smaller protected basin to the north
  - A few shoals and islands in the southwestern portion
  - Max depth of 25 feet
  - Average depth >10 feet

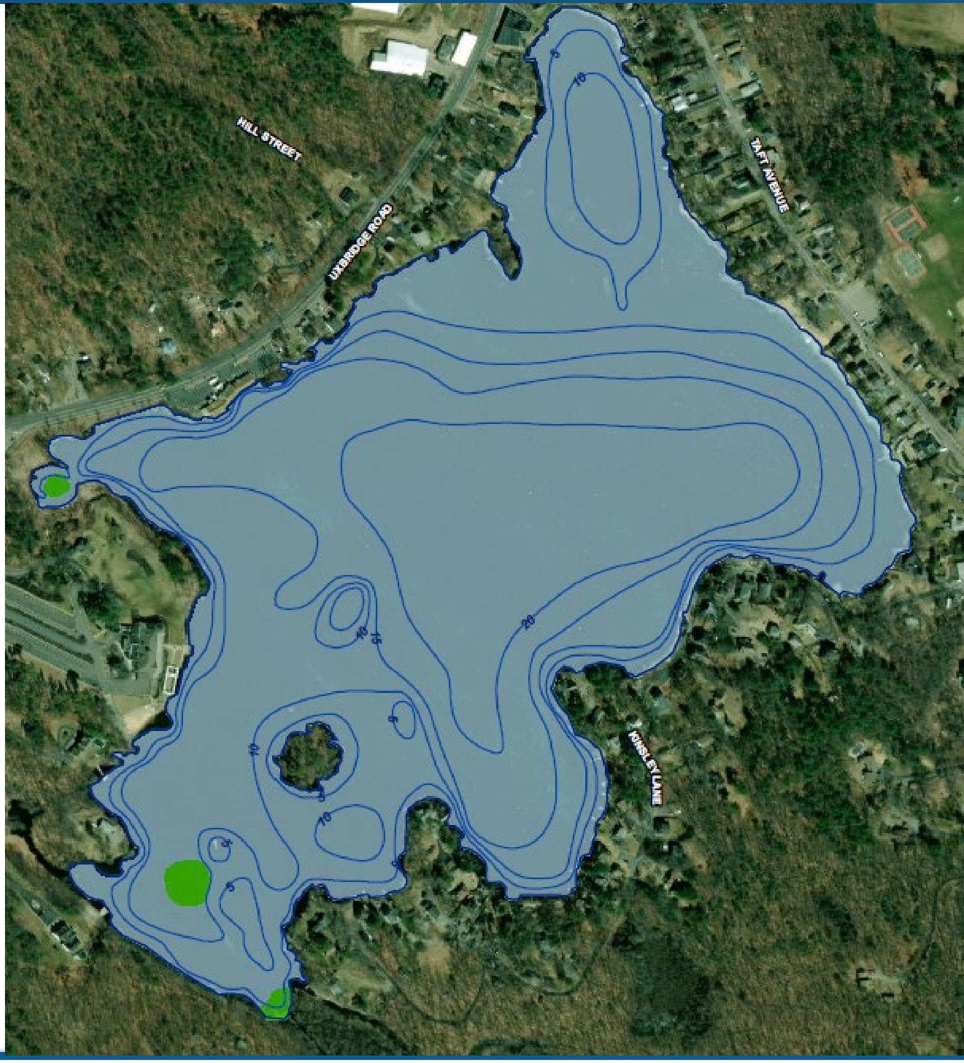


Mapping – Aquatic Plants

- Mapped in June just prior to treatment by Water & Wetland
- Overall aquatic plant cover and biovolume low to moderate with localized spots of dense plants
- Growth down to ~20 ft
- Twelve native species identified
- Three aquatic invasive species documented but not particularly dense or widespread
  - Eurasian milfoil (*Myriophyllum spicatum*)
  - Variable-leaf milfoil (*Myriophyllum heterophyllum*)
  - Water chestnut (*Trapa natans*)



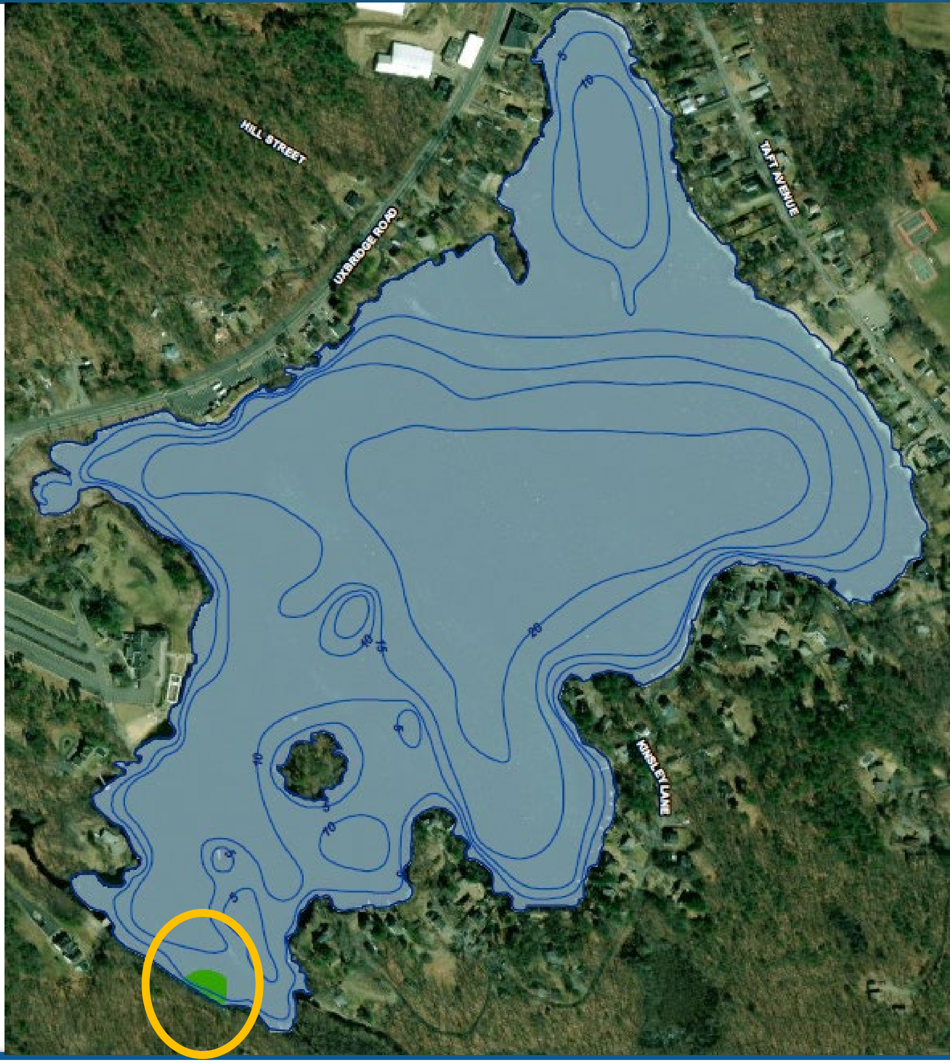
Mapping – Aquatic Invasive Plants: Variable-leaf Milfoil



Mapping – Aquatic Invasive Plants: Eurasian Milfoil

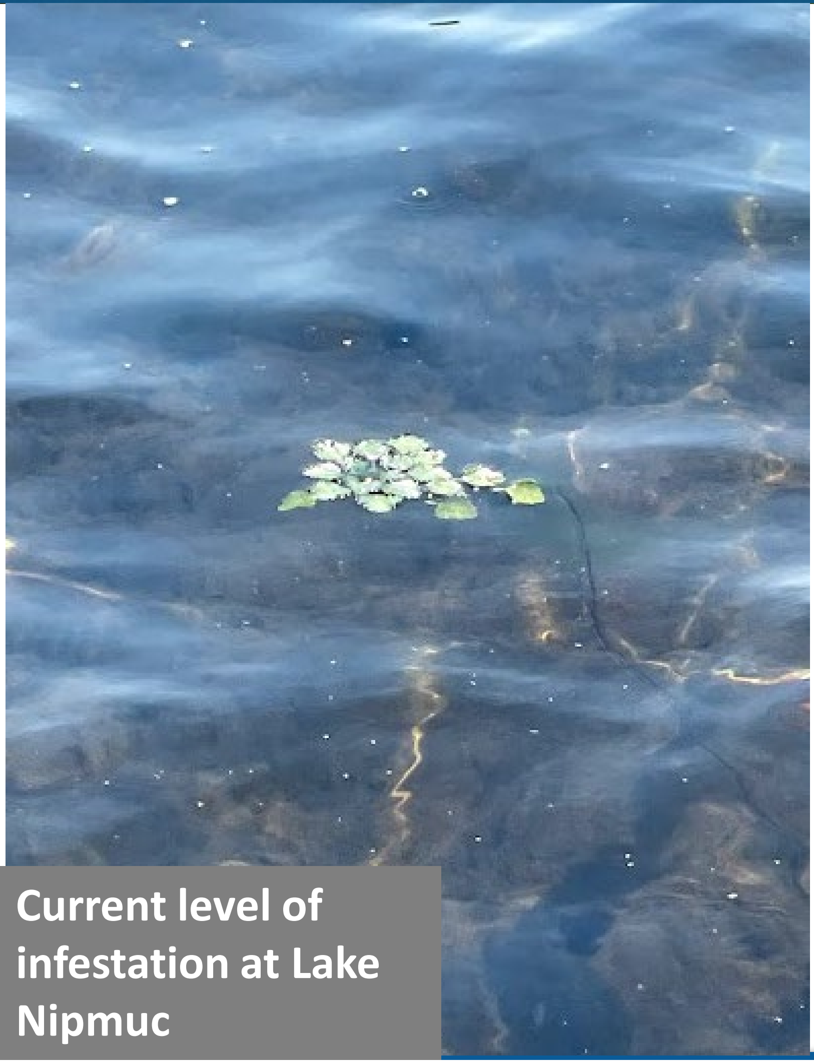
What Eurasian milfoil looks like in larger infestations

Current level of infestation at Lake Nipmuc



Mapping – Aquatic Invasive Plants: Water Chestnut

What water chestnut looks like a few years after uncontrolled infestation



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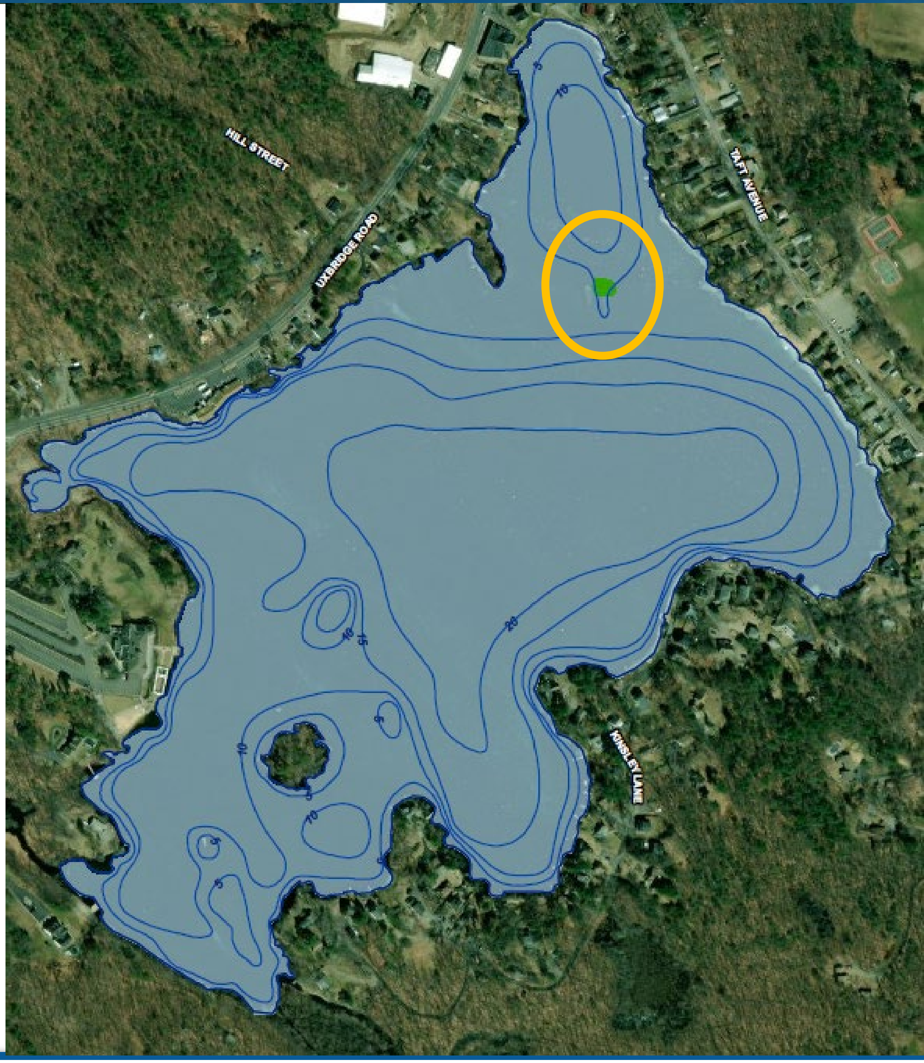
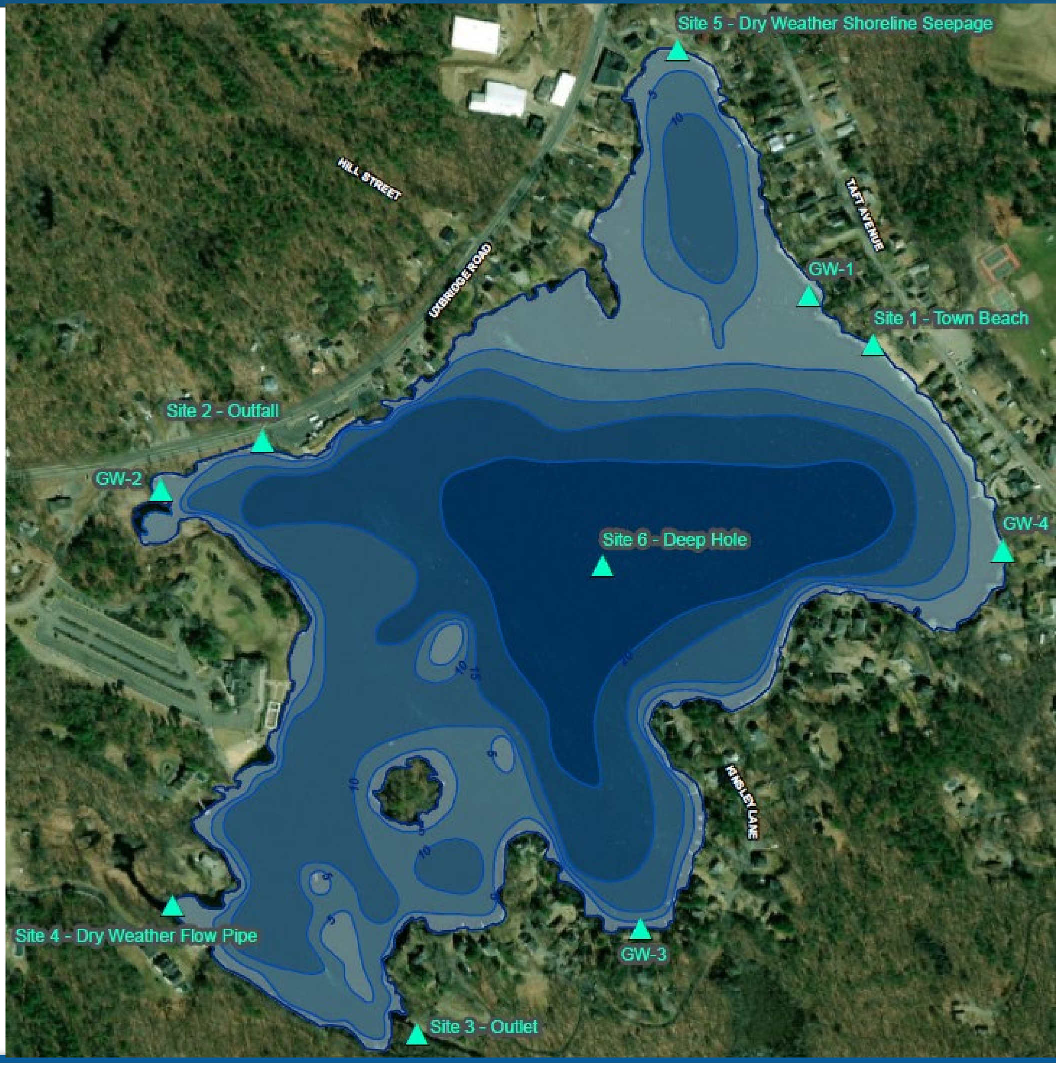


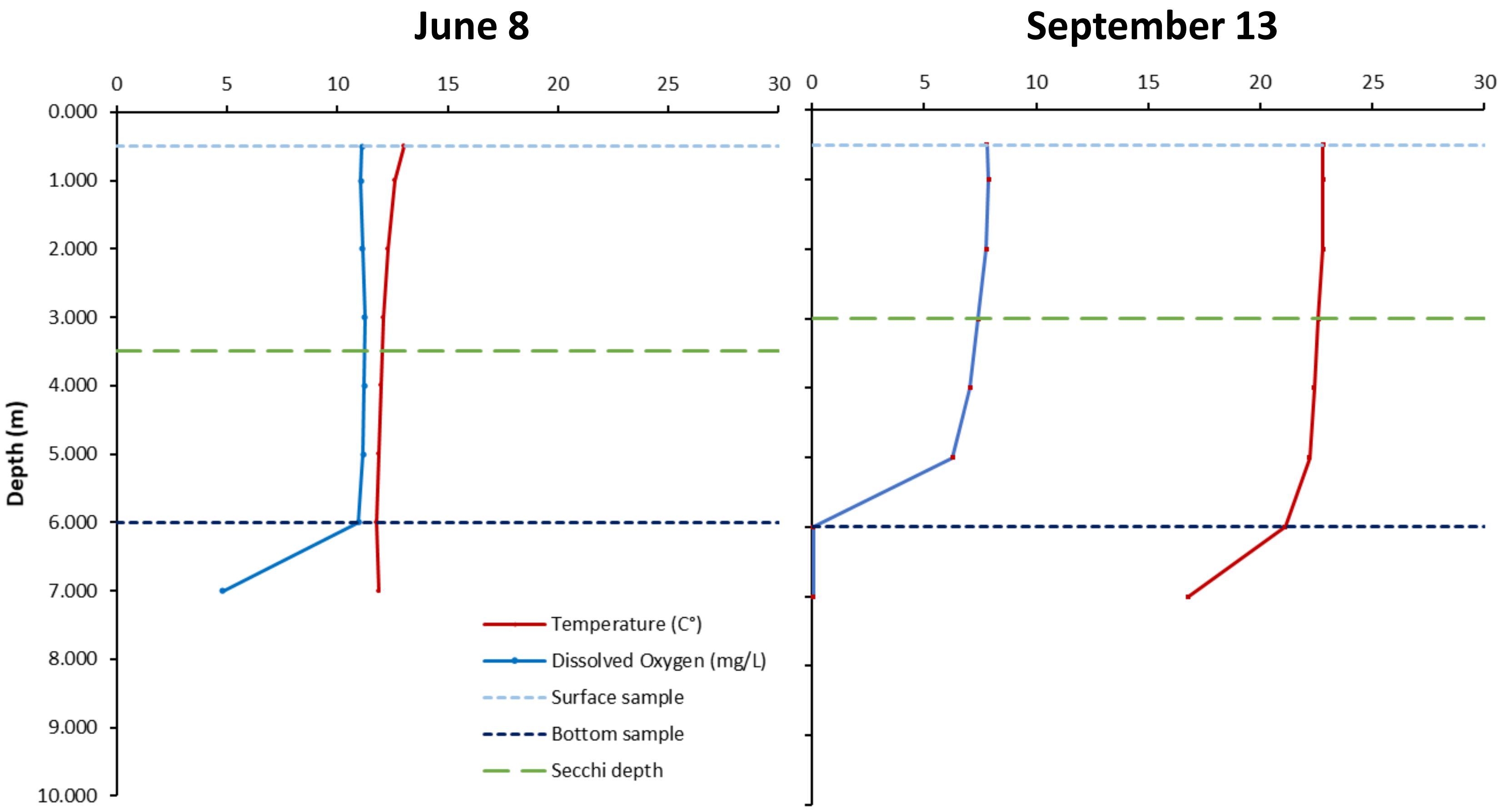
Water Quality – Sampling Locations

- Site 1 – Two events - sampled during dry and wet weather.
- Site 2 – Single event - wet-weather only.
- Site 3 – Single event - dry-weather only.
- Site 4 – Single event - dry-weather only
- Site 5 – Single event - wet-weather only
- Site 6 – Single full event (one partial) - dry-weather surface and bottom with vertical profiles.
- GW-1 thru GW-4 – Single event. Shallow porewater samples and seepage meter measurements.



Water Quality – Surface Water Results: In-Lake

- Dissolved oxygen adequate in most of water column in June
- Some anoxia developing at lake bottom in late summer
- Water transparency slightly lower late summer



Water Quality – Surface Water Results: In-Lake

- Phosphorus
  - <0.01 mg/L at surface
  - 0.027 mg/L at bottom
  - May indicate some release of phosphorus from bottom sediments (internal recycling)
- Nitrogen
  - <1 mg/L at surface and bottom
  - Mostly in form of Kjeldahl nitrogen (ammonia + organic)
  - No detection of nitrate/nitrite-nitrogen
- Bacteria (*E. coli*)
  - 50-60 MPN – compare with Town beach monitoring results at right

Sample Date	analyzed date	Average = 100.74 Geomean = 20.32 MPN
6/14/21	6/16/21	2
6/21/21	6/23/21	816.4
6/24/21	6/28/21	2
6/28/21	6/30/21	5.2
7/6/21	7/8/21	5.2
7/12/21	7/13/21	101.9
7/19/21	7/21/21	9.8
7/26/21	7/28/21	17.3
8/2/21	8/4/21	15.5
8/9/21	8/11/21	172.2
8/16/21	8/18/21	18.3
8/23/21	8/25/21	135.4
8/30/21	9/1/21	8.5

Water Quality – Surface Water Results: Other Sources

- Dry Weather
  - Phosphorus
    - Modest – no red flags
  - Nitrogen
    - High in pipe - otherwise modest
  - Bacteria (*E. coli*)
    - Low in pipe with dry weather flow
- Wet Weather
  - Phosphorus, Nitrogen, and Bacteria (*E. coli*)
    - All highest concentrations in beach runoff
    - All lowest concentrations at Site 5, in channelized shoreline flow
    - Loading actually highest from Site 2

Dry Weather

Location	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	E. coli (MPN)
Site 1 - Beach (Lake)	0.014	0.45	54.75
Site 3 - Outlet	0.013	0.39	13.23
Site 4 - Pipe	<0.010	1.30	<1

Wet Weather

Location	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	E. coli (MPN)
Site 1 - Beach (Runoff)	0.050	2.00	4,266
Site 2 - Outfall	0.027	0.73	68.44
Site 5 - Shoreline Flow	0.012	0.37	14.8

Water Quality – Groundwater Results

- Phosphorus *concentrations* highest at GW-3 and lowest at GW-2
- Nitrogen *concentrations* highest at GW-4 (easternmost cove) and lowest at GW-2 (westernmost cove)
    - Mainly in form of ammonia – up to 1.16 mg/L
    - Nitrate not detectable at 0.02 mg/L
- Highest *loading* rate for both at GW-4
- Aside from seep emerging near shoreline at Site 5 and dry weather pipe flow at Site 4, no other visible signs of *potential* septic sources
- Low nitrate levels precluded stable isotope analysis

Other Observations of Note

- Fish kill reported on June 8. Appeared to mainly affect area north of Town Beach. Uncertain cause.
- Resident geese observed in groups of up to 15 over the course of the study.
- Phytoplankton sample collected September 13 contained cyanobacteria at sub-bloom densities.
- Several complaints of swimmer's itch-like symptoms (skin rash) after swimming.

Diagnostics in Summary: Key Factors to Consider

- Lake Nipmuc is a moderately shallow lake with some summer stratification
- Northernmost cove may have limited exchange with rest of lake, especially during low water – could trigger local events (blooms, low DO, fish kills, etc.) and provide shelter for aquatic invasive plants
- Aquatic invasive plants present but not extensive at time of survey
- Surface water inputs likely to contribute majority of pollutant load to lake – limited evidence suggests looking further at stormwater outfalls and direct runoff
- Groundwater (septic) and waterfowl likely to be secondary contributors but may be important during more sensitive times of the year
- Internal recycling of phosphorus may also be a factor during summer/early fall
- Cercarial dermatitis (swimmer's itch) nuisance to sensitive individuals who participate in primary contact recreation

Initial Feasibility Assessment: What Can Be Done?

- Most Relevant Options
  - In-Lake
    - Aeration/circulation
    - Benthic barriers
    - Chemical controls (algaecides/herbicides)
    - Hand/diver harvesting
    - Nutrient inactivation
    - Resident waterfowl controls
    - Others
  - Watershed
    - Septic upgrades
    - Stormwater improvements
  - Monitoring
  - Public education and outreach
- Other Options
  - Barley Straw
  - Bioaugmentation
  - Biomanipulation
  - Dilution or Flushing
  - Drawdown
  - Dredging
  - Herbivores
  - Hydroraking
  - Mechanical harvesting
  - Plant competition
  - Sonication
  - This list is not exhaustive

Initial Feasibility Assessment: What Can Be Done?

Approach	Issue(s) Addressed				
	Algae	Bacteria	Nutrients	Plants	Other
In-lake Options					
Aeration/Circulation	✓	?	?		✓
Algaecides	✓				
Benthic Barriers				✓	?
Harvesting (Hand/Diver)			?	✓	?
Herbicides				✓	?
Nutrient Inactivation	✓		✓		
Resident Waterfowl Controls		✓	✓		✓
Watershed Options					
Septic System Improvements		✓	✓		
Stormwater Improvements		✓	✓		✓
Other Options					
Monitoring					✓
Public Education and Outreach	✓	✓	✓	✓	✓

Aeration/Circulation

- Mixing and/or introduction of air/oxygen
- Controls cyanobacteria through one or more mechanisms (light limitation, enhanced P binding, etc.)
- Can also be used to encourage circulation into stagnant coves
- Costs vary substantially by volume and tech

Pros	Cons
• When properly designed/implemented may... • Improve dissolved oxygen levels • Enhance P removal • Reduce nuisance algae • Few negative impacts to non-target species	• Requires power supply resulting in substantial operational costs (some solar-powered options) • Maintenance required • Difficult to achieve success at large scale

Algaecides

- Many copper-based formulations (copper sulfate, chelated copper) but there are others, too
- Chemically kills algae
- Relatively low cost per dose

Pros	Cons
• The fastest way to control algae, especially over large areas • Some selectivity possible with different formulations	• Rapid lysing of cells may release cyanotoxins (if present) and drag down dissolved oxygen • May impact some non-target organisms • Does not address cause/no lasting water quality benefits

Benthic Barriers

- Smothers aquatic plant growth
- Can be moved from location to location within a lake for control of discrete areas
- Best for shallow areas where plant growth may interfere with swimming or boat access

Pros	Cons
• Directly eliminates habitat for aquatic plant growth, resulting in nearly 100% control • Can be deployed by trained volunteers	• Labor-intensive to deploy, maintain, and retrieve • Cost per acre of control among the highest of any technique • Non-selective - impacts to non-target organisms

Hand/Diver Harvesting

- Direct pulling or removal of nuisance plant species
- Would be preferred for most pioneer infestations of new species
- Requires dewatering and disposal

Pros	Cons
• Selective – allows for precision control • Simple approach – trained volunteers can conduct hand harvesting	• Only cost-effective for modestly sized beds • Insufficient for control of most established infestations • Can spread plant fragments/seeds (this can be mitigated)

Herbicides

- Wide variety of formulations and modes of action to control aquatic plant growth
- Contact vs. systemic, selective vs. broad-spectrum
- Cost-effective compared to most other means for control of moderate to extensive infestations

Pros	Cons
• Many different formulations to address almost every nuisance plant species • Systemic herbicides can result in multi-season control • One of the fastest ways to control nuisance plants, especially when infestations are extensive	• Water use restrictions after application (some products) • Potential for dissolved oxygen sag as plants die • Resistance in some populations of target species • Potential for impacts on non-target organisms, although these vary substantially by product and lake

Nutrient Inactivation

- Aluminum sulfate or other phosphorus-binding compound
- Different application strategies
  - Stripping
  - Maintenance
  - Sediment dosing
- Cost per unit P removed is very low

Pros	Cons
• Addresses typical cause of cyano dominance (excess phosphorus) • Works quickly and can be effective for extended periods of time (decades, in some cases)	• More logistically difficult than algaecide treatments • If not well-designed or monitored, can result in non-target species impacts (typically at higher doses)

Resident Waterfowl Controls

- Variety of passive / active measures to discourage persistent use of lake by resident geese
- Most effective passive measures are fencing or vegetation
- Reduced mowing is easy

Pros	Cons
• Addresses a source of excessive nutrients and bacteria • Passive measures can provide secondary ecological, water quality, or aesthetic benefits	• Fencing and revegetation must form effective exclosures to work, which may restrict access (but this can be mitigated)

Septic System Improvements

- Includes repairs, upgrades, and more frequent maintenance of onsite wastewater systems
- May also include regulatory changes
- Targets excessive nutrients and bacteria

Pros	Cons
• Addresses watershed sources of nutrients and bacteria	• Improved systems may reduce septic loading but will not eliminate it • Generally requires large scale adoption have a measurable impact on in-lake water quality • Overall costs could be high, although these may vary by residence

Stormwater Improvements

- Can include retrofits, low impact development (LID), green infrastructure
- May also include regulatory changes
- Targets vary by feature but can include excessive nutrients, bacteria, and other pollutants

Pros	Cons
• Addresses watershed sources of a wide variety of pollutants • Can be designed to attenuate stormwater discharge volumes, which may help address flooding • Can be used to reduce impact of new development	• Maintenance costs tend to be high, which may lead to failure • Fewer choices in areas with shallow bedrock or high water • Requires large scale implementation and time to have measurable impact on water quality

Public Education and Outreach

- Wide variety of education and outreach actions – from informational kiosks to social media postings and workshops
- Primarily focuses on raising awareness of issues and benefits of behavioral changes
- Can include public participation, too

Pros	Cons
• Cost-effective • Allows community to stay informed • May lead to improvements in water quality or biological condition	• Improvements likely to be marginal and require time to be realized • Must be paired with other management activities to achieve substantial improvements

Monitoring

- A key part of every management program…
  - Detects problems
  - Allows for identification of trends
  - Tracks results
  - Needed for successful evolution and optimization of the management program
  - Can be sized to budget or scaled to needs



What's Next?

- Develop a lake and/or watershed management plan
  - Define goals
  - Fill in data gaps
  - Select prioritized management actions to advance
  - Set a timeline and budget for implementation
- Pursue funding and implement the plan
- Monitor progress and adjust/optimize plan over time

Examples of Funding and Technical Assistance

- MassDEP 604(b) Watershed Assessment Grants – assessment, planning, and concepts
- MassDEP 319 Non-Point Source Grants – design, permitting, and implementation
- MassDEP Monitoring Grants – for water quality monitoring programs by non-profits
- Community Preservation Act Funding – subject to rules of local CPC for open space & recreation projects but typically limited to acquisition and non-maintenance actions
- Southeast New England Program (SNEP) Network Technical Assistance – training and assistance for stormwater and watershed management, ecological restoration, and climate resilience
- SNEP Grants – funding for wide variety of projects
- Municipal Vulnerability Preparedness Action Grants – funding to address climate change impacts

Thank You.

Questions?

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