

Arcadia Lake & Metacomet Lake Watershed NPS Assessment Project

**Final Report
2012-03/604b**

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Prepared By Pioneer Valley Planning Commission

**For Massachusetts Department of Environmental
Protection Bureau of Water Resources**

and

U.S. Environmental Protection Agency, Region 1

**Arcadia Lake & Metacomet Lake
Watershed NPS Assessment Project**

**2012-03/604
2012 through 2015**

Prepared by: Pioneer Valley Planning Commission

Prepared for:

Massachusetts Department of Environmental Protection Bureau of Water Resources

and

U.S. Environmental Protection Agency, Region 1

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Executive Summary

Arcadia Lake (33 acres) and Metacomet Lake (52 acres) are part of a hydrologically connected chain of lakes, known as the Tri Lakes, in Belchertown, Massachusetts. (The third, much smaller lake, is known as "Holland Pond.") The lakes, which are publicly accessible, including the Town beach at Arcadia Lake and the boat ramp at Metacomet Lake, are used extensively for fishing, boating, and swimming.

Metacomet and Arcadia lakes continue to be shown on the Massachusetts Integrated List of Waters as

impaired, Category 5, waters requiring a TMDL. Impairments indicated at Metacomet Lake are for non-native aquatic plants and dissolved oxygen. Impairments at Arcadia Lake are for non-native aquatic plants and nutrient/eutrophication biological indicators. The non-native invasive aquatic plants impacting the lakes are Variable milfoil (*Myriophyllum heterophyllum*) and Fanwort (*Cabomba caroliniana*).



The work of this Section 604b funded grant yielded information about Arcadia and Metacomet Lakes to indicate that these are now relatively high quality waters in a watershed that has improved vastly over the past 10 to 15 years. Improvements have been possible thanks to MassDEP's Water Pollution Abatement Trust and more than \$6 million in additional investments from the Town for extension of sewer infrastructure to homes around the lakes. Watershed residents have also spearheaded efforts to manage aquatic weed growth and conduct annual clean ups around the lake through the Tri Lakes Watershed Association. More recently the Town has formed the Lakes Committee, led by municipal staff to ensure that lake activities are timely and well coordinated.

Key results from this Section 604b grant funded work show the following from water quality sampling, an aquatic vegetation survey, and preliminary stormwater BMP design recommendations.

Water quality sampling (July - September 2013)

- There were no localized nutrient loadings detected during the 2013 summer sampling season.
- Specific conductance has been used as an indicator for nutrient sources and results indicate that there are no hot spots of nutrient or salt pollution.
- Oxygen dynamics are normal for both lakes. Arcadia Lake waters remained highly oxygenated

throughout the sampling season; and Metacomet Lake waters undergo normal oxygen deprivation in the deep waters during thermal stratification.

- Plant management protocol does not appear to have affected the lakes' water chemistries.
- secchi depth measurements are in line with the oligo-mesotrophic classification of lakes.

Aquatic vegetation survey (July 2014)

- Previous herbicide applications have controlled the non-native species in both lakes (the most recent being Sonar in the summer of 2012).
- Herbicide activities have shifted the dominant members of the plant community in both lakes.
- Continued chemical management is not necessary in either lake this year; non-native species are not strongly dominant or impeding recreation in either lake.
- *Potamogeton bicupulatus* is or will be at nuisance levels in Arcadia Lake. Mechanical harvesting is recommended.
- A monitoring approach to non-native species management is recommended for both lakes; this should include triggers for chemical management.

Stormwater BMP recommendations (May 2015)

There are two locations along the lakes where there are direct stormwater runoff inputs from local roadways. At Metacomet Lake, a pipe at the boat ramp delivers flow from 3 catch basins along Poole Road. The heavily used boat ramp itself drains approximately 900 pounds of sediment from erosion each year into Metacomet Lake. At Arcadia Lake, Federal and Metacomet streets each have one catch basin that deliver flow into the lake. Sheet flow from Federal Street also travels directly from the roadway, down an embankment, and into Arcadia Lake.

Metacomet Lake stormwater BMP recommendations are to:

- Replace the 3 existing conventional catch basins on Poole Road with a deep sump catch basin with a hood, and connect to an infiltration catch basin
- Stabilize the pipe outlet with rip rap and stabilize the nearby bank abutting the pipe with bio-logs and vegetation
- Install GravelPave over 12 inches of crushed stone at the top of the boat ramp and a concrete plank with crushed stone surface at the lower, land-water interface of the boat ramp

Arcadia Lake stormwater BMP recommendations are to:

- Replace the 2 existing conventional catch basins on Federal and Metacomet streets with pre-cast deep sump catch basin with a hood, and connect to an infiltration catch basin
- Intercept direct run-off from the roadway to the lake with a bioswale

Introduction

Study area

Arcadia Lake (33 acres) and Metacomet Lake (52 acres) are part of a hydrologically connected chain of lakes, known as the Tri Lakes, in Belchertown, Massachusetts. The lakes, which are publicly accessible, including a Town beach at Arcadia Lake and a state-owned boat launch at Metacomet Lake, are used extensively for fishing, boating, and swimming.

Waters in this system begin in Holland Pond, the third lake in "Tri Lakes," which delivers flow from the north to Arcadia Lake through a culvert under Channel Drive. Arcadia Lake also receives flow from a stream that drains the slopes of an area known as Holland Glen and then moves through a wetland before entering the lake. Arcadia Lake outlets on the southeast side through a series of culverts that pass and then return underneath the railroad tracks. These waters move through a large wetland before entering the east side of Metacomet Lake. Waters from Metacomet Lake discharge into Bachelor Brook, a Class B warm water stream, which travels approximately 14 miles before joining the Connecticut River.

The lakes themselves are not designated in 314 CMR 4.06 or listed in the tables to 314 CMR 4.00, and are thus presumed to be Class B waters, designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. Also, they are not designated in the regulations as cold water fisheries, and thus considered warm water fisheries.

Arcadia and Metacomet Lakes are listed as Category 5 waters for non native aquatic plants on the Year 2014 Integrated List of Waters. (Holland Pond, is listed as a Category 4c water for non native aquatic plants.) Arcadia Lake is also listed for nutrient/eutrophication biological indicators and Metacomet Lake is also listed for dissolved oxygen. The non-native invasive aquatic plants impacting the lakes are Variable milfoil (*Myriophyllum heterophyllum*) and Fanwort (*Cabomba caroliniana*).

The watershed for the lakes is relatively small, encompassing 1.8 square miles, and much of the land draining to the lakes from the lower reaches of the watershed involves roadways, including Route 9, and areas of dense to moderate residential development. Early on, the source of the problem at the lakes was identified as excess loading of phosphorous from *septic leachate*, 62% at Arcadia and 64% at Metacomet, and from *surrounding land uses*, 20% at Arcadia and 28% at Metacomet. (Lycott 1985 D/F Study)

Addressing the issue of septic leachate ultimately came with implementation of the Tri Lakes Sewer Extension Project in 2003-2007. This project demonstrated important commitments: an agreement among residents to the formation of a Betterment District, funding from DEP's Water Pollution Abatement Trust, and \$6 million in additional investments from the Town.

Watershed residents have also spearheaded efforts to manage aquatic weed growth and conduct annual clean ups around the lake through the Tri Lakes Watershed Association (established in 1988). Weed management has involved several methods, including herbicide applications and the use of benthic barriers in some locations. Though some of this work has proven effective, good long term control has not been achieved to date given the difficulties for a wholly volunteer organization to be persistent and consistent in this work.

In 2011, the Town of Belchertown stepped forward to take a more active role in working with residents to ensure more regular management of the invasive aquatic weed problem, as well as promote additional restoration activities. They established the Lakes Committee, which is staffed by municipal officials in combination with Tri Lakes Watershed Association members.

While there had been some important strides toward improving water quality, very little had been done to understand and address nonpoint pollution sources in the surrounding watershed. Nonpoint sources,

though not studied, had been cited as a source of problems in several past reports. In addition, water quality monitoring results available from the summer of 2010, suggested that nonpoint sources of phosphorous remained a problem.¹ Though the sampling done in 2010 was not designed to coincide with wet weather events, it appeared that based on a check of weather records, all of the sampling occurred during weather that qualified as wet (>0.1 inches of rain within the previous 24 hours).

Project goals and strategies

Through this 604b funded project, the Pioneer Valley Planning Commission originally aimed to identify and assess nonpoint pollution sources to Arcadia and Metacomet Lakes and assist watershed residents and Town officials in the development and implementation of a stormwater management project to address problem areas. PVPC, with input from the Town and approval from MassDEP, adjusted objectives part way through the project, however, because water quality sampling results from 3 dry and 3 wet events indicated no nonpoint source problems in the two lakes. So rather than address specific nonpoint source problems and locations, the project shifted to focus on strategies to help preserve the health of the lakes. Strategies listed below are organized to show those that were part of the project's first phase versus the second phase of the project with the revised focus.

First phase:

1. Conduct shoreline surveys of each of the two lakes to identify and map potential sources of pollution;
2. Identify water quality monitoring locations;
3. Conduct water quality sampling
4. Analyze water quality results to determine which subwatersheds deliver the greatest pollutant loads to the lakes;

Second phase:

1. Develop preliminary Green Infrastructure/Low Impact Development BMP design and cost estimates for nonpoint source control at two high priority locations
2. Conduct aquatic macrophyte survey and develop integrated plant management protocol for implementation;
3. Enhance education and outreach with 2 to 3 meetings with watershed residents, including an educational event on best management practices for residential properties, as well as a targeted mailing to those property owners still on septic identifying resources available to connect to sewer lines;

Project partners

For this project, the Pioneer Valley Planning Commission (PVPC) partnered with the Town of Belchertown Lakes Committee, composed of town officials and members from the Tri Lakes Watershed Association. The Tri Lakes Watershed Association, an association of residents who live around the lakes, worked with the Lakes Committee and PVPC to host several meetings and a large event to advance education and outreach objectives.

The project received matching funds from the Town of Belchertown in the form of in-kind staff time, use of facilities, and mailing costs for the letter that went to the 97 property owners around the lakes who are still on septic systems. Some members of the Lakes Committee and Lakes Association generously volunteered their time to help with running water quality samples to the analytical laboratory in Agawam and hosting the lakes event at the Town Beach in May of 2014.

¹ This water quality monitoring study was undertaken by volunteers with the help of Fuss & O'Neill and is the only such known effort within the community. Samples were collected at two locations in each of the lakes once a month, between May 27 and September 28, 2010.

Final products

There are six final products for this project. All are included in the Appendixes of this report.

- A. Shoreline survey data sheets with accompanying maps
- B. MassDEP and EPA approved Quality Assurance Project Plan for water quality monitoring, including water quality monitoring locations with GPS coordinates
- C. Water quality sampling report on results, analysis, and recommendations
- D. Aquatic macrophyte survey report and recommendations with QAPP
- E. Report on preliminary design and costs for stormwater BMP facilities at 2 priority locations
- F. Materials from public education and outreach (technology transfer)

Project Approach

This project entailed various strategies aimed in the first phase to evaluate water quality in Arcadia and Metacomet Lakes. When the results from water quality sampling showed no indication of nonpoint source problems in the two lakes, the approach shifted to focus on strategies to help the Town and Tri Lakes Association in preserving the health of the lakes. The elements below describe the approach within each of the project's major components: water quality sampling; aquatic macrophyte survey; preliminary BMP design; and education and outreach (technology transfer).

Water quality sampling

Site selection

Sampling locations were identified based on a pre-project field survey of the lakes area with the DPW director, shoreline surveys performed during the fall of 2012, and recommendations from DEP staff to add deep pool locations. Sampling locations were also discussed with the Conservation Agent and members of the Tri Lakes Association at an April 2013 meeting. There were a total of 10 sampling locations selected:

- 8 “near-shore” sites targeted contributing subwatersheds, providing an opportunity to understand land use patterns affecting water quality on a subwatershed basis. These sampling sites were all in-lake locations that sought to identify where the lakes may be receiving contaminated flows from the following: an upgradient lake or wetland (5 sites), stormwater pipes (2 sites), pipes of unknown origin (1 site). This approach also provided a strategy for later follow-up with locational source tracking of pollutants if identified. The water in these locations is at least 1 foot deep.
- 2 additional sites were located in the deep pool locations of each lake and were selected to ascertain whether there is internal loading of phosphorous from lake sediment.

Purpose

The water quality sampling work of this project sought to do the following:

- Produce data of known and documented quality, in support of state monitoring programs, and municipal infrastructure improvements as appropriate
- Describe the degree to which non point sources are contributing to water quality problems on the lakes
- Identify subwatersheds delivering the greatest phosphorous loads to the lakes
- Describe whether dissolved oxygen may be low enough to impact internal loading from sediment within the lakes

Study design

PVPC staff collected grab samples for *E. coli* and Total Phosphorous from eight near-shore locations during three wet weather and three dry weather events. Dry weather was considered <0.1” of rain within the previous 24 hours. Five of these near-shore sites were located on Arcadia Lake and three of these sites were located on Metacomet Lake. Water temperature, dissolved oxygen, and conductivity were measured in the field using a YSI Professional Plus meter. In addition, air temperature was collected in the field with a thermometer. Observations at each sampling site was recorded on a field data sheet

Sampling Events - 2013

Tuesday, July 9 - dry
Thursday, July 11 - wet
Wednesday, July 31 - dry
Monday, August 5 - dry
Tuesday, August 27 - wet
Tuesday, September 9 - wet

and included odor, water color, signs of wildlife, and any other noteworthy observations during the time of sampling.

At two deep pool locations, PVPC collected epilimnetic grab samples for Total Phosphorous and took readings for dissolved oxygen and water temperature in a depth profile of 1 meter increments with the last reading being .5 meters from the bottom. Transparency was measured in these locations using a secchi disk. Sampling occurred at the same time of day so that dissolved oxygen measurements were comparable.

Because dissolved oxygen readings were so low in the deep hole on Metacomet Lake (Site id: ML-3) during the first sampling event, PVPC collected hypolimnetic phosphorous samples at this location on all subsequent sampling dates. Except for the ML1 site at Lake Metacomet, where the sample was collected from the shore, all other samples were collected from a kayak.

PVPC staff began each event by collecting samples first at Metacomet Lake and then handing off all of those samples on ice to a volunteer from the Tri Lakes Association who then transported samples to Spectrum Analytical, Inc. located at 11 Almgren Drive, Agawam, MA. PVPC staff then proceeded to Arcadia Lake, collected samples, and delivered samples on ice directly to Spectrum Analytical in Agawam. Metacomet Lake samples were delivered by volunteer due to the desire to stay well within the 6 hour holding time for the *E. coli* samples.

Note that because media for the 1604 *E. coli* analytical method was not available following the first sampling event, the QAPP was adjusted for use of analytical method 1603 by the laboratory.

See maps of sampling locations on following pages.

MassDEP water quality standards provided comparative values for three of the parameters analyzed in this study: *E. coli*, water temperature, and dissolved oxygen. For total phosphorous, conductivity, and transparency, EPA guidance was used as there are no regulated standards for Massachusetts surface waters.

Aquatic macrophyte survey

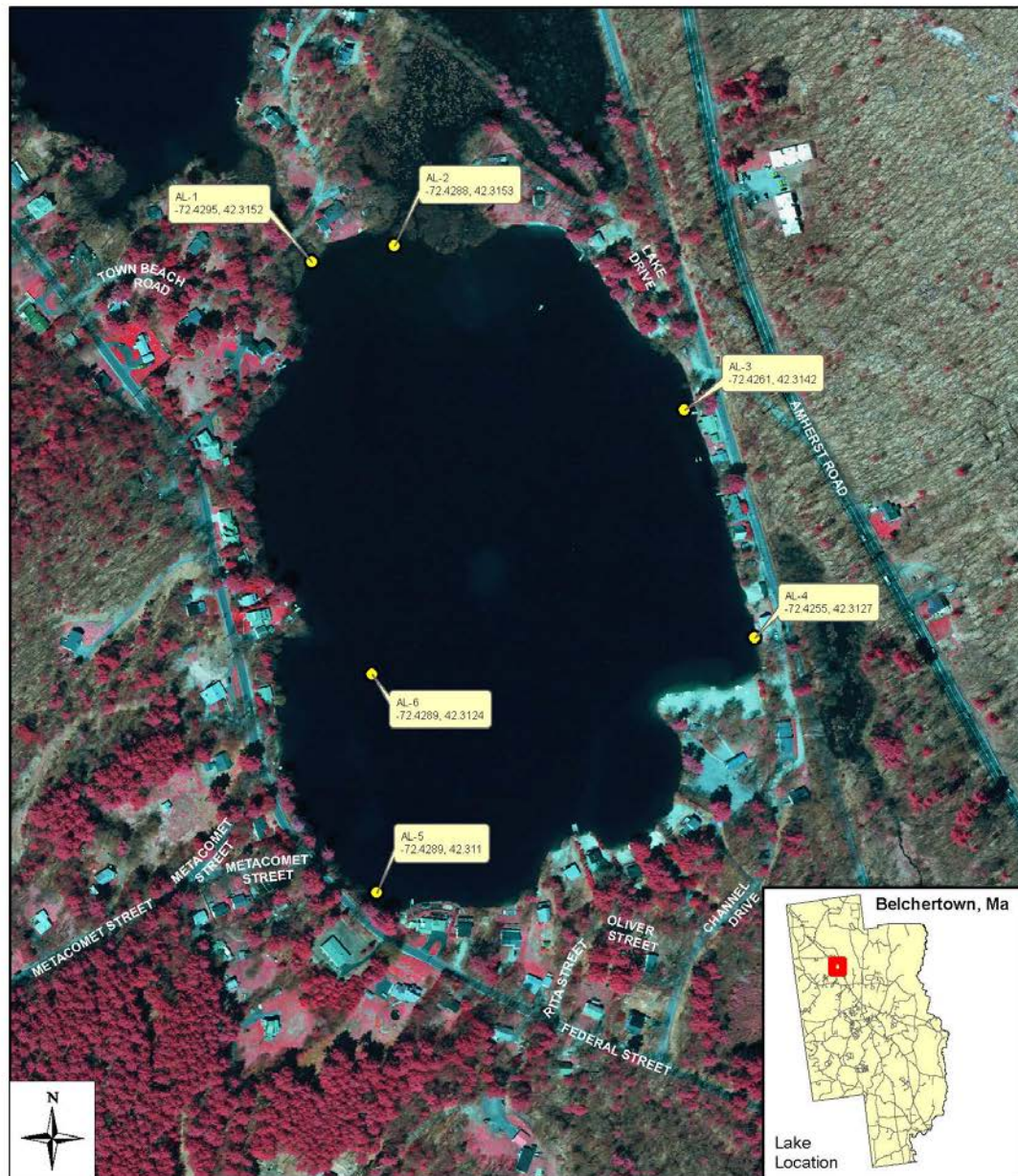
For the aquatic macrophyte survey, PVPC continued to work with limnologist Mark June Wells of New England Environmental, Inc. Mr. Wells was hired originally through a quote solicitation process of four firms to review water quality data and determine whether water chemistry might have any connection with herbicide treatment over the summer of 2012. See description of this work in "Results" section.

Mr. Wells conducted the plant survey on Arcadia and Metacomet Lakes during July of 2014.

Purpose

The water quality analysis work identified a gap in understanding the effectiveness of plant control measures to manage populations of *Cabomba caroliniana* and *Myriophyllum heterophyllum*. This gap -- the lack of contemporary plant data for Arcadia and Metacomet lakes -- made the assessment of plant control measures difficult. The main purpose of the survey was to fill the knowledge gap about the composition of the plant community within the two lakes and to make recommendations going forward.

Arcadia Lake Water Quality Monitoring Locations



● Water Quality Locations

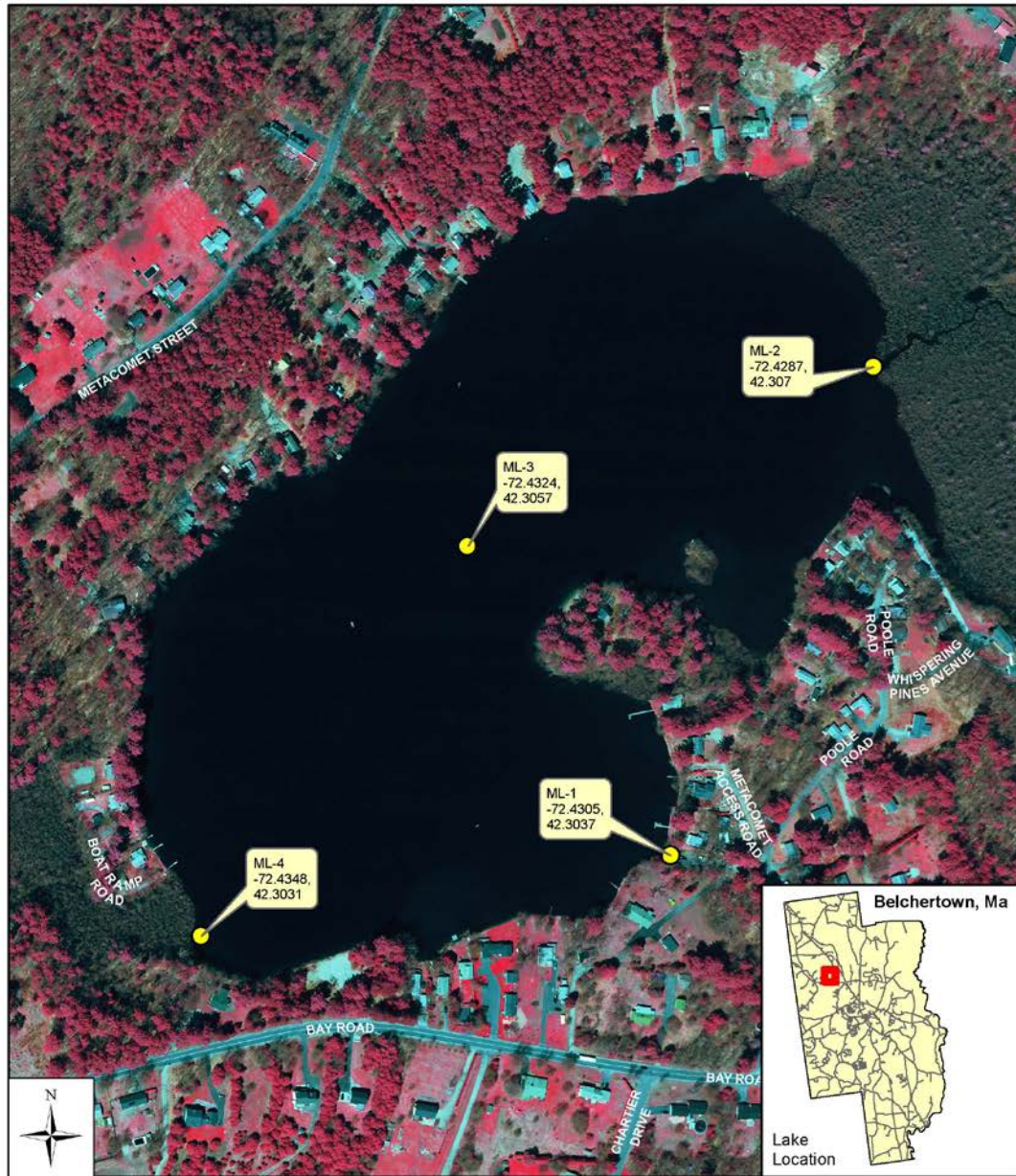
0 250 500 Feet



Pioneer Valley Planning Commission

Map Prepared: 4/11/13

Metacomet Lake Water Quality Monitoring Locations



● Metacomet Water Quality Monitoring

0 250 500 Feet

pvp Pioneer Valley Planning Commission

Map Prepared: 4/22/2013

The quantitative plant assessment sought to provide the following information:

1. Inventory of all aquatic plant species in Arcadia and Metacomet Lakes.
2. Determine the relative abundances of each species in the lakes.
3. Model the distribution of each species as they relate to depth, light, and
4. sediment type.
5. Determine the distribution of non-native plant species in the lakes.
6. Map the distribution of non-native plant species.
7. From those data, make recommendations on plant control and peat mat removal.

Study design

Mr. Wells used a random block design for the study, which is well documented in contemporary ecological literature and is well suited for characterizing the structures of aquatic plant communities. Furthermore, this type of design affords the data analyst the ability to mathematically characterize the plant community with a 95-99% species detection rate.

The basic structure of this technique, as it applies to Arcadia and Metacomet Lakes, involved establishing 20 geo-referenced points from 0.1 – 4m. At each point, the plant community was sampled using a grapple tied to a 20m line; four grapple samples were taken at each point. The plant species collected were given rank abundances by two independent observers. The ranks were as follows:

- 1= rare
- 2 = present but not abundant
- 3 = abundant but not dominant
- 4 = dominant
- 5 = dense monoculture

Using these data, community metrics were established (i.e. species relative abundances, diversity, and richness) as they apply to depth. Finally, a full littoral zone survey was conducted by slowly motoring around the entire perimeter of the lake. Species were identified visually after collection with a long handled rake or grapple. This portion of the protocol was used to create a vegetation map, which indicates the relative locations of all species throughout the water body.

The Quality Assurance Project Plan for the plant assessment was inadvertently not sent to MassDEP until after completion of the survey. The aquatic plant survey followed all measures established in the QAPP. (This QAPP is in the Appendixes and follows the report for the plant survey under a New England Environmental, Inc. memo dated August 26, 2014.)

Preliminary BMP design

Purpose

As part of the shoreline survey work conducted at the start of the project under the water quality work above, it was noted that stormwater moves directly from roadways into the lakes at two locations:

- a pipe at the Metacomet Lake boat ramp, draining Poole Road; and
- direct runoff from Federal Street along Arcadia Lake's southwestern shore

When the focus of the project shifted to maintaining lake health, these two sites became priority locations for preliminary BMP design.

Approach

PVPC solicited quotes from 10 engineering firms and used project funding to hire Polaris Consultants, LLC, who teamed up with the Massachusetts Watershed Coalition, and Deborah Shriver Consulting. The Polaris team visited the site on several occasions, including a visit on May 1, 2015 with the Town Conservation Agent, Town Engineer, and PVPC staff.

Analysis entailed a review of existing information on existing drainage, soils, flood zones, wetlands, great pond status, and groundwater. Consultants also reviewed available right of way and other property available for the installation of stormwater Best Management Practices. They developed a summary of BMPs to reduce nutrient and sediment loading into the lakes (shown on page 9 of their final report) and talked with town officials about preferred options.



When it rains, storm flow from Federal Street drains directly into Arcadia Lake.

A final report took the form of a Technical Memorandum, evaluating each site in terms of available space, soils (Hinckley loamy sand), potential nutrient reduction, cost and other factors (i.e. depth to groundwater, permitting, flood zones). In this Memorandum (included in the Appendixes) the Polaris team also provides preliminary designs, model pollutant reduction achieved by each BMP facility, and cost estimates for facilities at each of these locations.

Education and outreach (technology transfer)

Approach

Project work, particularly water quality monitoring and vegetation survey, provided an excellent way to engage property owners around the lakes. This population, particularly those actively involved with the Tri Lakes Watershed Association, has a high level of concern about the lakes and are interested in what they might do to help improve and protect water quality. Volunteers helped with transport of water quality samples. They also advised PVPC on the most effective approach to promoting best management practices with their neighbors: a major public outreach event at the Town Beach. PVPC worked with the Belchertown Lakes Committee and Tri Lakes Watershed Association to host a total of five meetings and events for this project.

Education and outreach work also targeted those still on septic with a mailing from the DPW Director to 97 property owners around the lakes. For this mailing, PVPC identified resources currently available for low interest loans, grants, etc. The letter emphasized the success of sewerage in reducing lake pollution and the need to eliminate all septic systems to preserve water quality over the long term.

A full list of education and outreach activities is shown in the following "Results" section.

Results

Water quality sampling

Water quality results showed the lakes to be in good health with inordinately low TP and *E. coli* levels observed. As such, Mark Mattson at MassDEP recommended a lab audit to determine if the reported TP and *E. coli* levels were correct or due to measurement error. Conducted on October 17, 2013, the lab audit did not reveal any problems with analytical results that were within 10% agreement.

As a next step, PVPC hired limnologist Mark June Wells of New England Environmental, Inc. (NEE) to more expertly evaluate water quality data, including the low DO readings at the deep hole location on Metacomet Lake, and prepare and deliver a report that analyzes the nature of results and potential causes, describes major findings, and makes recommendations for further investigation if needed.

Mr. Wells was tasked specifically to:

- Review and analyze all data from 2013 monitoring season and refer to data from 2010 and 2003 studies as well as other information that can help inform analysis, including history of herbicide treatments.
- Prepare and deliver report that analyzes the nature of results and potential causes, describes major findings, and makes recommendations for further investigation if needed.

Following is a summary of the results on the sampling parameters. See the full report in the Appendixes.

E. coli

E. coli is used as an indicator organism because it is easily cultured, and its presence in water in certain amounts indicates the possible presence of sewage. If sewage is present in water, pathogenic or disease-causing organisms may also be present.

All eight of the near shore sampling sites were monitored for *E. coli* (Table 1). None had *E. coli* values in excess of primary contact standards (235 MPN/100 mls on a single sample). The number of colonies also did not differ significantly during dry and wet events. The NEE report concludes, "Overall, *E. coli* concentrations were statistically uniform; both temporally and spatially suggesting that anthropogenic loadings have been mitigated. Finally, the concentrations of *E. coli* in either lake were not at levels that violated standards for recreational waters."

Table 1: *E. coli* Results (in colonies per 100 ml)

Metacomet Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
ML-1	2	4	4	10	44	10
ML-2	14	<2	8	<2	6	18
ML-4	10	<2	10	6	6	14

Arcadia Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
AL-1	14	16	8	8	<2	2
AL-2	16	28	10	4	<2	10
AL-3	2	<2	<2	<2	<2	30
AL-4	16	2	10	<2	<2	4
AL-5	8	30	8	34	<2	4

Total Phosphorus

The values for Total Phosphorous (TP) may be compared to the “Ambient Water Quality Criteria Recommendations” prepared by the U.S. Environmental Protection Agency for lakes: the 25th percentile value is considered the background concentration because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility. For Total phosphorous the 25th percentile is 8 (ug/L) and the range is 8 to 20 (ug/L). Otherwise, there is no numeric standard for phosphorous unless a TMDL is implemented relative to an identified impairment. 8 to 20 (ug/L) = .008 to .02 milligrams per liter.

Phosphorus like nitrogen is an essential nutrient for plant growth. The accelerated input of these two nutrients into aquatic ecosystems due to human activity is the primary cause of most algal bloom problems.

TP results from the first sampling event on 7/9/13 are not shown as they were considered invalid due to improper procedure in the field. Otherwise, TP did not differ significantly between wet and dry conditions in either lake (Table 2). The NEE report concludes,

Overall, phosphorous dynamics were found to be stable over the temporal and spatial scaled during the study. Wet weather did not lead to an increase in aqueous phosphorous in these lakes and there were no spatial asymmetries among sampling points. Furthermore, there was not significant release of phosphorous from sediments during thermal stratification. Metacomet and Arcadia lakes exhibited phosphorous means of 14 ug/L and 7ug/L, respectively. These levels of phosphorus suggest that these lakes are oligotrophic by most standards.

Table 2: Total Phosphorous Results (in mg/l)

Metacomet Lake						
	7/9/2013 DRY*	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
ML-1		0.0137	<.005	0.0181	0.01	0.0082
ML-2		0.0106	0.0085	0.0143	0.0104	0.007
ML-3 epi		0.0118	0.0088	0.0141	0.0101	0.0054
ML-3 hyp		0.0575	0.0096	0.0394	0.0326	0.0211
ML-4		0.0115	0.0083	0.0156	0.0102	0.009
Arcadia Lake						
	7/9/2013 DRY*	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
AL-1		0.0099	0.007	0.0111	0.0102	<.005
AL-2		0.0069	0.0066	0.0055	0.0106	<.005
AL-3		0.0094	0.0061	0.0073	0.0098	<.005

AL-4		0.0099	0.0118	<.005	0.0087	<.005
AL-5		0.0091	0.0089	0.0085	0.0086	<.005
AL-6		0.0078	0.0078	0.0065	0.0055	<.005

* QC problem; TP results not valid.

Dissolved oxygen

The presence of dissolved oxygen is vital to bottom dwelling organisms as well as fish and amphibians. Aquatic plants and algae produce oxygen in the water during the day, but consume oxygen during the night. Class B Massachusetts Surface Water Quality Standards indicate that dissolved oxygen concentration shall not be less than 5.0 mg/L in warm water fisheries, such as the lakes. The NEE report concludes the following about the dissolved oxygen data (Table 3):

Overall, results suggest that wet and dry weather conditions are not affecting the oxygen conditions of either lake. Furthermore, the depravation of oxygen from the hypolimnion in Metacomet Lake under thermally stratified conditions is a normal phenomenon that is driven by inhibited mixing of the water column and sediment microbial activities. Arcadia Lake is not deep enough to develop a thermally stratified condition thereby resulting in uniform oxygen conditions throughout the depth gradient of the lake. Finally, no spatial differences in oxygen concentration were detected for either lake, suggesting that there are no “hotspots” of microbial activity.

Table 3: Dissolved Oxygen Results (in mg/l)

Metacomet Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
ML-1	5.98	5.998	7.91	8.02	7.42	7.1825
ML-2	6.13	6.67	8.08	7.795	7.82	7.57
ML-3						
surface	6.57	6.55	8.5	8.25	7.78	7.45
1 meter	6.37	6.36	8.4	7.81	7.84	7.25
2 meter	1.52	2.16	8.22	6.97	7.17	6.34
3 meter	0.16	0.06	0.3	0.23	0.91	0.33
4 meter	0.5	0.05	0.07	0.06	0.06	0.06
ML-4	4.92	26.63*	8.92	8.82	7.76	

Arcadia Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
AL-1	6.4925	7.29	7.09	7.67	7.51	7.24
AL-2	6.15	7.33	7.1675	7.46	7.83	6.88
AL-3	6.31	7.36	7.31	7.495	7.84	7.43
AL-4	6.5	7.38	7.28	7.69	7.99	7.43
AL-5	5.78	7.04	7.28	7.46	7.94	7.47
AL-6						
surface	6.57	7.07	7.06	7.39	7.86	7.26
1 meter	6.36	6.95	7.32	7.47	7.78	7.38
2 meter	6.57	6.03	7.21	7.57	7.58	7.13
2.5 meter	7.4	6.17	-	-	7.78	-

* Result not valid.

Water temperature

Water temperature is a critical parameter for aquatic life and has an impact on other water quality parameters such as dissolved oxygen concentrations and the activity of bacteria in water. Water temperature controls the metabolic and reproductive processes of aquatic species and can determine which fish and macroinvertebrate species can survive. A number of factors can have an impact on water temperature, including the quantity and maturity of riparian vegetation along the shoreline, the rate of flow, percent of impervious surfaces contributing stormwater, thermal discharges, impoundments and the influence of groundwater.

Class B Massachusetts Water Quality Standards: Temperature shall not exceed 28.3 degrees celsius (83 degrees fahrenheit) in warm water fisheries. Water temperature exceeded this standard at both Metacomet and Arcadia lakes on a few occasions.

Temperature results show the decay of the thermal difference between top and bottom waters (Table 4). This indicates both that the lakes do not have enough depth to thwart the effects of solar energy over long periods of time and that the energy required to mix the epilimnion and hypolimnion was not achieved during the 2013 summer season, contributing to deep water oxygen depletion specifically in Metacomet Lake.

Table 4 Water Temperature Results (in degrees Celsius)

Metacomet Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
ML-1	28.2	27.3	26.6	23.6	24.53	25.2
ML-2	28.73	27.7	27.4	24.5	25.1	25.8
ML-3						
surface	28.7	27.7	27	24.7	25.1	25.6
1 meter	28.7	27.6	26.2	24.5	25	25.3
2 meter	25.4	25.6	25.1	24.1	24.6	24.8
3 meter	17.4	18.3	20.6	21.2	22.1	21.7
4 meter	14.1	14.4	15.1	15.3	19.9	17.6
ML-4	28.7	27.875	28.5	25.2	25.1	25.9

Arcadia Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
AL-1	29	28.35	29.08	26.68	25.98	25.95
AL-2	29.08	28.33	29.275	26.75	25.85	25.9
AL-3	29.1	28.6	28.9	25.98	26	25.8
AL-4	29.13	28.6	29.03	26.4	26.2	25.9
AL-5	29.1	28.68	28.5	26.1	25.9	25.9
AL-6						
surface	29.1	28.3	28.7	26.1	25.7	25.7
1 meter	29.1	28.1	27.1	25.7	25.4	25.4
2 meter	26.7	27	26.5	25.5	25.2	25.3
3 meter	24.3	23.9	-	-	25.2	

Specific Conductance

Specific conductance is a general measure of surface water health. It can be related to geology, but high specific conductance values may indicate pollution from sources such as road salting, septic systems, wastewater, or urban/agricultural runoff. The only standards for specific conductance seem to be for rivers. Specific conductance is measured in micromhos per centimeter or microsiemens per centimeter (abbreviated as $\mu\text{mhos/cm}$ or $\mu\text{s/cm}$, respectively). According to EPA, freshwaters within the range of 150 to 500 $\mu\text{mhos/cm}$ indicate a stream that is supporting good mixed fisheries. Conductivity outside this range could indicate water not suitable for certain species of fish or macroinvertebrates.

For this study, specific conductance was used as an indicator for nutrient sources and road salts. Results suggest that there are no hot spots of nutrient or salt pollution and that the electrical conductivity of these waters is stable (Table 5).

Table 5: Specific Conductance (in $\mu\text{mhos/cm}$)

Metacomet Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
ML-1	80.4	80.7	85.38	85.1	86.08	86.625
ML-2	80	80.93	85.98	86.275	86.6	86.8
ML-3						
surface						
1 meter						
2 meter						
3 meter						
4 meter						
ML-4	80.2	79.925	84.43	84.95	86.2	85.73

Arcadia Lake						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
AL-1	64.65	64.7	66.08	65.73	64.5	63.9
AL-2	64.48	64.6	66.325	65.53	64.45	63.85
AL-3	63.7	64.63	66.13	65.6	64.4	64
AL-4	63.6	64.7	66.03	65.6	64.43	64.1
AL-5	64.28	64.6	66.08	65.23	64.5	64.1
AL-6						
surface						
1 meter						
2 meter						
3 meter						

Secchi Disc Transparency

Transparency is an integrated measure of light scattering and absorption. It measures water clarity and is affected by a number of factors, including: amount of dissolved and suspended solids, phytoplankton populations, and weather conditions. There are no numeric standards for transparency. However, transparency is related to solids and turbidity, of which there are narrative standards

Solids: Waters shall be free from floating, suspended, and settleable solids in concentrations and combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

Color and Turbidity: Waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.

Secchi disc transparency readings were taken at the deep pool locations at each Metacomet and Arcadia lakes. NEE observes that results suggest that water clarity increases throughout the summer season, which is an opposite pattern compared to many other lakes and nutrient sources that are normally related to wet weather conditions were not of a nature that diminished water clarity. Finally, these secchi depth measurements are in line with the oligo-mesotrophic classification of lakes (Table 6).

Table 6: Secchi Disc Transparency (in centimeters)

Metacomet Lake - at deep pool location ML3						
	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
Depth Measured (meters)	4.5	4.5	4.5	4.5	4.25	4.5
1st secchi reading (meters)	1.5	1.87	2	2	2.625	2.625
2nd secchi reading (meters)	1.75	2	1.5	2.25	2.625	2.875
Arcadia Lake - at deep pool location AL6						

	7/9/2013 DRY	7/11/2013 WET	7/31/2013 DRY	8/5/2013 DRY	8/27/13 WET	9/3/13 WET
Depth Measured (meters)	3	2.75	2.75	2.75	2.75	2.75
1st secchi reading (meters)	2.5	2.5	2.75	2.75	2.75	2.75
2nd secchi reading (meters)	2.25	2.625	2.5	2.75	2.75	2.75

Herbicide Effects on Water Chemistry

While the water quality sampling was not designed for understanding possible impacts from the 2012 herbicide treatments on water chemistry, NEE was asked to compare water quality data from 2013 and 2011 and report on any apparent impacts. They concluded that the plant management using fluridone to control *M. heterophyllum* and *C. caroliniana* did not affect measured water quality variables appreciably.

As part of their report they comment on the need to revise the approach to manage nuisance aquatic plants without harming the lake system. NEE writes,

The first issue to be noted regarding plant communities is that all species (native or non-native) serve important functions to the health of a system (i.e. nutrient cycling and oxygen production). Secondly, eradication of non-native plants in aquatic systems is an impossibility or, at maximum, highly unlikely. Therefore, integrated plant management techniques using species environmental relationships to favor native species in areas where conditions are suitable is a more responsible approach. This approach requires a complete understanding of the environmental relationships of species in the system, including a full inventory of species and their relative abundances. A plan developed with these ideas in mind is an approach that can conserve the health of the lake systems over the long term these resources are available to future generations.

Aquatic macrophyte survey

A team from New England Environmental headed by Mark June Wells surveyed Arcadia and Metacomet Lakes On July 12 and 19, 2014. Each survey incorporated a full littoral zone inspection and the assessment of 20 georeferenced points ranging in depth from 0.1 – 4m. The results obtained from these surveys were used to develop littoral zone vegetation maps and to describe the mathematical properties of the plant communities. These findings can be used in the decision making processes associated with future plant control initiatives and the holistic management of these lake systems.

Arcadia Lake:

The survey of Arcadia Lake identified 17 aquatic macrophyte species, including two invasive species; namely, *Cabomba caroliniana* and *Myriophyllum heterophyllum*. The invasive *M. heterophyllum* was distributed in moderate abundance throughout Lake Arcadia. It was present in greatest abundance along the southern and western shorelines of the lake. This species was also present on the fringes of the northern population of *N. odorata*. The other invasive species *C. caroliniana* was present in small patches along the northwestern edge of Lake Arcadia.

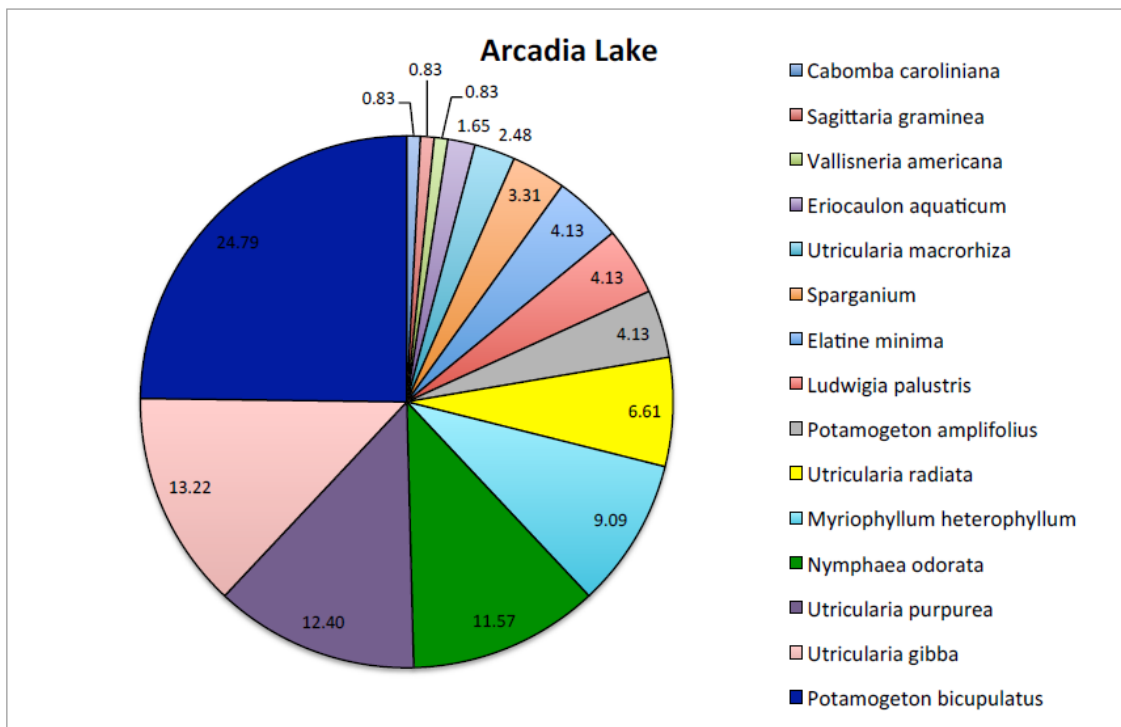
The most abundant plant species found during the survey was *Potamogeton bicupulatus*. It represented 24.79% of the plant community.

Utricularia gibba and *Utricularia purpurea* were the secondary and tertiary contributors to the aquatic plant community, respectively.

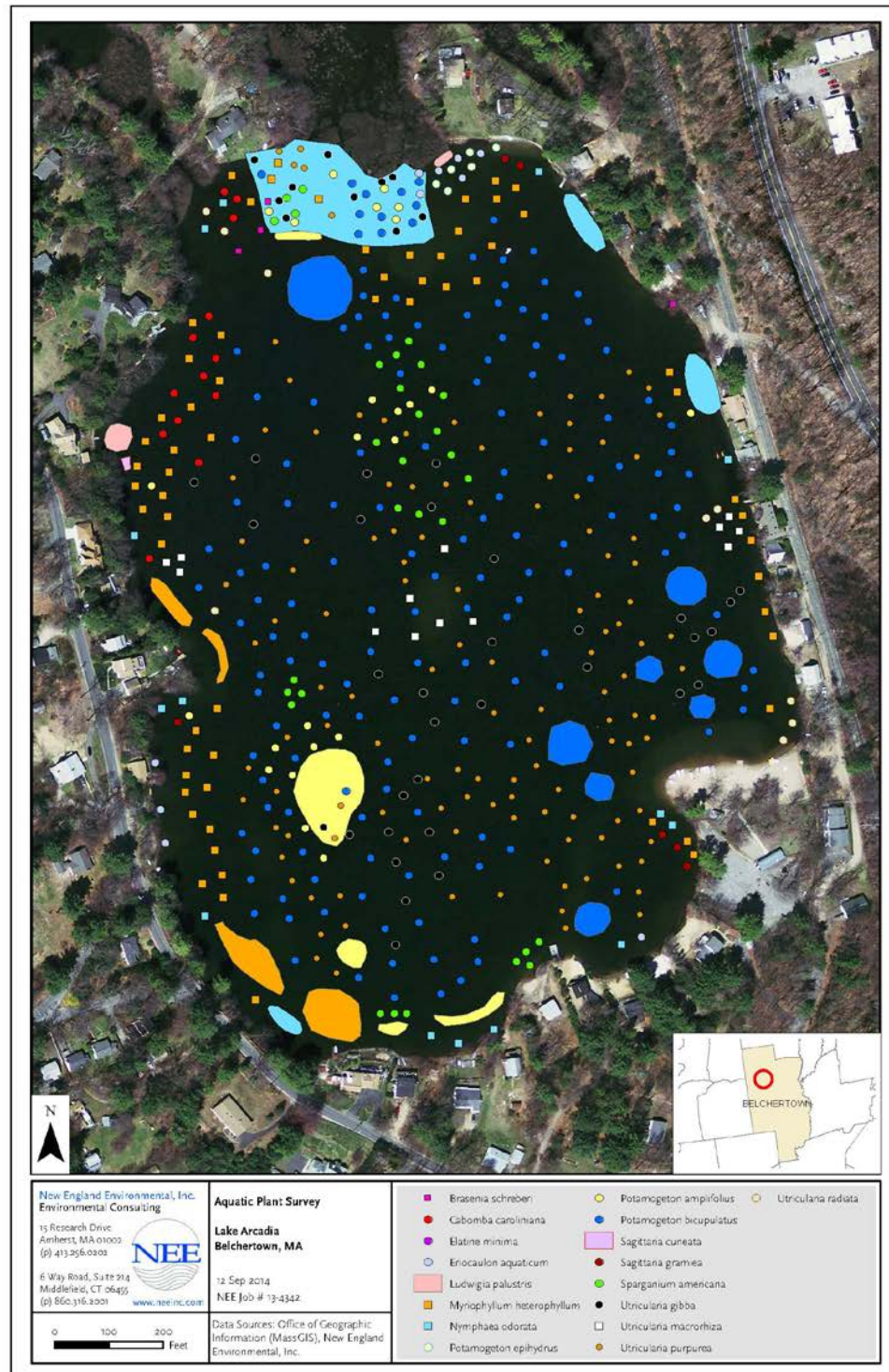
The fourth most prevalent species in Lake Arcadia was the lily species *Nymphaea odorata*.

In the survey report, NEE notes that along the northern edge of Lake Arcadia there were a few peat mats, which may require removal. (For more on this, see "Aquatic macrophyte survey" in Conclusions and Lessons Learned section below.)

Plant Community Composition in Arcadia Lake



Map of Arcadia Lake Plant Community



Metacomet Lake:

The survey of Metacomet Lake identified 15 aquatic macrophyte species including two invasive species: *Myriophyllum heterophyllum* and *Cabomba caroliniana*. The invasive *C. caroliniana* was distributed around the entirety of lake in small to medium sized patches. It is most prevalent along the southern and southwestern shore line to a depth of about 2.5m. *M. heterophyllum* was diffusely distributed throughout the littoral zone, principally along the northwestern shoreline of the lake and, to a lesser extent, along the southeastern edge of Metacomet Lake.

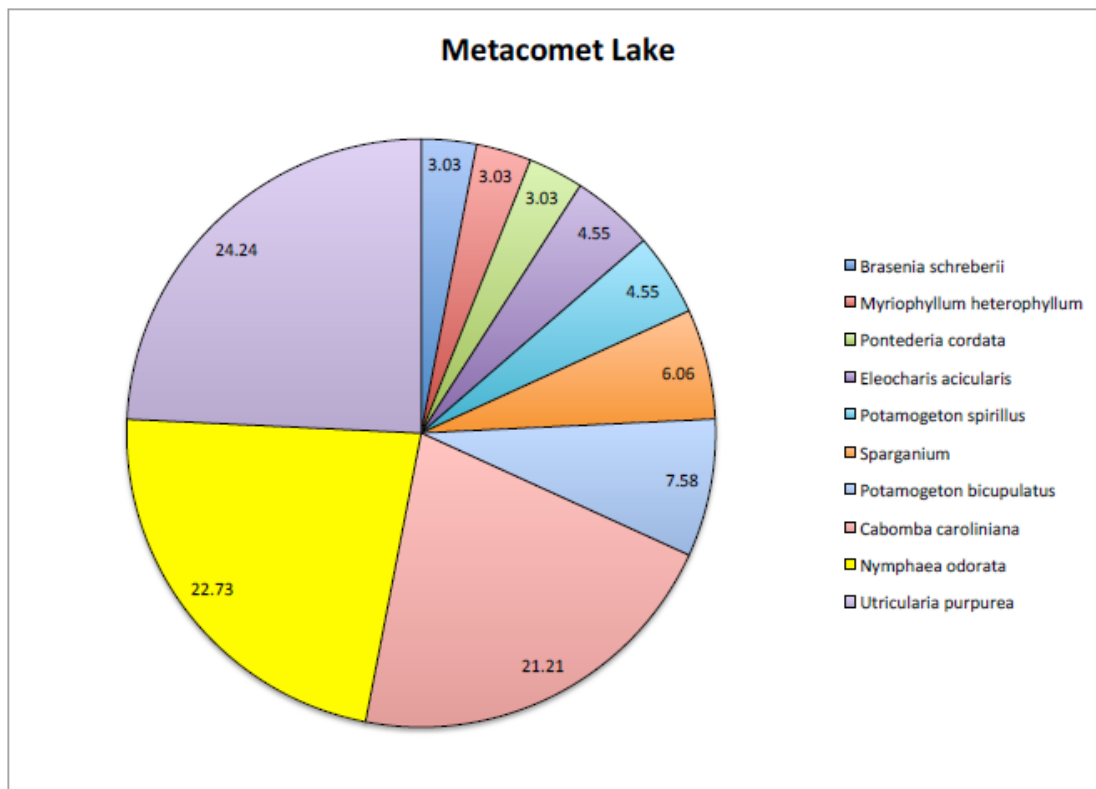
The most abundant species in Lake Metacomet was *Utricularia purpurea*. It represented 24.24% of the plant community.

The secondary and tertiary species contributing to the plant community were *Nymphaea odorata* and *C. caroliniana*.

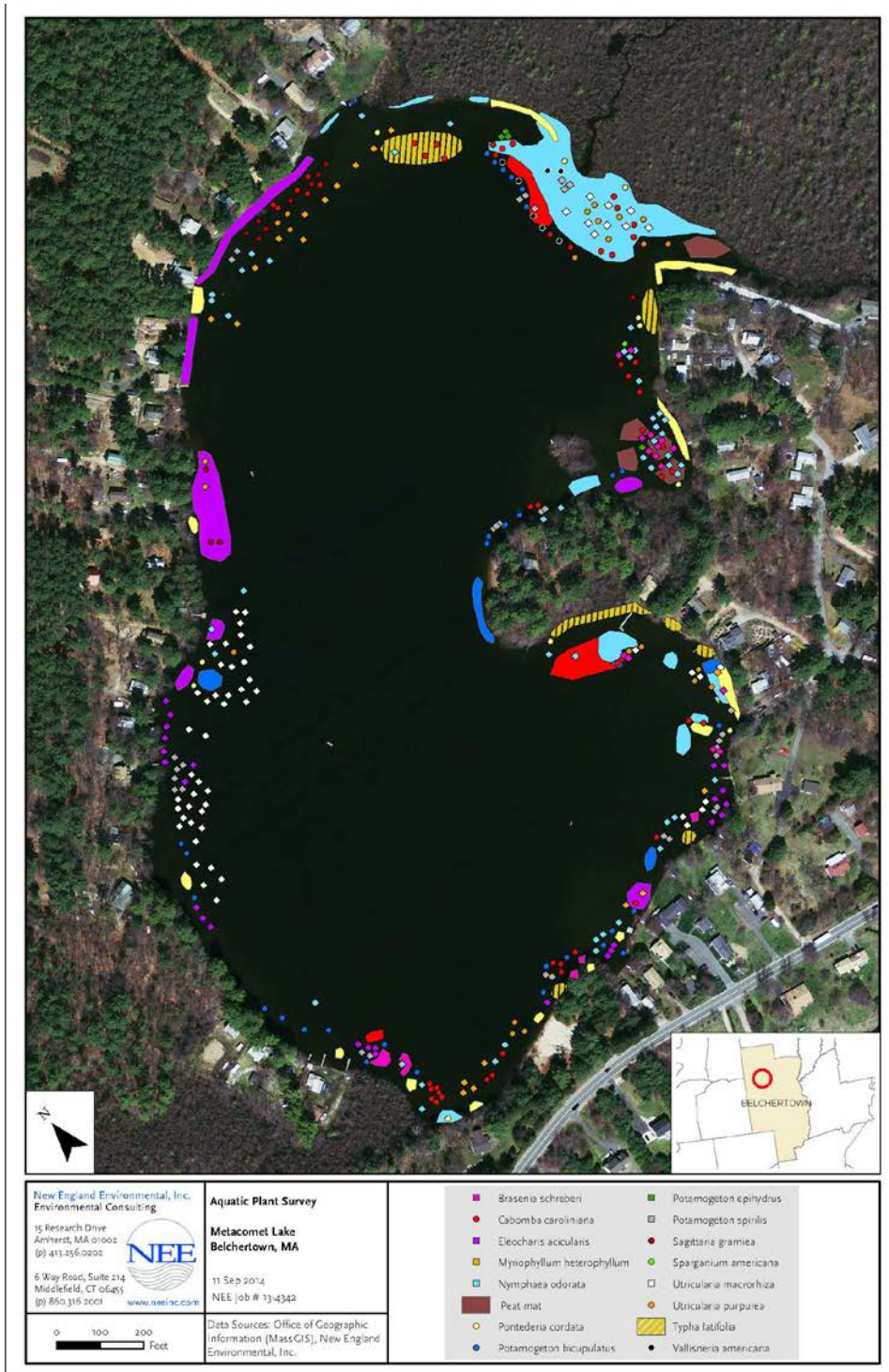
The fourth most prevalent species found during this survey was *Potamogeton bicupulatus*.

In the two northeastern bays of Metacomet Lake, NEE reports that there were numerous peat mats that may be inhibiting flow into and out of the system. These areas have substantial depth reduction due to these peat mats and are likely inhibiting recreational uses of these areas. (For more on this, see "Aquatic macrophyte survey" in Conclusions and Lessons Learned section below.)

Plant Community Composition in Metacomet Lake



Map of Metacomet Lake Plant Community



Preliminary BMP design

The Polaris consulting team more accurately described the direct stormwater inputs locations as part of their work:

- At Metacomet Lake, a pipe at the boat ramp delivers flow from 3 catch basins along Poole Road. The heavily used boat ramp itself drains approximately 900 pounds of sediment from erosion each year into Metacomet Lake.
- At Arcadia Lake, Federal and Metacomet streets each have one catch basin that deliver flow into the lake. Sheet flow from Federal Street also travels directly from the roadway, down an embankment, and into Arcadia Lake.

Findings from their work revealed both locations suitable for stormwater BMP facilities. See Table 7.

Table 7: Background Summary for Proposed BMP Sites

Background Issue	Boat Ramp Site	Arcadia Lake Site
Soils	Hinckley loamy sand	Hinckley loamy sand
Infiltration Rate	2.4 inches/hour	2.4 inches/hour
Flood Zone	First 50-75 feet of boat ramp within 100 year flood zone.	Outside 500 year flood
Wetland	• Resource Areas along pond edge. • Possible work in Buffer Zone.	• Resource Areas along pond edge. • Possible work in Buffer Zone.
Permitting	• Possible Filing with Belchertown Conservation Commission. • Notice to DEP regarding Chapter 91.	Possible Filing with Belchertown Conservation Commission.
Groundwater	8-9 feet below ground surface	6-8 feet below ground surface

Education and outreach (technology transfer)

For this project PVPC worked with the Town of Belchertown Lakes Committee and the Tri Lakes Watershed Association to host a total of 5 meetings and events. These were as follows:

February 12, 2013 - meeting with Town of Belchertown Lakes Committee and officials of Tri Lakes Watershed Association regarding project status, scope of work, and planning for April meeting with full membership of association. (7 attended)

April 17, 2013 - kick off meeting with Tri Lakes Watershed Association. Talked about project and solicited input on water quality sampling locations and how might be most effective to work together through the meetings planned under the project. (11 attended)

February 25, 2014 - meeting with the Town of Belchertown Lakes Committee and members of Tri Lakes Watershed Association to present findings from water quality study and to discuss most effective form for educational event to draw and reach lake residents. Emphasis for event is on providing an experience that is as interactive and engaging as possible. Through roundtable conversation came up with idea of an event where have series of tables/stations staffed with an “expert” on each topic/BMP: status of lakes; better lawn and garden care and buffers; strategies for capture and reuse of

stormwater; importance of connecting to the sewer system; and forthcoming plant analysis. Some ideas include, several pop up talks at the beginning to excite people about visiting the tables, acknowledgement of homeowners who have good practices to showcase, and a raffle drawing that will provide incentive for people to take a next step with best practices. Town Beach would be great venue. Saturday, May 31st seems like good date. (16 attended)

May 31, 2014 - successful education event at Arcadia Town Beach with approximately 50 people attending. Promoted event widely with flyer and press release. Local newspaper ran article before and after event. Had five learning stations on the following: water quality of the lakes, better lawn and garden care, the importance of buffers between yards and lake, aquatic plants and best management practices, and stormwater best management practices. As an incentive to circulate to all the learning stations, the event raffled off a rain barrel, as well as a season pass to the Town Beach. Participants had to get signatures on their raffle ticket from each learning station manager before entering the raffle. (approximately 50 attended)

October 21, 2014 - meeting with Tri Lakes Watershed Association to present results of aquatic macrophyte survey. The more than 15 people attending had lots of good questions for the consultant and generated lively discussion about good aquatic plant control going forward.

Another important outreach activity involved an April 14, 2015 mailing from the Town's DPW Director to 97 property owners around the lakes who are still using septic systems for wastewater disposal. The letter included a description of resources currently available to help with financing connection to the Town's sewer system. Resources listed included: the Department of Revenue tax credit to defray cost of septic repairs; Mass Housing's septic repair loan program; USDA's Rural Development loan program, and pending Community Development Block Grant that if awarded could help with emergency sewer connections for income qualifying households. The letter emphasized the success of sewerage in reducing lake pollution and the need to eliminate all septic systems to preserve water quality over the long term. The letter is included in the Appendixes.

Conclusions and Lessons Learned

Water quality sampling

Conclusions coming from the water quality analysis by NEE are as follows:

1. Future water quality monitoring will require an overhaul of sampling protocols.
2. There were no localized nutrient loadings detected during the 2013 summer season.
3. Wet weather sampling suggested an increase in the water clarity of Metacomet Lake.
4. Wet weather resulted in a decrease in the specific conductance of the waters of Arcadia Lake.
5. There was no spatial asymmetry in water chemistry in either lake.
6. Oxygen dynamics are normal for both lakes. Arcadia Lake waters remained highly oxygenated throughout the sampling protocol; and, Metacomet Lake waters undergo normal oxygen deprivation in the deep waters during thermal stratification.
7. The 2012 plant management protocol does not appear to have affected the water chemistries of the two lakes.

In their water quality analysis report NEE also had several recommendations about the sampling protocol that would help develop long term, analyzable, data sets that can be used in the conservation and management of Metacomet and Arcadia Lakes. These modifications are as follows:

- Remove E. coli assessments – unnecessary based on current and previous monitoring results.
- Remove wet/dry assessment from “in-lake” monitoring.
- Monitor the following variables at the point of greatest depth:
 - Dissolved oxygen at every meter to the bottom.
 - Total phosphorus and Total nitrogen at depths 0.5m from surface and 0.5m from the bottom (find a laboratory capable of measuring these variables at the ppb resolution.)
 - Alkalinity at depths 0.5m from surface and 0.5m from the bottom.
 - Conductivity at every meter to the bottom.
 - Algae community at 0.5m from the surface.
 - Oxidative-Reductive Potential (ORP) at every meter to the bottom.
 - Secchi depth.
- Modify the temporal properties of the sampling protocol by expanding it to include spring and fall assessments. And conduct winter assessments at least every 5 years.

Additional recommendations included:

- Consider conducting a basic watershed study and, if possible, develop an EPA 9 key element watershed plan.
- Consider conducting a quantitative plant survey to understand the plant environment relationships of species in the lakes. It is suggested that the entity conducting this survey is capable of identifying plants to species level and capable of modeling the trends in those data.
- Consider developing an integrated plant management protocol that incorporates the functional properties of the resident plant species.

Note that the last two items listed here were tasks added to the project and subsequently completed.

Protocol going forward

The protocol recommended by New England Environmental, Inc. for water quality sampling going forward is as follows.

Timing: Monthly from May and October.

Parameters:

Class 1: Secchi Depth

Class 1 variables should be measured at the point of maximum depth. The Secchi depth should be measured using a standard Secchi Disk.

Class 2: Dissolved Oxygen

pH

Conductivity

Specific Conductance

Class 2 variables should be measured at the point of maximum depth. Those variables should be assessed using a YSI Professional Meter.

Class 3: Algae Community – Cell counts.

Alkalinity

Ammonia

Nitrite/Nitrate

Total Kjeldahl Nitrogen

Orthophosphate

Total Phosphorus

Class 3 variables should be sampled at the point of maximum depth. Samples should be taken at the surface (0.5m) and the bottom (0.5m from the bottom of the lake). Samples at 0.5m of depth should be taken by hand (grab sample). A Van Dorn Sampler should be used to obtain samples at 0.5m from the bottom of the lake. Deep-water samples should not include algal assessments. A certified laboratory should process all samples.

It will be important for the Town of Belchertown Lakes Committee to ensure that water quality monitoring work continues, drawing on available resources and the deep caring that residents have for these lakes.

Aquatic macrophyte survey

Major conclusions and recommendations from the study are as follows:

- 1) Populations of the non-native species *Cabomba caroliniana* and *Myriophyllum heterophyllum* should be monitored yearly in both lakes so it will be known when these species reach nuisance levels.
- 2) No plant management is recommended in Metacomet Lake. However, *Potamogeton bicupulatus* is nearly at nuisance levels in Lake Arcadia. Mechanical control (i.e. Plant Harvester) is recommended prior to seed production (late June – early July).
- 3) Peat mats are present in both lakes. They are present along the northern edge of Lake Arcadia and in both of the northeastern bays of Metacomet Lake. These sediment structures may be inhibiting hydrologic flushing. Therefore, hydraulic dredging coupled with forebay construction should be investigated. MassDEP has noted that an in-lake forebay would require both a Wetlands and Chapter 91 permit. Additional feasibility analysis to determine scope, cost, and the extent of permit requirements would be essential.

For Arcadia Lake, the recommendations are as follows:

- 1) Yearly inspections to monitor for *M. heterophyllum* and *C. caroliniana* to ensure their abundance is known on a yearly basis. Monitoring will also allow for observation of when these species reach a nuisance level, which should trigger a management initiative.

For control of these species, use Flumioxazin for spot treatment. This is preferable to using Fluridone, which requires treatment of the entire water body. Use of Flumioxazin will help to retain as much native species diversity as possible.

2) Monthly water quality sampling during the summer season (May-October) to monitor the health of the lake.

3. Diver assisted suction harvesting or a mechanical harvester to reduce *P. bicupulatus* biomass. This should be done before the plant reaches seed. Preferably in late June or early July.

4) Peat mats in the northern portion of the lake may threaten hydrologic flows in the future. NEE recommends dredging using a hydraulic technique (i.e., surface dredge and geotextile bags). If this initiative is undertaken, the contractor could use the bagged spoils to create forebays, which will slow the flow and collect sediment in areas that are easy to maintain in subsequent years.

Note that MassDEP does not recommend removal of the peat mats as this would change the nature of the ponds. Hydraulic dredging to remove the peat mats would require additional feasibility analysis to determine scope, cost, and permitting requirements.

For Lake Metacomet, the recommendations are as follows:

1) Yearly inspections to monitor for *M. heterophyllum* and *C. caroliniana* to ensure their abundance is known on a yearly basis. Monitoring will also allow for observation of when these species reach a nuisance level, which should trigger a management initiative.

For control of these species, use Flumioxazin for spot treatment. This is preferable to using Fluridone, which requires treatment of the entire water body. Use of Flumioxazin will help to retain as much native species diversity as possible.

2) Monthly water quality sampling during the summer season (May-October) to monitor the health of the lake.

3) Peat mats in the northeastern bays may threaten hydrologic flows in the future. NEE recommends dredging using a hydraulic technique (i.e., surface dredge and geotextile bags). If this initiative is undertaken, the contractor could use the bagged spoils to create forebays, which will slow the flow and collect sediment in areas that are easy to maintain in subsequent years.

Note that MassDEP does not recommend removal of the peat mats as this would change the nature of the ponds. Hydraulic dredging to remove the peat mats would require additional feasibility analysis to determine scope, cost, and permitting requirements.

In addition to supporting water quality monitoring over the long term, the Town of Belchertown Lakes Committee could organize to make sure that monitoring of non-native species occurs and that there is good follow through on other recommendations.

Preliminary BMP design

Metacomet Lake

Stormwater BMP recommendations for Metacomet Lake are to:

1. Replace the 3 existing conventional catch basins on Poole Road with a deep sump catch basin with a hood, and connect to an infiltration catch basin
2. Stabilize the pipe outlet with rip rap and stabilize the nearby bank abutting the pipe with bio-logs and vegetation
3. Install GravelPave over 12 inches of crushed stone at the top of the boat ramp and a concrete plank with crushed stone surface at the lower, land-water interface of the boat ramp

With these BMPs at Metacomet Lake, the Polaris Team calculated pollutant removal based on the Simple Method to be:

Total Suspended Solids	1,512 lbs.
Total Phosphorous	3.03 lbs.
Total Nitrogen	16.06 lbs.

Costs for the Metacomet Lake facilities are estimated to be as follows:

Deep Sump Catch Basins and Hoods (3 @ \$5,000).....	\$15,000
Leaching Catch Basins (3 @\$5,000)	\$15,000
Rip Rap and Bank Stabilization	<u>\$4,000</u>
Construction Sub-Total.....	\$34,000
Survey	\$4,000
Design.....	\$4,500
Permitting (Notice of Intent)	<u>\$2,500</u>
Design Sub-Total	\$11,000
Total Project Cost.....	\$45,000

Arcadia Lake

Stormwater BMP recommendations for Arcadia Lake are to:

1. Replace the 2 existing conventional catch basins on Federal and Metacomet streets with pre-cast deep sump catch basin with a hood, and connect to an infiltration catch basin
2. Intercept direct run-off from the roadway to the lake with a bioswale

With these BMPs at Arcadia Lake, they calculated pollutant removal based on the Simple Method to be:

Total Suspended Solids	2,874 lbs.
Total Phosphorous	3.4 lbs.
Total Nitrogen	15.4 lbs.

Costs for the Arcadia Lake facilities are estimated to be as follows:

Costs

The following presents the preliminary cost estimate for this work.

Deep Sump Catch Basins and Hoods (2 @ \$5,000)	\$10,000
Leaching Catch Basins (2 @\$5,000)	\$10,000
Bioswale	\$17,500
Pipe Replacement (50 feet @125/Ft)	\$6,250
Rip Rap and Bank Stabilization	<u>\$1,000</u>
Construction Sub-Total	\$44,750
Survey	\$4,000
Design	\$6,500
Permitting (Notice of Intent)	<u>\$2,500</u>
Design Sub-Total	\$13,000
Total Project Cost	\$57,750

To keep the lakes in good condition, the Town of Belchertown is already pursuing implementation of all stormwater BMP recommendations coming out of the 604b grant funded study. The Director of Public Works is in conversation with the State Access Board about improvements to the boat ramp area at Metacomet Lake and the Town worked with PVPC to apply to the Section 319 grant program, committing a 40% project match, to fund the stormwater BMPs at Arcadia Lake.

Education and Outreach

By pulling together the recommendations coming out of this project, this final report provides another important education and outreach tool. PVPC is planning to meet with the Town of Belchertown Lakes Committee and the Tri Lakes Watershed Association later this summer to review all recommendations. Fortunately, the Lakes Committee is organized to provide impetus and support to continue protecting lake health.

It is recommended that in the short term there be follow up with homeowners still on septic systems should CDBG funding be awarded for emergency repairs. For the longer term occasional reminders to septic system owners could help encourage all to make connections to the sewer system. Continued tracking of households connecting to the sewer system will help measure success over the longer term.

Appendices

- A. Shoreline survey data sheets with accompanying maps
- B1. MassDEP and EPA approved Quality Assurance Project Plan for water quality monitoring, including water quality monitoring locations with GPS coordinates
- B2. Quality Assurance Project Plan Revision for E. coli method
- C. Water quality sampling report on results, analysis, and recommendations
- D. Aquatic macrophyte survey report and recommendations with QAPP
- E. Memorandum on preliminary design and costs for stormwater BMP facilities at 2 priority locations
- F. Materials from public education and outreach (technology transfer)
 - April 2015 mailing to residents around lakes still connected to septic systems
 - October 2014 presentation to Tri Lakes Watershed Association on results of aquatic macrophyte survey and recommendations going forward
 - May 2014 flyer, media release, program, and press coverage from Town Beach public outreach event at Arcadia Lake
 - February 2014 hand out for Tri Lakes Watershed Association on findings of water quality study and additional outreach to lakes residents
 - April 2013 presentation to Tri Lakes Watershed Association on project scope of work