Zebra Mussel Phase II Assessment

Physical, Chemical, and Biological Evaluation of Waterbodies in the Connecticut River Watershed of Massachusetts

prepared by
Biodrawversity LLC

prepared for
Massachusetts Department of Conservation and Recreation, Lakes and Ponds Program

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Massachusetts Department of Conservation and Recreation
Lakes and Ponds Program
251 Causeway Street, Suite 700
Boston, Massachusetts 02114-2104

Prepared by:

biodrawversity

Biodrawversity LLC
433 West Street, Suite 6
Amherst, Massachusetts 01002

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EXECUTIVE SUMMARY

Biodrawversity LLC assessed 26 lakes and reservoirs and four rivers in the Connecticut River watershed to determine presence of zebra mussels (*Dreissena polymorpha*) and to evaluate the potential for these waterbodies to support zebra mussels based on physical, chemical, and biological parameters. Fieldwork was conducted during May and June of 2010. Data were collected at one to five sites per lake (40 total sites), six sites in the Connecticut River, and one site each in the Westfield River, Deerfield River, and Chicopee River. Most of the following parameters were recorded for each waterbody: secchi depth, water temperature, water chemistry (dissolved oxygen, pH, alkalinity, conductivity, calcium, total nitrogen as N, total phosphorus as P, and total suspended solids). Presence of adult zebra mussels or veligers, physical habitat characteristics, and species composition and abundance of submerged aquatic plants, snails, and native freshwater mussels were also documented. This report also uses data from the Acid Rain Monitoring (ARM) Project of the University of Massachusetts Water Resources Research Center and the Phase I Zebra Mussel Assessment in Berkshire County (Biodrawversity 2009) to provide a comprehensive risk assessment for 166 waterbodies (including multiple sites along the mainstem Housatonic and Connecticut Rivers) in central and western Massachusetts. This included 108 waterbodies in the Connecticut River watershed and 58 waterbodies in the Housatonic River and Hudson River watersheds of Berkshire County.

Neither zebra mussel adults nor veligers were detected during the survey, although the physical and chemical suitability of waterbodies for zebra mussels varied considerably and four lakes showed characteristics somewhat favorable for zebra mussel colonization, reproduction, and growth. A total of 56 aquatic plant species, 14 snail species, and seven native mussel species were documented during the study. Among the waterbodies sampled, species richness of aquatic snails ranged from zero to seven (average = 3.0), and three lakes considered most susceptible to zebra mussel invasion contained a higher average species richness of aquatic snails (combined average = 6.0) than low-risk lakes (combined average = 2.4). Species richness of native freshwater mussels ranged from zero to six (average = 1.4) among the waterbodies and showed no trend with regard to water chemistry. Lakes and ponds usually contained only one or mussel two species, whereas six mussel species were documented in the Connecticut River. Known biological indicators of an aquatic ecosystems' vulnerability to zebra mussel invasion (e.g., presence of the submerged aquatic algae *Chara* and calciphilous aquatic snails) were not observed in this study although *Chara* had been documented in Congamond Lakes prior to this study. A non-native bivalve, the Asian clam (*Corbicula fluminea*), was encountered in the Connecticut River (Easthampton), Aldrich Lake (Granby), Congamond Lakes (Southwick), and Five Mile Pond (Springfield).

Research suggests that zebra mussels are not likely to become established in waterbodies with pH below 7.4 and calcium below 12.0 mg/L. Higher pH and calcium levels are more suitable for this species. The following water chemistry thresholds were used to determine susceptibility to zebra mussels:

- **Low Risk:** pH <7.4, Calcium <12.0 mg/L, Alkalinity <20.0 mg/L
- **Medium Risk:** pH 7.4-8.0. Calcium 12.0-20.0 mg/L, Alkalinity 20.0-65.0 mg/L
- **High Risk:** pH >8.0, Calcium >20.0 mg/L, Alkalinity >65.0 mg/L

For waterbodies in the Connecticut River watershed, including those monitored as part of the ARM Project, pH ranged from 4.9 to 8.7 (average = 6.7), and calcium concentrations ranged from 0.4 to 27.0 mg/L (average = 6.6 mg/L). These pH and calcium values indicated a very low risk that zebra mussels could become established in the region; only nine of 109 (8.3 percent) waterbodies assessed were considered to have medium or high risk of zebra mussel establishment based on water chemistry parameters. Moreover, several small and eutrophic ponds in the highly urbanized Springfield area (Watershops Pond, Porter Lake, Silver Lake, and Harts Pond) had pH and calcium levels near or within the optimal range for zebra mussels, but physical and biological parameters of these urban ponds made them less suitable than the chemistry data indicated. Based on the dual role of water chemistry and physical habitat, only four of the waterbodies assessed in the Connecticut River watershed are considered susceptible to zebra mussel invasion, including Pequot Pond (Westfield), Congamond Lakes (Southwick), Ashfield Lake (Ashfield), and Wrights Pond (Holyoke). All but the latter experience moderate to heavy recreational use (boating and angling) that increases the likelihood of zebra mussel introduction. We recommend public education, boat ramp inspections, and monitoring for Pequot Pond, the Congamond Lakes, and Ashfield Lake.

Zebra mussel education and monitoring ramped up in Massachusetts in 2009 after zebra mussels were discovered in Laurel Lake in Lee.

INTRODUCTION

Adult zebra mussels (*Dreissena polymorpha*) were detected in Laurel Lake in 2009, prompting a series of actions by state agencies that were summarized in the Massachusetts Interim Zebra Mussel Action Plan (DCR 2009). This was the first occurrence of zebra mussels in Massachusetts. The zebra mussel was accidentally introduced to North America in the late 1980s by commercial shipping vessels carrying freshwater ballast from the Black or Caspian Sea region of Eastern Europe (Hebert *et al*. 1989, Strayer 2009). Within ten years of its discovery in Lake Erie in 1987, the zebra mussel had spread throughout much of central and eastern North America, including susceptible waterbodies in New England and eastern New York. The United States Geological Survey's (USGS) Nonindigenous Aquatic Species (NAS) Program website provides time series maps, current sightings, and other information relevant to the spread of zebra mussels in all of North America.

Zebra mussels and the closely related quagga mussel (*Dreissena bugensis*) have caused ecological and economic damage throughout North America (MacIsaac 1996, Strayer 2009). Like blue or ribbed mussels in marine environments—and unlike any native freshwater mollusks in North America—adult dreissenid mussels attach to solid objects using strong byssal threads. Once established in a waterbody, they have the potential to alter basic ecosystem functions such as nutrient cycling and food web dynamics, they may eliminate native freshwater mussels via fouling and competition, and they can influence the transport and fate of contaminants (Nalepa 1993, Bruner *et al*. 1994a-b, MacIsaac 1996, Strayer 1999).

The discovery of zebra mussels in Laurel Lake raised concern that this species might exist in other waterbodies in the region, or that some waterbodies might be susceptible to zebra mussels due to suitable water chemistry and prevalence of dispersal vectors. In general, waterbodies with high calcium concentrations and high pH are considered most suitable for zebra mussel growth and reproduction (Strayer 1991, Murray *et al*. 1993, Smith 1993, Cohen and Weinstein 2001). In Massachusetts, only the Hoosic and Housatonic River watersheds had been characterized as highly susceptible to zebra mussel invasion according to these water chemistry criteria (Smith 1993). The Connecticut River watershed (with the exception of

Adult zebra mussel from the Housatonic River in Massachusetts.

the Millers and Chicopee watersheds) and most of eastern Massachusetts were considered moderately to marginally susceptible. Due to low pH and low calcium, waterbodies in the Millers and Chicopee watersheds, the coastal plain of southeastern Massachusetts, and Cape Cod were considered immune to zebra mussels (Smith 1993). There is considerable variation in the water chemistry of lakes and streams in these regions. Therefore, specific studies of numerous waterbodies were needed to predict where zebra mussels would be most likely to survive, if they were to be spread more widely in the region.

A Phase I Assessment of 20 Berkshire County lakes and the Housatonic River was completed in October 2009 that documented zebra mussels in the mainstem Housatonic River for the first time and identified susceptible waterbodies in Berkshire County (Biodrawversity 2009). Biodrawversity was contracted to conduct a Phase II Assessment of waterbodies in the Connecticut River watershed (Figure 1) in 2010 to determine (1) if zebra mussels were already present and (2) the susceptibility of waterbodies to the establishment of zebra mussel populations based on physical, chemical, and biological parameters. The Phase II Assessment included a synthesis of ARM data to expand the risk assessment to waterbodies in the Connecticut River watershed that were not included in the 2010 field assessment, and for the Housatonic and Hudson watersheds of Berkshire County.

Table 1. Waterbodies surveyed in 2010 and number of survey sites for each. The lake categories "primary", "secondary", and "additional" are described in the text.

Waterbody	Town	Subwatershed	Date	# Sites
Primary Lakes				
Ashfield Lake	Ashfield	Deerfield	6/22/10	3
Congamond Lakes	Southwick	Westfield	6/18/10	5
Five-Mile Pond	Springfield	Connecticut	6/11/10	1
Littleville Lake	Chester	Westfield	6/15/10	3
Pequot Pond	Westfield	Westfield	6/15/10	4
Secondary Lakes				
Aldrich Lake	Granby	Connecticut	6/1/10	1
Cranberry Pond	Sunderland	Connecticut	6/3/10	1
Lake Warner	Hadley	Connecticut	6/1/10	1
Lake Wyola	Shutesbury	Connecticut	6/3/10	2
Lower Highland Lake	Goshen	Connecticut	6/6/10	1
Upper Highland Lake	Goshen	Connecticut	6/6/10	1
Porter Lake	Springfield	Connecticut	6/11/10	1
Watershops Pond	Springfield	Connecticut	5/19/10	1
Additional Lakes				
Arcadia Lake	Belchertown	Connecticut	6/2/10	1
Chicopee River Reservoir	Ludlow	Chicopee	6/4/10	1
Damon Pond	Chesterfield	Westfield	5/30/10	1
Forge Pond	Granby	Connecticut	6/2/10	1
Hammond Pond	Chesterfield	Westfield	5/30/10	1
Lake Mattawa	Orange	Millers	5/31/10	1
Lake Rohunta	Orange	Millers	5/31/10	1
Laurel Lake	Erving	Millers	6/4/10	1
Metacomet Lake	Belchertown	Connecticut	6/2/10	1
Pelham Lake	Rowe	Deerfield	6/21/10	3
Plainfield Pond	Plainfield	Deerfield	6/21/10	1
West Lake	Sandisfield	Farmington	6/9/10	1
Westfield Reservoir	Montgomery	Westfield	5/30/10	1
Rivers				
Chicopee River	Chicopee	Chicopee	6/10/10	1
Connecticut River	Chicopee	Connecticut	6/10/10	1
Connecticut River	Easthampton	Connecticut	6/8/10	1
Connecticut River: Bartons Cove	Gill	Connecticut	6/7/10	1
Connecticut River	Hatfield	Connecticut	6/8/10	1
Connecticut River	Northfield	Connecticut	6/7/10	1
Connecticut River: Oxbow	Northampton	Connecticut	6/8/10	1
Deerfield River	Deerfield	Deerfield	6/7/10	1
Westfield River	Westfield	Westfield	6/10/10	1
	Total Survey Sites			49

STUDY SITE SELECTION

A total of 26 lakes and four rivers were selected for field assessments in 2010 (Table 1, Figure 2). Lakes were selected based on available water chemistry data and degree of public access, as well as to provide adequate spatial coverage of the target geographic area. Based on zebra mussels well-documented water chemistry requirements, we knew in advance that some target waterbodies were resistant to zebra mussels because of low pH and low calcium yet we gathered field data to provide a more comprehensive assessment. Lakes were divided into three categories (Table 1):

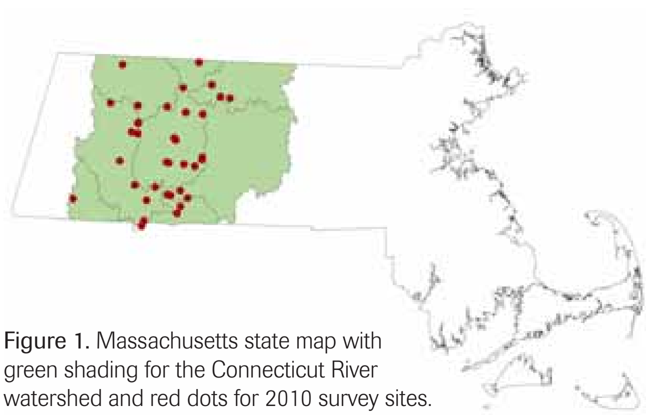

Figure 1. Massachusetts state map with green shading for the Connecticut River watershed and red dots for 2010 survey sites.

- **Primary Lakes:** Included five lakes with higher pH and calcium levels that were more likely to support zebra mussels. All contained public boat access. These were surveyed for a minimum of one-half day by boat and at multiple sites throughout each lake. The full suite of physical, chemical, and biological parameters were recorded at these lakes.
- **Secondary Lakes:** Included eight lakes that we thought had marginal pH and calcium levels based on available information. These lakes tended to be small with only one primary access point and less frequent visitation by trailered boats than primary lakes. These were surveyed for one-half day or less. Sites were accessed by boat or by land, usually only at or near the primary access points. The full suite of physical, chemical, and biological parameters were usually recorded at these lakes but at fewer sites than in primary lakes.

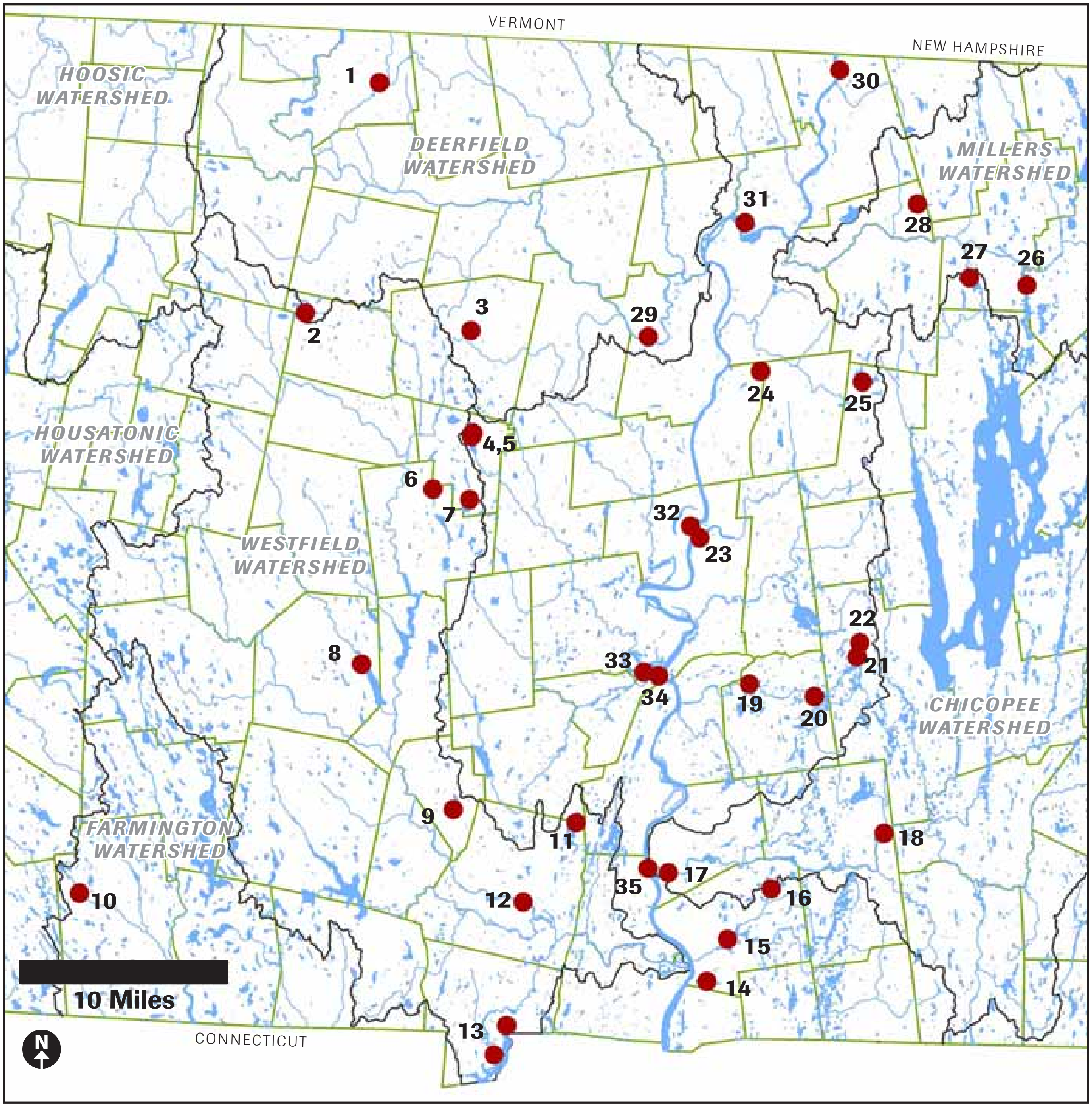

Figure 2. Waterbodies assessed for water chemistry, physical habitat, and biology (zebra mussel adults or veligers, plants, and other molluscs) in the Connecticut River watershed in 2010. Green lines indicate town boundaries.

1. Pelham Lake, Rowe
2. Plainfield Pond, Plainfield
3. Ashfield Lake, Ashfield
4. Upper Highland Lake, Goshen
5. Lower Highland Lake, Goshen
6. Hammond Pond, Chesterfield
7. Damon Pond, Chesterfield
8. Littleville Lake, Chester
9. Westfield Reservoir, Montgomery
10. West Lake, Sandisfield
11. Pequot Pond, Westfield
12. Westfield River, Westfield
13. Congamond Lakes (North and South), Southwick
14. Porter Lake, Springfield
15. Watershops Pond, Springfield
16. Five Mile Pond, Springfield
17. Chicopee River, Chicopee
18. Chicopee Reservoir (Red Bridge Pool), Ludlow
19. Aldrich Lake, Granby
20. Forge Pond, Granby
21. Metacomet Lake, Belchertown
22. Arcadia Lake, Belchertown
23. Lake Warner, Hadley
24. Cranberry Pond, Sunderland
25. Lake Wyola, Shutesbury
26. Lake Rohunta, Orange
27. Lake Mattawa, Orange
28. Laurel Lake, Erving
29. Deerfield River, Deerfield
30. Connecticut River, Northfield
31. Connecticut River, Gill (Bartons Cove)
32. Connecticut River, Hatfield
33. Connecticut River, Northampton (Oxbow)
34. Connecticut River, Easthampton
35. Connecticut River, Chicopee

OFBA ramps, such as this one in Chicopee, were targeted for surveys in the Connecticut River.

- **Additional Lakes:** Included 13 lakes that we thought had unsuitable pH and calcium levels based on available information; some of these were also small and had limited access. Only field measurements of water chemistry (including pH, conductivity, temperature, and dissolved oxygen) were taken from ten of these lakes, more cursory biological surveys were conducted and usually from a single access point (none if access was denied), and plankton samples were only collected from waterbodies with pH above 7.0.

Survey sites within the five primary lakes were intended to include a minimum of three areas: (1) the lake outlet, (2) the public boat ramp, and (3) the deep basin. Sampling sites in the eight secondary and 13 additional lakes were usually restricted to primary access points, which often overlapped with outlets and deep areas. Many of the lakes were very small, shallow, eutrophic, heavily vegetated, and contained mostly soft substrates. Likely surfaces for zebra mussel colonization, such as rocky substrates, piers, anchors, mooring lines, concrete walls, bridge abutments and other surfaces were generally targeted for adult zebra mussel surveys. The number of sampling sites per lake ranged from one to five, for a total of 40 lake sites.

Nine sites in four rivers were also surveyed: six sites in the Connecticut River (including the Oxbow in Northampton), and one site apiece in the Westfield River (Westfield), Deerfield River (Deerfield), and Chicopee River (Chicopee). Connecticut River survey sites were at OFBA boat launches and survey sites at the other three rivers were at convenient access points.

METHODS

Specific methods used at each lake are noted in Appendix 1. Decontamination procedures generally followed guidelines in the Massachusetts Interim Zebra Mussel Action Plan (DCR 2009), supplemented with more specific measures for field technicians and SCUBA divers. The field crew possessed redundant sets of field gear so that field equipment was not transferred to a new waterbody without undergoing proper decontamination. This included boats, sample collecting equipment, SCUBA/snorkel gear, and wetsuits.

Physical and Chemical Parameters

- **Laboratory Chemistry:** One or two water samples were collected for all primary and secondary lakes but for only three of the additional lakes. A single water sample was collected for each of the river sites. Water samples were collected in early to mid-May, two to four weeks prior to biological surveys. Berkshire Envirolabs in Lee, Massachusetts, provided sample containers and completed the analyses, except for the Five Mile Pond sample that was analyzed by Spectrum Analytical in Agawam. Samples were kept on ice and brought to the lab each afternoon so that pH could be accurately measured. The lab measured the following six parameters: pH, alkalinity (mg/L), calcium (mg/L), total nitrate as N (mg/L), total phosphorus as P (mg/L), and total suspended solids (mg/L).
- **Field Chemistry:** Field measurements of pH, temperature, dissolved oxygen, and conductivity were recorded at all lakes and rivers using a YSI (Yellow Springs Instruments)

Model 200 DO probe and YSI pH 63 probe. Measurements were taken in early to mid-May two to four weeks prior to biological surveys, and some parameters (especially dissolved oxygen and temperature) were recorded a second time when biological sampling occurred.

- **Secchi Depth:** Secchi depth was recorded at survey sites where the bottom was not visible from the surface.
- **Physical Habitat:** Surveyors recorded the water depth, substrate characteristics, and shoreline condition at each survey site.

Biological Parameters

- **Adult Zebra Mussels:** Surveyors searched for adult zebra mussels by SCUBA diving, snorkeling in shallow water, and wading along shorelines to collect any live animals or shells with an aquatic D-frame net or clear-bottom bucket. Surveys were qualitative and focused on visual searches for adult or juvenile mussels. Surveyors looked on the undersides of hard objects and conducted tactile searches underneath rocks and undercut riverbanks. All surface types were surveyed at each site but hard substrates were targeted.
- **Larval Zebra Mussels (Veligers):** Plankton samples were collected from one to five locations within each lake and combined into a single composite sample for each lake. Surveyors used the 33-E28 Veliger Net from the Wildlife Supply Company (length = 80 inches; opening width = 20 inches, mesh size = 63 microns, dolphin bucket = 1,000 mL). Nets were connected to a 60-ft line marked in 3-ft (1-meter) increments, and a sliding line weight so that the net could quickly be lowered to the desired starting point. At shallow sites, horizontal plankton tows were collected from areas of relatively clear water (i.e., few macrophytes) at a depth that prevented the net from dragging on the bottom and scooping up mud. At deeper sites, plankton nets were lowered to within 3-6 feet of the bottom (or a maximum of 25 feet) while the boat was stationary, then the boat was driven at trolling speed for two or three minutes while the net collected plankton throughout the water column. At river sites, the plankton net was held in light current for two to three minutes. Contents were filtered and rinsed into a 500 mL container and preserved in 70 percent ethyl alcohol. The final composite samples were decanted several hours later, after contents had settled, and then topped off with fresh alcohol to ensure that alcohol concentrations were suitable for preservation. In the laboratory, samples were examined using a 45x dissecting microscope fitted with cross-polarized light (Johnson 1995).
- **Snails and Native Mussels:** Surveyors documented and/or collected snails and native mussels while searching for adult zebra mussels. Native mussels were identified in the field and released unharmed. In most cases, snails were identified in the field but some were also collected and preserved for identification in the laboratory using keys of Jokinen (1983, 1992) and Smith (1995). The species and relative abundance of snails and mussels were recorded for each survey site. Snails with a more patchy distribution or whose habitat did not overlap with our target habitats (e.g., shallow littoral areas) were underrepresented in our samples.

Plankton tow in shallow water.

- **Aquatic Plants:** Species composition and relative abundance of submerged aquatic plants were recorded at each survey site, and in some cases, other locations throughout the lake. Because the study focused on zebra mussels, a limited number of sites were surveyed per waterbody and a comprehensive botanical inventory of each lake and river was not completed. Furthermore, surveys were conducted before flowering and fruiting stages of most aquatic plants. Supplemental information on plant communities was gathered from other sources.
- GPS coordinates were taken to record locations of survey sites. Reference photographs of survey sites and other interesting or unique features of each waterbody were taken.

Mapping

- Bathymetric maps were available for many of lakes and ponds assessed in this study. In addition, 0.5-meter orthophotos for each lake were downloaded from the Massachusetts Office of Geographic Information Systems (MassGIS) and used to display survey sites. Field data were imported into ArcGIS 9.2 to create maps. Appendix 3 provides brief profiles of some waterbodies surveyed for this report.

Decontamination Procedure

- Decontamination procedures generally followed guidelines in the Massachusetts Interim Zebra Mussel Action Plan (DCR 2009), supplemented with more specific measures for field technicians and SCUBA divers who are specifically studying zebra mussels.
- The field crew possessed redundant sets of field gear so that field equipment was not transferred to a new waterbody without undergoing proper decontamination. This included boats (multiple canoes and kayaks were used), sample

collecting equipment, SCUBA/snorkel gear, wetsuits, etc.

- After use, equipment was either bagged so that it could be washed later, left to soak in buckets of vinegar, sprayed with a 10 percent bleach solution and left to dry, or soaked and/or wiped down with 90 percent isopropyl alcohol. Plant fragments were removed from all gear. Boats were used in one location per day, and they were cleaned with a hot powerwash each evening. Plankton nets, wetsuits, and SCUBA gear were washed in hot soapy water, sprayed with a 10 percent bleach solution, rinsed, and dried.

Supplemental Chemical Data

We reviewed available data on surface water chemistry of lakes and rivers in the region, with particular emphasis on three parameters considered most important to zebra mussels: pH, calcium, and alkalinity. Most supplemental data came from the ARM Project of the University of Massachusetts Water Resources Research Center (Appendix 2). The dataset included 108 waterbodies in the Connecticut River watershed when combined with the 2010 field data (among these 108 "waterbodies" were six sites in the mainstem Connecticut River). ARM data were gathered for waterbodies in the Housatonic and Hudson watersheds and combined with 2009 field data (Biodrawversity 2009) to create a dataset of 58 waterbodies for these two watersheds. The full dataset included 166 waterbodies or river sites in the Connecticut, Housatonic, and Hudson River watersheds. Thresholds for pH, calcium, and alkalinity were used to define risk categories for zebra mussel invasion (Table 2).

Table 2. Risk of zebra mussel colonization based on thresholds for three water chemistry parameters: pH, calcium, and alkalinity.

Risk	pH	Calcium (mg/L)	Alkalinity (mg/L)
Low	< 7.4	< 12.0	< 20.0
Medium	7.4 - 8.0	12.0 - 20.0	20.0 - 65.0
High	> 8.0	> 20.0	> 65.0

RESULTS

I. Physical and Chemical Parameters

Table 3 summarizes much of the physical and chemical data for the 30 waterbodies surveyed in 2010. In these waterbodies, pH ranged from 5.9 to 8.7 (average = 7.2), calcium concentrations ranged from 2.0-27.0 mg/L (average = 9.3), and alkalinity

Table 3. Physical and chemical data for the 26 lakes and four rivers in the Connecticut River watershed that were surveyed in 2010. Data for ARM waterbodies are provided in Appendix 2.

Waterbody	Acres	Depth (ft)	Secchi (ft)	DO (mg/L)	Temp1 (C)	Temp2 (C)	pH*	Calcium (mg/L)	Alkalinity (mg/L)	Nitrate (mg/L)	Phosphorus (mg/L)	TSS (mg/L)
Aldrich Lake	66	?-13	7.0	7.2	14.1	25.7	7.36	11	32	0.08	0.065	4
Arcadia Lake	-	-	-	-	24.9	-	**7.17**	-	-	-	-	-
Ashfield Lake	37	7-20	13.5	9.5	12.8	23.4	7.63	14	34	<0.01	0.010	2
Chicopee River Reservoir	106	-	-	-	13.9	-	7.11	6	8	0.19	0.031	2
Chicopee River	-	-	*	9.8	15.6	21.2	7.25	5	8	0.24	0.022	1
Congamond Lakes (North)	465	?-40	5.0	12.7	16.8	25.5	8.21	16	46	0.32	0.028	4
Congamond Lakes (South)	465	?-40	-	-	15.6	-	7.71	14	42	0.33	0.029	2
Connecticut River: Chicopee	-	-	*	8.9	14.8	23.7	7.36	8	26	0.29	0.016	6
Connecticut River: Easthampton	-	-	*	8.4	12.9	23.2	7.52	10	26	0.29	0.015	3
Connecticut River: Gill	-	-	*	8.7	12.2	24.6	7.63	8	26	0.14	0.020	3
Connecticut River: Hatfield	-	-	-	8.5	12.3	24.3	7.58	8	26	0.17	0.026	6
Connecticut River: Northfield	-	-	*	8.4	10.6	23.2	7.52	8	29	0.14	0.022	2
Connecticut River: Oxbow	204	7-18	6.0	9.5	14.2	22.8	7.54	10	22	0.11	0.024	7
Cranberry Pond	27	4-26	*	-	14.0	-	6.96	5	12	0.02	0.011	1
Damon Pond	-	-	-	-	25.4	-	**6.47**	-	-	-	-	-
Deerfield River	-	-	*	-	10.9	-	7.26	8	6	0.12	0.036	<1
Five Mile Pond	48	12-35	*	8.6		22.2	7.48	6.5	16.6	<0.01	0.032	13
Forge Pond	68	5-6	-	-	25.5	-	**7.27**	-	26.3	-	-	-
Hammond Pond	-	-	-	-	24.2	-	**6.94**	-	-	-	-	-
Lake Mattawa	112	17-40	-	8.3	24.3	24.2	**7.25**	-	-	-	-	-
Lake Rohunta	383	4-15	*	7.2	25.0	27.3	6.61	3	4	0.01	0.026	<1
Lake Warner	68	3-10	9.0	8.8	13.8	23.8	7.27	10	22	0.53	0.037	4
Lake Wyola**	129	11-33	*	8.2	13.2	24.1	6.17	5	<2	0.01	0.014	3
Laurel Lake	51	15-32	*	8.3	12.5	24.5	5.94	2	4	<0.01	0.009	2
Littleville Lake**	275	34-86	14.0	9.5	15.1	21.9	7.24	5	10	0.03	0.007	2
Lower Highland Lake	88	9-16	*	8.3	12.1	24.7	6.99	3	6	<0.01	0.005	1
Metacomet Lake	74	10-18	*	7.8	-	27.6	-	-	-	-	-	-
Pelham Lake	71	5-8	9.0	8.5	23.6	25.1	**6.54**	-	-	-	-	-
Pequot Pond**	198	15-31	12.5	10.4	16.1	22.8	7.67	20	39	0.18	0.020	3
Plainfield Pond***	57	5-9	*	7.5	23.6	24.3	**6.88**	-	6	-	-	-
Porter Lake	21	-	4.5	11.2	15.6	19.4	8.11	27	51	0.98	0.054	8
Upper Highland Lake	53	8-14	10.0	8.2	12.2	23.6	7.05	3	6	<0.01	0.006	2
Watershops Pond	186	?-21	-	-	17.1	-	8.72	22	48	0.63	0.053	14
West Lake	60	8-13	*	7.9		20.1	7.35	7.2	22.9			
Westfield Reservoir	-	-	-		26		**7.08**	-	-	-	-	-
Westfield River	-	-	*	10.2	11.7	18.6	7.34	5	16	0.14	0.010	1

*Bold value indicates field measurement; all values not in bold were analyzed by Berkshire Envirolabs or Spectrum Analytical (Five Mile Pond)

**Two water samples taken to the lab, average value reported.

***Some chemistry data from ARM Project

Temp 1 = Recorded when water samples were taken, Temp 2 = Recorded during biological sampling when dissolved oxygen was recorded

Table 4. Freshwater snails documented in lakes and rivers during the 2010 surveys.

	Snails														
Waterbody	HeCa	HeAn	HeTr	PhGy	PhAn	AmLi	CaDe	PsCo	LaFu	ViGe	GyDe	GyPa	LyGr	CiCh	# Taxa
Aldrich Lake			X	X		X	X			X					5
Ashfield Lake		X		X			X			X					4
Chicopee Reservoir						X							X		2
Chicopee River			X	X		X			X						4
Congamond Lakes	X		X	X	X	X	X				X				7
Connecticut River		X		X		X	X	X						X	6
Cranberry Pond														X	1
Deerfield River															0
Five Mile Pond						X				X				X	3
Forge Pond				X		X		X						X	4
Lake Mattawa	X			X		X									3
Lake Rohunta		X				X	X								3
Lake Warner				X		X		X							3
Lake Wyola							X								1
Laurel Lake															0
Littleville Lake							X			X					2
Lower Highland Lake						X									1
Metacomet Lake				X		X		X							3
Pelham Lake															0
Pequot Pond	X	X		X		X				X	X			X	7
Plainfield Pond		X					X								2
Porter Lake			X	X						X			X	X	5
Upper Highland Lake		X				X				X		X			4
West Lake		X								X					2
Westfield River			X			X	X								3
# Waterbodies	3	7	5	11	1	15	9	4	1	8	2	1	2	6	

Helisoma campanulatum	HeCa	*Amnicola limosa*	AmLi	*Gyraulus deflectus*	GyDe
Helisoma anceps	HeAn	*Campeloma decisum*	CaDe	*Gyraulus parvus*	GyPa
Helisoma trivolvis	HeTr	*Pseudosuccinia columella*	PsCo	*Lyogyrus grana*	LyGr
Physa gyrina	PhGy	*Laevapex fuscus*	LaFu	*Cipangopaludina chinensis*	CiCh
Physa ancillaria	PhAn	*Viviparus georgianus*	ViGe		

ranged from 4.0-51.0 mg/L (average = 22.3). These values are higher than the regional average because we selected waterbodies that were more suitable for zebra mussels, with a few exceptions such as Laurel Lake, Lake Rohunta, and Lake Wyola that we knew were unsuitable. Among the 108 waterbodies in the Connecticut River watershed considered in this assessment, including the ARM waterbodies, pH ranged from 4.9 to 8.7 (average = 6.7), calcium concentrations ranged from 0.4 to 27.0 mg/L (average = 6.6 mg/L), and alkalinity ranged from -0.5 to 51.0 mg/L (average = 12.2 mg/L). This larger dataset is probably a better indication of the regional susceptibility to zebra mussels. Only four waterbodies had a pH higher than 8.0, including one of the Congamond Lakes (Southwick), Porter Lake (Springfield), Harts Pond (Agawam), and Watershops Pond (Springfield). The latter three are urban ponds in the greater Springfield area, and along with Pequot Pond (Westfield), they are the only ones with with calcium levels higher than 20.0 mg/L.

II. Molluscs

Mollusc surveys were conducted in a total of 21 lakes and four rivers, and neither zebra mussel adults nor veligers were detected. Fourteen aquatic snail species were encountered during the survey and species richness ranged from zero to seven (average = 3.0) among the waterbodies (Table 4). The three lakes considered most susceptible to zebra mussel invasion (Ashfield Lake, Pequot Pond, and Congamond Lakes) contained a higher average species richness of aquatic snails (combined average = 6.0) than low-risk lakes (combined average = 2.4). Most snail species encountered are widespread in southern New England and not indicative of calcareous conditions. The most common native snail species were *Amnicola limosa*, *Physa gyrina*, and *Campeloma decisum*. *Amnicola limosa* was found in 12 lakes and three rivers, *Physa gyrina* was found in nine lakes and two rivers, and *Campeloma decisum* was found in seven lakes and two rivers. The non-native *Viviparus georgianus* was present in eight lakes and none of the river sites, making it far less prevalent in the region that it was in the Berkshire County lakes surveyed in

State-listed freshwater mussels were found during the survey, including this yellow lampmussel (*Lampsilis cariosa*; Endangered) from the Connecticut River.

Table 5. Native freshwater mussels and the non-native Asian clam (*Corbicula fluminea*) documented in lakes and rivers during the 2010 surveys.

	Bivalves								
Waterbody	CoFl	PyCa	ElCo	AnIm	LaRa	LaCa	LeOc	AlUn	# Taxa
Aldrich Lake	X	X	X						2
Ashfield Lake		X							1
Chicopee Reservoir			X						1
Chicopee River			X						1
Congamond Lakes	X	X	X						2
Connecticut River	X	X	X	X		X	X	X	6
Cranberry Pond		X							1
Deerfield River			X						1
Five Mile Pond		X	X						2
Forge Pond									0
Lake Mattawa			X						1
Lake Rohunta			X						1
Lake Warner		X	X						2
Lake Wyola									0
Laurel Lake			X						1
Littleville Lake		X	X						2
Lower Highland Lake		X							1
Metacomet Lake			X						1
Pelham Lake		X							1
Pequot Pond		X	X		X				3
Plainfield Pond		X							1
Porter Lake		X							1
Upper Highland Lake									0
West Lake									0
Westfield River			X					X	2
# Waterbodies	3	13	15	1	1	1	1	2	

Corbicula fluminea	CoFl	*Lampsilis radiata*	LaRa
Pyganodon cataracta	PyCa	*Lampsilis cariosa*	LaCa
Elliptio complanata	ElCo	*Leptodea ochracea*	LeOc
Anodonta implicata	AnIm	*Alasmidonta undulata*	AlUn

2009. The non-native *Cipangopaludina chinensis*, which was not detected in Berkshire County during the Phase I Assessment, was found in five lakes and in the Connecticut River.

Seven native mussel species were encountered during the survey (Table 5). *Elliptio complanata* was found in 11 lakes and all rivers and *Pyganodon cataracta* was found in 12 lakes and one river. *Lampsilis radiata* was only found in Pequot Pond, and four species—including *Lampsilis cariosa*, *Leptodea ochracea*, *Anodonta implicata*, and *Alasmidonta undulata*—were confined to the Connecticut River or Westfield River. Three of the mussel species are protected in Massachusetts and location data was submitted to the Massachusetts Natural Heritage and Endangered Species Program. A non-native bivalve, the Asian clam (*Corbicula fluminea*), was encountered in the Connecticut River, Aldrich Lake (Granby), Congamond Lakes (Southwick), and Five Mile Pond (Springfield). To our knowledge, these are the first reports of the Asian clam upstream of the Holyoke Dam in the Connecticut River and in Aldrich Lake.

III. Aquatic Plants

Species composition of aquatic plants was recorded for 19 lakes. A list of 30 genera and 56 species (including nine genera not identified to species) was compiled from field observations or available reports (Table 6). Our field observations were biased toward the more common aquatic plants that are recognizable early in the growing season, and thus our lists may have greatly underestimated species richness and community composition in most waterbodies. Other investigators had conducted moderately to highly rigorous aquatic plant inventories in Lake Rohunta, Laurel Lake, Lake Wyola, and Congamond Lakes. Average plant species richness for these four lakes was 24.7, whereas the 2010 fieldwork reported an average plant species richness of only 7.3 for the other 15 lakes. We cannot draw any conclusions about aquatic plant community patterns in these lakes because plant surveys were a small part of the fieldwork and survey effort was not consistent among lakes.

The most prevalent native submergent aquatic plants were species in the genus *Potamogeton* (especially *P. epihydrus*, *P. amplifolius*, and *P. robbinsii*), *Elodea* (*E. nuttallii* or *E. canadensis*), *Vallisneria americana*, and species in the genus *Utricularia* (seven species; most common were *U. purpurea* and *U. radiata*). Some of the more prevalent non-native submergent species included *Myriophyllum spicatum*, *Ceratophyllum demersum*, and *Najas minor*. *Trapa natans* was also observed in Forge Pond in Granby.

DISCUSSION

As described in the 2009 Phase I Assessment, weight-of-evidence suggests that zebra mussels may exist within a range of chemical conditions and are more likely to become established in waterbodies with high pH (>8.0) and high calcium (>20.0 mg/L). Studies that reviewed water chemistry parameters in waterbodies where zebra mussels are established are more informative than studies that attempt to predict where zebra mussels might occur based on thresholds. Zebra mussels are established in several northeastern lakes and rivers whose calcium concentrations may seem marginal based on early predictions, such as Lake Zoar in Connecticut (17.0 mg/L), Lake Bomoseen in Vermont (18.0 mg/L calcium), West Twin Lake in Connecticut (21.0 mg/L calcium), and portions of the lower Hudson River and middle and northern Lake Champlain (Cohen and Weinstein 2001, Pete Stangel, Vermont Agency of Natural Resources, personal communication). In 2010, zebra mussels were discovered in Lake Zoar and Lake Lillinonah in Connecticut (Biodrawversity 2010), which are large impoundments of the lower Housatonic River. More than 800 zebra mussels were collected from these two impoundments. Most individuals (>90 percent) were found in Lake Zoar, yet water chemistry in Lake Zoar is considered marginal (pH = 7.6, calcium = 17.0 mg/L). Although Lake Lillinonah is upstream of Lake Zoar and has higher calcium levels (23.1 mg/L) and similar pH (7.5), far fewer animals were found in Lake Lillinonah. The presence of zebra mussels in Lake Zoar indicates that other waterbodies with suitable pH and calcium levels in the mid to upper teens might be more susceptible than previously thought.

In this study, lakes were categorized according to their potential to support reproduction and growth of zebra mussels based primarily on water chemistry (calcium, pH, and alkalinity) but physical habitat was also considered because many

Table 6. Aquatic plants observed, or reported to occur, in study lakes and rivers. WL: Rare species, on the state's Watch List.

		Lakes and Ponds																			Rivers								
Species	Origin	Aldrich	Ashfield	Congamond	Cranberry	Five Mile	Forge	Laurel	Littleville	L. Highland	Metacomet	Pelham	Pequot	Plainfield	Rohunta	Porter	U. Highland	Warner	West	Wyola	Deerfield	Chicopee	Westfield	CT; Oxbow	CT; Easthampton	CT; Chicopee	CT; Gill	CT; Northfield	CT; Hatfield
Submerged Plants																													
Cabomba caroliniana	I										x				x														
Callitriche sp.	N-I	x		x	x	x																	x	x	x				
Ceratophyllum demersum	N	x		x			x						x			x				x							x		
Ceratophyllum echinatum	N														x			x						x					
Elatine minima	N							x																					
Elatine sp.	N			x																									
Elodea sp.	N	x	x	x	x	x	x		x		x					x		x				x		x			x	x	
Isoetes sp.	N											x	x				x			x									
Isoetes echinospora	N							x																					
Lobelia dortmanna	N							x																					
Myriophyllum heterophyllum	I														x														
Myriophyllum humile	N							x																					
Myriophyllum spicatum	I			x			x		x		x		x							x				x	x		x		
Myriophyllum tenellum	N			x																									
Najas sp.	N-I			x									x																
Najas flexilis	N			x				x							x														
Najas gracillima	N							x							x														
Najas guadalupensis	N			x																									
Najas minor	I			x																									
Podostemon ceratophyllum	N																					x							
Potamogeton amplifolius	N	x		x	x		x				x								x										
Potamogeton bicuspulatus	N			x																									
Potamogeton confervoides (WL)	N							x																					
Potamogeton crispus	I			x			x									x						x		x					
Potamogeton diversifolius	N							x																					
Potamogeton epihydrus	N		x		x			x		x					x			x		x							x		
Potamogeton gramineus	N			x																									
Potamogeton illinoensis	N			x																									
Potamogeton natans	N			x											x														
Potamogeton oakesianus	N							x																					
Potamogeton perfoliatum	N			x																									
Potamogeton pulcher	N														x														
Potamogeton pusillus	N			x											x														
Potamogeton robbinsii	N			x	x	x							x		x					x									
Potamogeton sp.	N	x	x	x	x	x							x			x	x			x				x	x	x	x	x	x
Proserpinaca palustris	N														x					x									
Sagittaria cristata	N			x																									
Scirpus subterminalis	N							x							x														
Stuckenia pectinata	N			x																									
Utricularia gibba	N												x		x														
Utricularia intermedia	N				x										x					x									
Utricularia macrorhiza	N				x			x		x					x														
Utricularia purpurea	N				x			x		x	x	x		x	x				x	x									
Utricularia radiata	N							x		x		x		x	x		x			x									
Utricularia resupinata (WL)	N							x																					
Utricularia sp.	N																x		x										
Utricularia vulgaris	N		x							x				x						x									
Vallisneria americana	N		x	x					x				x										x	x		x	x		
Zosterella dubia	N			x																									
Floating-leaved Plants																													
Brasenia schreberi	N				x		x	x			x	x		x	x				x	x									
Lemna minor	N	x		x			x								x	x		x											
Nuphar variegata	N			x	x		x	x					x	x	x					x									
Nymphaea odorata	N		x	x	x		x	x			x		x	x	x			x		x									
Nymphoides cordata	N							x						x	x														
Spirodela polyrhiza	N	x		x			x								x			x											
Trapa natans	I						x																						
Wolffia sp.	N	x		x			x											x											
Emergent Plants																													
Eloeocharis acicularis	N							x				x	x		x		x												
Eleocharis palustris	N														x														
Eleocharis robbinsii	N							x																					
Eriocaulon aquaticum	N							x							x					x									
Gratiola aurea	N			x				x					x																
Sparganium sp.	N	x			x		x			x		x					x	x	x	x		x	x						
Sparganium americanum	N			x				x							x														
Sparganium chlorocarpum	N														x														
Total Species		9	6	31	13	4	13	24	3	6	7	6	12	7	28	5	6	8	5	16	0	4	3	7	3	2	6	2	1

Table 7. Number and percent of waterbodies in the Connecticut River watershed with pH, calcium, and alkalinity within high, medium, or low ranges for susceptibility to zebra mussels.

Parameter	Number of Waterbodies	Percent of Waterbodies
pH (n = 108)		
High	4	3.7
Medium	16	14.8
Low	88	81.5
Calcium (n = 77)		
High	4	5.2
Medium	5	6.5
Low	68	88.3
Alkalinity (n = 99)		
High	0	0
Medium	25	25.3
Low	74	74.7

ponds assessed in this study were very small, shallow, heavily vegetated, and eutrophic (none of these traits are particularly suitable for zebra mussels). Among the 2010 survey sites and the ARM waterbodies in the Connecticut River watershed (a total of 108 waterbodies or river sites), 12 waterbodies had at least marginal pH (>7.4), nine waterbodies had at least marginal calcium levels (>12.0 mg/L), and 25 waterbodies had at least marginal alkalinity levels (>20.0 mg/L) (Tables 7-8). For the three water chemistry parameters combined, only nine waterbodies were classified as having medium or high risk of zebra mussel invasion (Table 8, Figure 3). Of these, four are small waterbodies in urban environments whose water chemistry is strongly influenced by myriad effects of urbanization and whose physical habitat is generally not suitable for zebra mussels and that receive no boat traffic. These include Watershops Pond (Springfield), Porter Lake (Springfield), Harts Pond (Agawam), and Silver Lake (Agawam). Wright Pond (Holyoke) has marginal water chemistry for zebra mussels but it is also a municipal water supply with no boat access or fishing allowed. We did not assess the habitat or biological community of Wright Pond. McLoed Pond is a small pond embedded in the Catamont State Forest in Colrain and has unusually high calcium levels (13.2 mg/L) and pH (7.4) for small high-elevation ponds in the region; we consider this pond only marginally susceptible to zebra mussels.

Only three waterbodies in the watershed with suitable water chemistry (medium or high risk) were considered to have physical habitat that would support zebra mussels and are accessible. These included Congamond Lakes (Southwick), Pequot Pond (Westfield), and Ashfield Lake (Ashfield). We consider these lakes at medium to high risk although calcium levels in Congamond Lakes (15.0 mg/L) and Ashfield Lake (14.0 mg/L) are toward the low end of zebra mussel's tolerance range. Pequot Pond has calcium levels of 20.0 mg/L and a pH of 7.7, making its chemical environment more suitable for zebra mussels than some other waterbodies in New England where zebra mussels are already established. We believe it is unlikely that zebra mussels could become established in the Connecticut River in Massachusetts based on low calcium, although other studies have suggested the Connecticut River might be at risk (Murray *et al.* 1993, Smith 1993). We also do not consider the Quabbin Reservoir capable of supporting zebra mussels based on low pH, calcium, and alkalinity.

Figure 4 shows susceptibility of 166 waterbodies in central and western Massachusetts to the establishment of zebra mussels based on available water chemistry data. The regional analysis includes the Connecticut, Housatonic, and Hudson River basins of Berkshire, Hampden, Hampshire, and Franklin counties as well as western parts of Worcester County that occur within the Connecticut River watershed. Nearly all of the naturally susceptible waterbodies in this region occur in the low elevation areas of the Housatonic and Hoosic watersheds. This

Table 8. Risk assessment for waterbodies in the Connecticut River watershed based on water chemistry and physical habitat. Only waterbodies with medium or high risk based on one or more chemical parameters are listed here. Appendix 2 provides a complete list of waterbodies and chemical parameters.

			Risk Based on Water Chemistry Alone				Considering	
Name	Town	Subwatershed	pH	Calcium	Alkalinity	Overall	Habitat	Data Source
Pequot Pond	Westfield	Connecticut	Medium	High	Medium	High	High	2010
Harts Pond	Agawam	Connecticut	High	Medium	Medium	High	Low	ARM
Porter Lake	Springfield	Connecticut	High	Medium	Medium	High	Low	2010
Watershops Pond	Springfield	Connecticut	High	Medium	Medium	High	Low	2010
Mcleod Pond; Crouch Pd	Colrain	Deerfield	Medium	Medium	Medium	Medium	?	ARM
Silver Lake	Agawam	Connecticut	Medium	Medium	Medium	Medium	Low	ARM
Ashfield Lake	Ashfield	Deerfield	Medium	Medium	Medium	Medium	Medium	2010
Wright Pond	Holyoke	Westfield	Medium	Medium	Medium	Medium	Medium	ARM
Congamond Lakes	Southwick	Westfield	High	Medium	Medium	Medium	Medium	2010
Newell Pond	Greenfield	Deerfield	Low	-	Medium	Low	Low	ARM
Robin Hood Lake	Becket	Westfield	Low	Low	Medium	Low	Low	ARM
Atwater Pond; Shade Pd	Sandisfield	Farmington	Low	Low	Medium	Low	Low	ARM
West Lake	Sandisfield	Farmington	Low	Low	Medium	Low	Low	ARM
Lake Warner	Hadley	Connecticut	Low	Low	Medium	Low	Low	2010
West Lake	Sandisfield	Farmington	Medium	Low	Medium	Low	Low	2010
Connecticut River	6 Sites	Connecticut	Medium	Low	Medium	Low	Low	2010
Aldrich Lake	Granby	Connecticut	Medium	Low	Medium	Low	Low	2010
Center Pond	Becket	Westfield	Medium	Low	Medium	Low	Low	2009
Five Mile Pond	Springfield	Connecticut	Medium	Low	Low	Low	Low	2010
Shaw Pond	Otis/Becket	Farmington	Medium	Low	Medium	Low	Low	2009

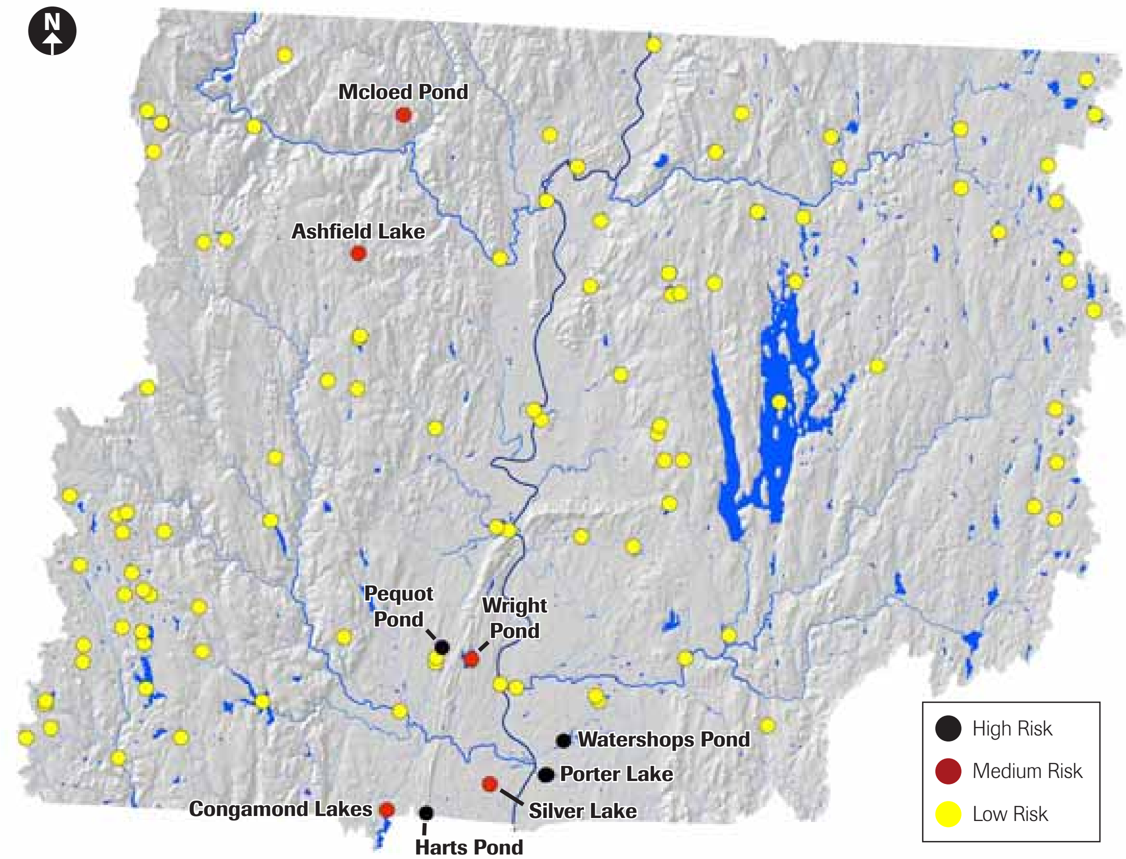

Figure 3. Risk assessment for waterbodies in the Connecticut River watershed based on water chemistry (2010 field studies and ARM data). Of these, only Congamond Lakes, Pequot Pond, and Ashfield Lake are thought to provide suitable habitat and are accessible.

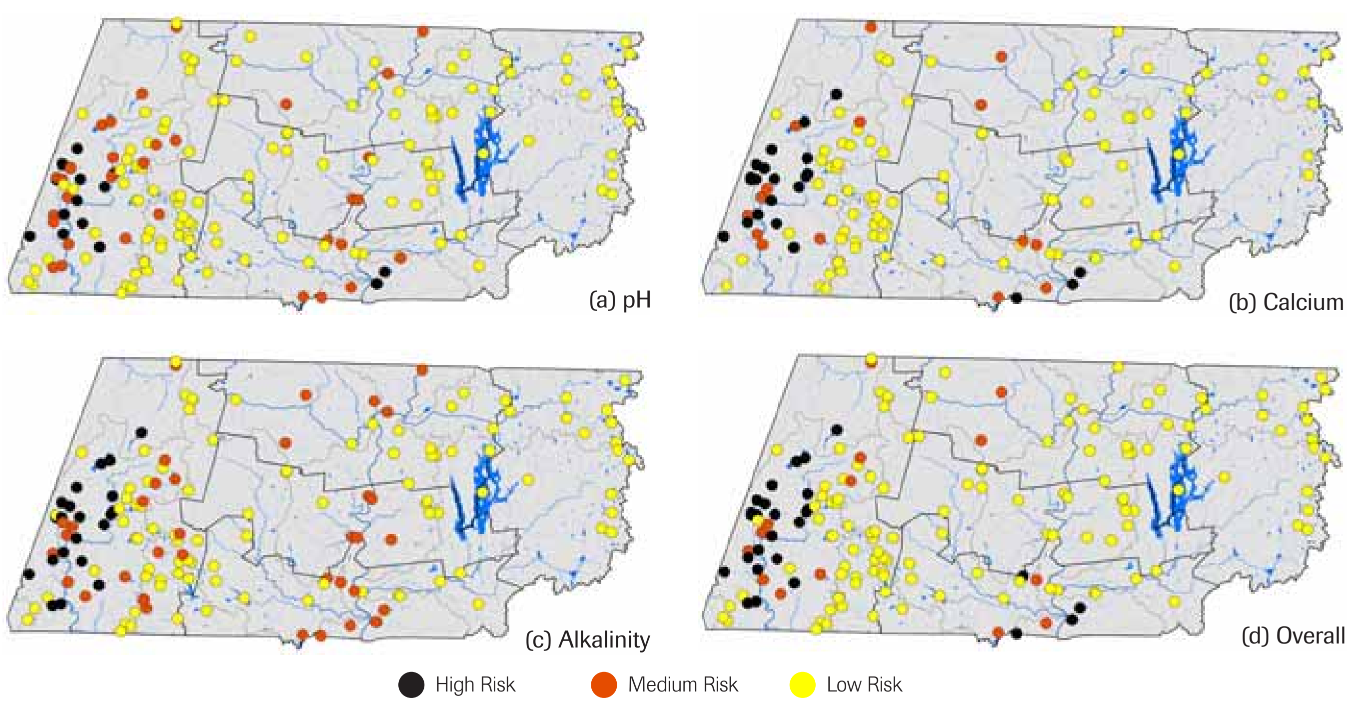

Figure 4. Susceptibility of waterbodies in central and western Massachusetts to zebra mussels based on (a) pH, (b) calcium, (c) alkalinity, and (d) combination of a-c. Habitat suitability is not considered in these maps, although most medium and high risk waterbodies in the southern Connecticut River watershed do not provide suitable zebra mussel habitat.

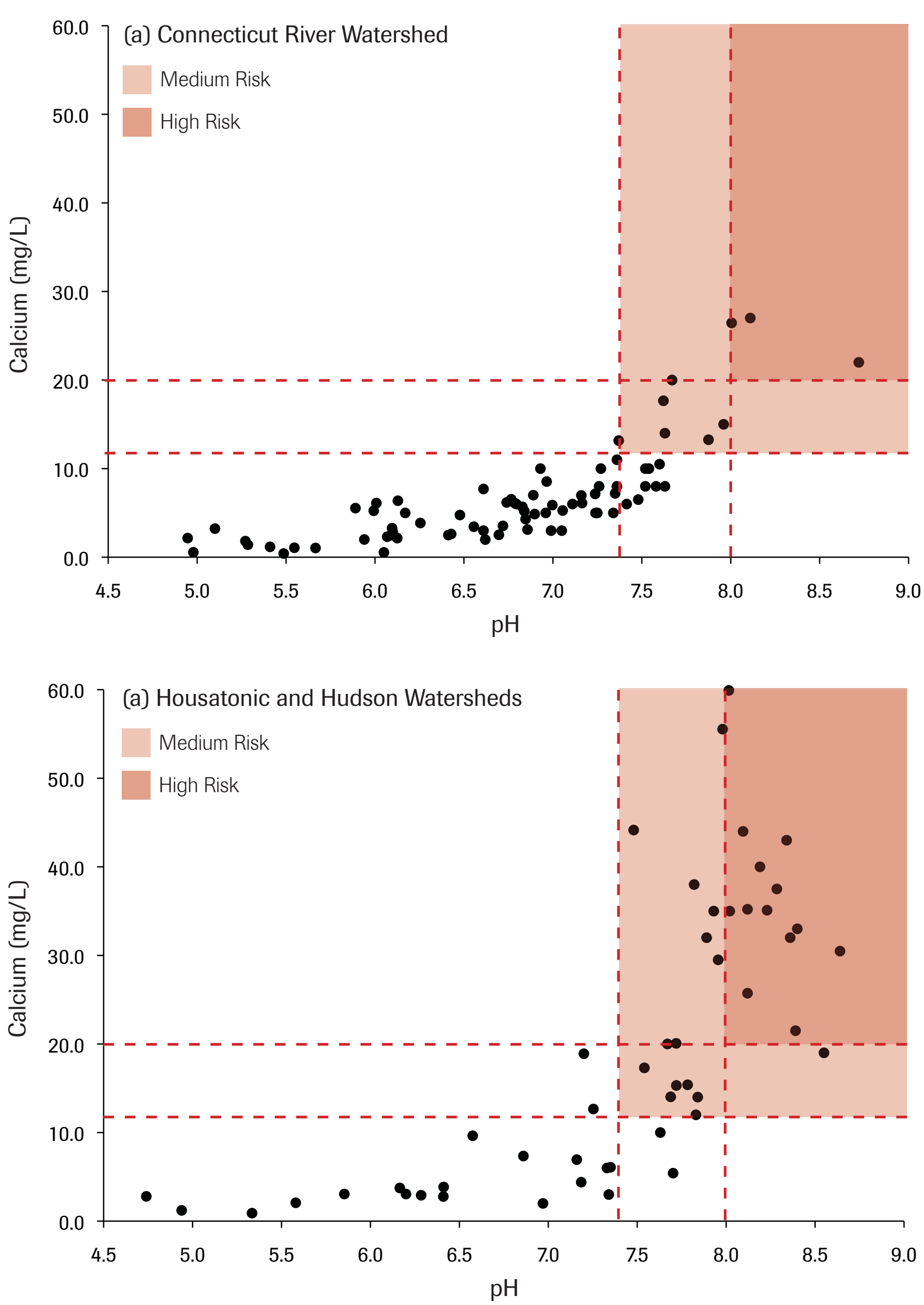

Figure 5. Plot of pH versus calcium for waterbodies in (a) the Connecticut River watershed, and (b) the Housatonic and Hudson watersheds of Massachusetts for which data were available on both parameters. Medium and high risk waterbodies are shown using thresholds outlined in Table 2.

area is part of the Western New England Marble Valleys ecoregion that is characterized by calcium-rich soil and water and extensive groundwater aquifers. Plots of pH versus calcium for waterbodies in the Connecticut River watershed (Figure 5a) and the Housatonic and Hudson River watersheds (Figure 5b), with risk thresholds overlaid on the plots, clearly show differences in the suscepibility of waterbodies in these areas.

Heavy recreational use increases the probability of zebra mussel introduction. The scientific literature shows that multiple introductions are needed to establish a population (Johnson and Carlton 1996, Padilla *et al.* 1996, Schneider *et al.* 1998, Kraft and Johnson 2000, Bossenbroek *et al.* 2001). Pequot Pond is very accessible, has multiple launch sites, and receives a fair amount of visitation. The Congamond Lakes are also very accessible, have multiple launch sites, and receive high visitation including competitive bass tournaments that draw anglers from around the region. This is one of the first lakes in southern New England where Asian clams became established and it is also infested with a variety of invasive aquatic plants. In 2008, 48 boats last used in zebra mussel infested waters (Lake George NY, Twin Lakes CT, Lake Ontario NY, and Lake Champlain VT) were launched in the Congamond Lakes (DCR 2008), indicating a high prevalence of potential dispersal vectors. Ashfield Lake is much smaller and primarily draws local anglers, especially because its small size and small ramp precludes foreign motorboats. Of the three lakes, Pequot Pond and Congamond Lakes are probably most in need of zebra mussel education and monitoring.

Despite the broad ecological tolerance of most snail species we encountered, there appeared to be a positive correlation between snail species richness, pH, and calcium (Figure 6). Poorly buffered, low-calcium lakes tended to have low species richness of aquatic snails compared to well-buffered high-calcium lakes. Neither of the two calciphilous snail species documented in the Phase I Assessment—*Marstonia lustrica* and *Valvata tricarinata*—were found in the 2010 study, but species richness of other documented snails followed the same trends observed in the Phase I Assessment. Lakes assessed in the 2010 study usually lacked algae of the genus *Chara*, a biological indicator of calcareous lakes found in several lakes in Berkshire County. The one exception was Congamond Lakes where *Chara* was reported in a 2009 study (Northeast Aquatic Research 2009), although we did not detect *Chara* in our more limited surveys. Marl, a calcium precipitate that settles on the bottom of calcareous lakes and is therefore a reliable predictor of high calcium levels, was not observed in any of the 2010 study lakes but was observed in several Berkshire County lakes.

Although there are a small number of lakes in the Connect-

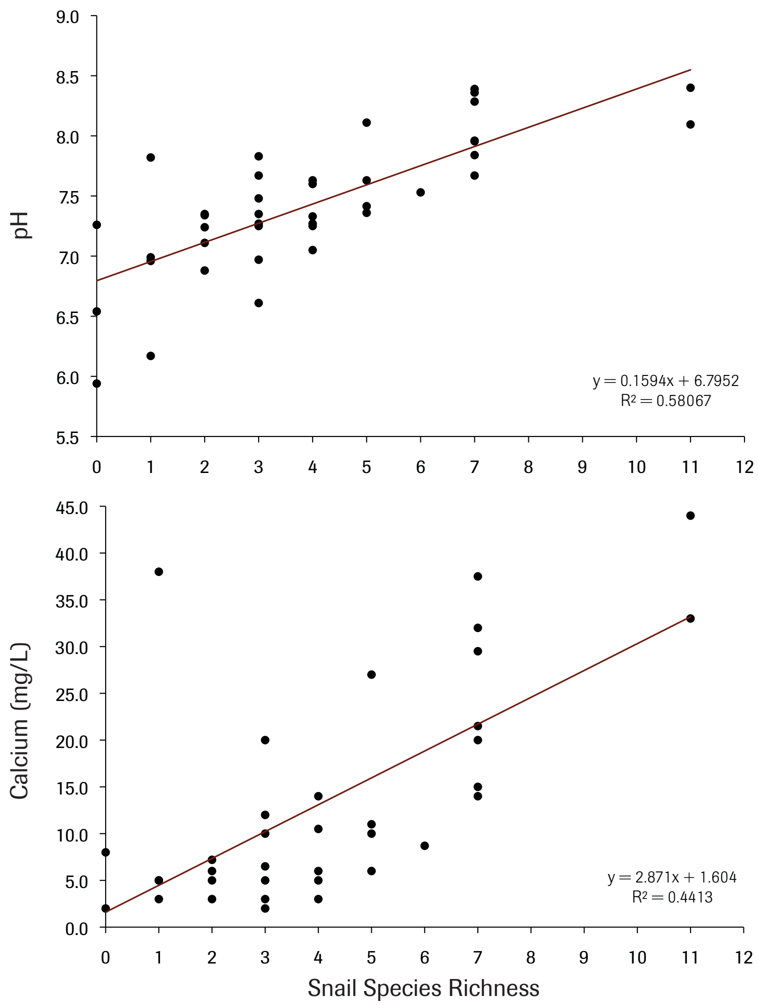

Figure 6. Correlation between snail species richness, pH, and calcium using data from the Phase I and Phase II zebra mussel assessments.

icut River watershed that might support zebra mussels, none are considered optimal for this species and they generally lack many of the strongest biological indicators of high-risk lakes that were documented in Berkshire County. Nevertheless, Pequot Pond has higher pH and calcium levels than several other waterbodies in the Northeast where zebra mussels are already established and should be considered at high risk. Congamond Lakes and Ashfield Lake may be less suitable for zebra mussels than Pequot Pond but might still be vulnerable. Anglers and boaters should carefully follow established decontamination procedures when visiting or leaving the Congamond Lakes, Pequot Pond, and Ashfield Lake. Signage and boat ramp monitoring are recommended. Periodic aquatic surveys are recommended to increase chances of early detection.

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Appendix 1
Survey Locations and Methods in Target Waterbodies

			Methods							
Waterbody/Site	Latitude	Longitude	SCUBA	Snorkel (1)	D-Net (1)	Plankton	Lab Chem (2)	Field Chem (3)	DO (4)	Secchi (5)
Aldrich Lake	42.283538	-72.532216	X		X	X	X(1)	X	X	X
Arcadia Lake	42.313433	-72.428034						X		
Ashfield Lake										
Boat Ramp	42.529164	-72.800575	X		X	X	X(1)	X	X	X
Ashfield 2	42.530751	-72.799297	X							
Ashfield 3	42.533069	-72.802709	X							
Chicopee Reservoir	42.170664	-72.551737		X		X	X(1)	X		
Chicopee River	42.150262	-72.606534		X	X	X	X(1)	X	X	
Congamond Lakes									X	
North Boat Ramp	42.041402	-72.757278	X	X	X	X	X(1)	X		X
Babb's Beach	42.030070	-72.751955	X	X	X			X		
Kayak Access	42.019983	-72.763878		X	X			X		X
South Boat Ramp	42.020726	-72.768638	X	X	X	X	X(1)	X		X
Ayotte Ramp	42.007887	-72.766387	X	X	X	X		X		X
Connecticut River										
Chicopee	42.153291	-72.625677	X			X	X(1)	X	X	
Easthampton	42.288396	-72.618225	X			X	X(1)	X	X	
Gill	42.607644	-72.541690		X	X	X	X(1)	X	X	
Hatfield	42.394002	-72.589958	X		X	X	X(1)	X	X	
Northfield	42.715502	-72.453044	X		X	X	X(1)	X	X	
Oxbow	42.291022	-72.632456	X			X	X(1)	X	X	X
Cranberry Pond	42.503210	-72.525140		X	X	X	X(1)	X		
Damon Pond	42.417348	-72.834562						X		
Deerfield River	42.526600	-72.632300		X		X	X(1)	X		
Five-mile Pond	42.139820	-72.509305	X		X	X	X(1)	X	X	X
Forge Pond	42.275339	-72.470454	X		X	X		X		X
Hammond Pond	42.410453	-72.799478						X		
Lake Mattawa	42.570433	-72.327450		X	X	X		X	X	
Lake Rohunta	42.565597	-72.273055		X	X		X(1)	X	X	
Lake Warner	42.385829	-72.581083	X	X	X	X	X(1)	X	X	X
Lake Wyola										
Boat Ramp	42.496678	-72.428338	X	X	X		X(1)	X		
Dam	42.501976	-72.436087	X			X	X(1)	X		
Laurel Lake	42.622067	-72.377867		X	X		X(1)	X	X	
Littleville Lake									X	
Littleville 1	42.293591	-72.899532	X	X	X		X(2)	X		
Littleville 2	42.268928	-72.879976	X	X	X	X		X		X
Littleville 3	42.263061	-72.880123	X	X	X			X		
Lower Highland Lake	42.454628	-72.798488	X		X	X	X(1)	X	X	X
Metacomet Lake	42.303632	-72.430546		X	X			X	X	X
Pelham Lake									X	
Dam	42.699724	-72.894361	X		X	X		X		X
Percy's Point	42.702204	-72.891689		X		X				
Pelham 3	42.698233	-72.868920	X							
Pequot Pond									X	
Boat Ramp	42.178942	-72.696935	X	X	X	X	X(2)	X		X
Pequot 2	42.187646	-72.696022	X	X	X			X		
Pequot 3	42.185462	-72.691626	X	X	X	X		X		
Pequot 4	42.181186	-72.691218	X	X	X			X		
Plainfield Pond	42.539758	-72.958162	X		X	X		X	X	
Porter Lake	42.074291	-72.569018			X	X	X(1)	X	X	
Upper Highland Lake	42.457269	-72.797214	X		X	X	X(1)	X	X	X
Watershops Pond	42.104163	-72.549690					X(1)	X		
West Lake	42.129337	-73.162086	X		X	X	X(1)	X	X	
Westfield Reservoir	42.192612	-72.810558						X		
Westfield River	42.128285	-72.743339	X		X	X	X(1)	X	X	

(1) Snorkel refers to visual surveys while snorkeling in shallow water, whereas D-net refers to surveys done while wading in shallow water and using an aquatic D-net to collect organisms.
(2) pH, alkalinity, calcium, TSS, total nitrates, total phosphates at Berkshire Envirolabs or Spectrum Analytical. Number of sample bottles in parentheses.
(3) DO, pH, conductivity, and temperature at time of water sample collection
(4) Secchi depth not recorded for shallow lakes where the bottom was always visible from the surface.
(5) Dissolved oxygen data for lakes and ponds was collected both near the surface and near the bottom, or as deep as the equipment permitted. Only near-surface DO data was collected for rivers.

Appendix 2
Location, Chemistry Data, and Risk Assessment for Regional Waterbodies

SOURCES OF INFORMATION

2009 = Biodrawversity. 2009. Zebra Mussel Phase I Assessment: Physical, Chemical, and Biological Evaluation of 20 Lakes and the Housatonic River in Berkshire County, Massachusetts. Report submitted to the Massachusetts Department of Conservation and Recreation, Lakes and Ponds Program.

2010 = Biodrawversity. 2010. Zebra Mussel Phase II Assessment. Physical, Chemical, and Biological Evaluation of Waterbodies in the Connecticut River Watershed of Massachusetts. Report submitted to the Massachusetts Department of Conservation and Recreation, Lakes and Ponds Program.

ARM = Acid Rain Monitoring Project Data, a project of the Water Resources Reseach Center at the University of Massachusetts Amherst. Online database at: www.umass.edu/tei/wrrc/arm/

Name	Town	County	Major Watershed	Watershed	pH	Calcium	Alkalinity	Longitude	Latitude	Source	Risk
Aldrich Lake	Granby	Hampshire	Connecticut	Connecticut	7.4	11.0	32.0	-72.5322	42.2835	2010	Low
Ames Pond	Shutesbury	Franklin	Connecticut	Connecticut	5.4	1.2	0.3	-72.4186	42.4978	ARM	Low
Anthony Pond	Dalton	Berkshire	Housatonic	Housatonic	5.9	3.1	2.4	-73.1594	42.5089	ARM	Low
Arcadia Lake	Belchertown	Hampshire	Connecticut	Connecticut	7.2	-	-	-72.4280	42.3134	2010	Low
Ashfield Lake	Ashfield	Franklin	Connecticut	Deerfield	7.6	14.0	34.0	-72.8006	42.5292	2010	Medium
Ashley Lake	Washington	Berkshire	Housatonic	Housatonic	7.7	5.4	42.3	-73.1631	42.3806	ARM	Low
Ashley Reservoir	Dalton	Berkshire	Housatonic	Housatonic	7.2	4.4	11.6	-73.1964	42.4133	ARM	Low
Ashmere Lake	Hinsdale/Peru	Berkshire	Housatonic	Housatonic	7.6	10.0	31.5	-73.0814	42.4368	2009	Low
Atkins Reservoir	Shutesbury	Franklin	Connecticut	Connecticut	6.1	2.2	1.0	-72.4875	42.4258	ARM	Low
Atwater Pond	Sandisfield	Berkshire	Connecticut	Farmington	7.2	7.0	20.8	-73.1544	42.1083	ARM	Low
Bassett Pond	New Salem	Franklin	Connecticut	Millers	5.5	1.1	0.9	-72.2815	42.5093	ARM	Low
Beaver Pond	Monson	Hampden	Connecticut	Chicopee	6.5	-	9.8	-72.9824	42.2166	ARM	Low
Beinecke Pond	Great Barrington	Berkshire	Housatonic	Housatonic	8.1	25.7	72.2	-73.3186	42.2286	ARM	High
Belmont Reservoir	Hinsdale	Berkshire	Housatonic	Housatonic	4.9	1.2	-0.2	-73.1500	42.4314	ARM	Low
Benedict Pond	Great Barrington	Berkshire	Housatonic	Housatonic	7.0	2.0	8.0	-73.2865	42.2039	2009	Low
Benton Pond	Otis	Berkshire	Connecticut	Farmington	6.9	-	17.3	-73.0467	42.1844	ARM	Low
Berry Pond	Hancock	Berkshire	Hudson	Kinderhook	6.4	2.8	2.0	-73.3189	42.5053	ARM	Low
Bickford Pond	Hubbardston	Worcester	Connecticut	Chicopee	6.1	-	1.5	-71.9276	42.4859	ARM	Low
Big Pond	Otis	Berkshire	Connecticut	Farmington	6.9	10.0	-	-73.0491	42.1942	2009	Low
Blair Pond	Blandford	Hampden	Connecticut	Westfield	6.6	-	7.0	-72.9775	42.1780	ARM	Low
Bog Pond	Savoy	Berkshire	Connecticut	Deerfield	7.2	6.1	11.4	-73.0375	42.6412	ARM	Low
Bog Pond; Anthony Pond	Savoy	Berkshire	Connecticut	Deerfield	6.0	6.1	3.9	-73.0367	42.6406	ARM	Low
Bourne Pond	Richmond	Berkshire	Housatonic	Housatonic	8.2	35.1	98.3	-73.3694	42.3778	ARM	High
Brass Mill Pond	Williamsburg	Hampshire	Connecticut	Connecticut	7.3	-	15.6	-72.7065	42.3770	ARM	Low
Brookside Pond	Great Barrington	Berkshire	Housatonic	Housatonic	7.7	14.0	52.7	-73.3536	42.1758	ARM	Medium
Browning Pond	Oakham	Worcester	Connecticut	Chicopee	6.5	-	4.3	-71.9969	42.3133	ARM	Low
Buck Pond	Westfield	Hampden	Connecticut	Westfield	7.1	-	19.5	-72.7022	42.1712	ARM	Low
Buckley-Dunton Lake	Becket	Berkshire	Connecticut	Westfield	6.1	2.3	2.1	-73.1375	42.3125	ARM	Low
Burnett Pond	Savoy	Berkshire	Connecticut	Deerfield	6.6	-	8.5	-73.0458	42.6158	ARM	Low
Card Pond	West Stockbridge	Berkshire	Housatonic	Housatonic	7.1	-	32.0	-73.3667	42.3267	ARM	Low
Carter Pond	Petersham	Worcester	Connecticut	Chicopee	6.9	-	7.9	-72.1838	42.4358	ARM	Low
Center Pond	Becket	Berkshire	Connecticut	Westfield	7.4	6.0	22.0	-73.0697	42.2984	2009	Low
Cheshire Reservoir	Cheshire	Berkshire	Housatonic	Housatonic	8.0	29.5	104.0	-73.1667	42.5556	2009	High
Chicopee Brook Pond	Monson	Hampden	Connecticut	Chicopee	6.8	6.5	12.4	-72.3097	42.1197	ARM	Low
Chicopee Reservoir	Ludlow	Hampden	Connecticut	Chicopee	7.1	6.0	8.0	-72.4076	42.1778	2010	Low
Chicopee River	Chicopee	Hampden	Connecticut	Chicopee	7.3	5.0	8.0	-72.6065	42.1503	2010	Low
Chimney Corners Pond	Becket	Berkshire	Connecticut	Westfield	6.3	3.9	4.5	-73.0742	42.2811	ARM	Low
Choquettes Pond	Clarksburg	Berkshire	Hudson	Hoosic	7.8	15.4	35.2	-73.0792	42.7264	ARM	Medium
Church Hill Pond	Otis	Berkshire	Connecticut	Farmington	6.7	6.2	9.0	-73.0703	42.2264	ARM	Low
Clam River	Sandisfield	Berkshire	Connecticut	Farmington	7.0	-	11.2	-73.0744	42.0831	ARM	Low
Clapp Pond	Washington	Berkshire	Housatonic	Housatonic	6.2	3.1	3.0	-73.1792	42.3717	ARM	Low
Cleveland Bk Reservoir	Hinsdale	Berkshire	Housatonic	Housatonic	7.2	6.9	12.5	-73.1125	42.4656	ARM	Low
Cloverdale Lane Pond	Rutland	Worcester	Connecticut	Chicopee	6.1	0.5	5.9	-71.9727	42.3993	ARM	Low
Cobble Mtn. Reservoir	Blandford	Hampden	Connecticut	Westfield	6.7	2.5	4.5	-72.9058	42.1349	ARM	Low
Cold River	Florida	Berkshire	Connecticut	Deerfield	6.6	3.4	4.9	-72.9269	42.6394	ARM	Low
Cone Brook Pond	Richmond	Berkshire	Housatonic	Housatonic	8.0	55.5	176.4	-73.3701	42.3404	ARM	High
Congamond Lakes	Southwick	Hampden	Connecticut	Westfield	8.0	15.0	44.0	-72.7573	42.0414	2010	Medium
Connecticut River	Northfield	Franklin	Connecticut	Connecticut	7.5	8.0	29.0	-72.4530	42.7155	2010	Low
Connecticut River	Gill	Franklin	Connecticut	Connecticut	7.6	8.0	26.0	-72.5417	42.6076	2010	Low
Connecticut River	Chicopee	Hampden	Connecticut	Connecticut	7.4	8.0	26.0	-72.6257	42.1533	2010	Low
Connecticut River	Hatfield	Hampshire	Connecticut	Connecticut	7.6	8.0	26.0	-72.5900	42.3940	2010	Low
Connecticut River	Easthampton	Hampshire	Connecticut	Connecticut	7.5	10.0	26.0	-72.6182	42.2884	2010	Low

Appendix 2. (continued)

Name	Town	County	Major Watershed	Watershed	pH	Calcium	Alkalinity	Longitude	Latitude	Source	Risk
Connecticut River	Northampton	Hampshire	Connecticut	Connecticut	7.5	10.0	22.0	-72.6325	42.2910	2010	Low
Conwell Pond	Worthington	Hampshire	Connecticut	Westfield	6.8	5.7	11.3	-72.8953	42.3492	ARM	Low
Coombes Dam Pond	Sheffield	Berkshire	Housatonic	Housatonic	7.8	-	126.5	-73.3928	42.1161	ARM	High
Cowee Pond	Gardner	Worcester	Connecticut	Millers	5.3	1.8	-0.3	-71.9830	42.6127	ARM	Low
Cranberry Pond	Sunderland	Hampshire	Connecticut	Connecticut	7.0	5.0	12.0	-72.5251	42.5032	2010	Low
Cranberry Pond	West Stockbridge	Berkshire	Housatonic	Housatonic	7.5	44.2	1.4	-73.3839	42.3458	ARM	High
Crane Lake	West Stockbridge	Berkshire	Housatonic	Housatonic	8.1	35.2	126.2	-73.3839	42.3397	ARM	High
Watson Pond	Otis	Berkshire	Connecticut	Farmington	6.6	7.7	9.8	-73.0486	42.2311	ARM	Low
Crystal Lake	Palmer	Hampden	Connecticut	Chicopee	5.0	0.6	-0.5	-72.3561	42.1984	ARM	Low
Crystal Lake	Richmond	Berkshire	Housatonic	Housatonic	8.0	59.9	124.5	-73.3492	42.3683	ARM	High
Curtin Pond	Otis	Berkshire	Housatonic	Housatonic	6.6	9.6	14.9	-73.1556	42.1894	ARM	Low
Damon Pond	Chesterfield	Hampshire	Connecticut	Westfield	6.5	-	-	-72.8346	42.4173	2010	Low
Davis Pond	Sheffield	Berkshire	Housatonic	Housatonic	4.7	2.8	1.0	-73.4056	42.1361	ARM	Low
Day Mill Pond	Templeton	Worcester	Connecticut	Millers	6.1	6.4	6.3	-72.0864	42.5925	ARM	Low
Deerfield River	Florida	Berkshire	Connecticut	Deerfield	6.7	3.5	5.9	-72.5783	42.5778	ARM	Low
Deerfield River	Deerfield	Franklin	Connecticut	Deerfield	7.3	8.0	6.0	-72.6323	42.5266	2010	Low
Demond Pond	Rutland	Worcester	Connecticut	Chicopee	6.8	6.1	8.9	-71.9708	42.3521	ARM	Low
Dimmock Brook Pond	Otis	Berkshire	Connecticut	Farmington	5.9	5.5	5.0	-73.0728	42.1978	ARM	Low
Doe Pond	Westfield	Hampden	Connecticut	Westfield	5.5	0.4	1.9	-72.7017	42.1755	ARM	Low
East Indies Pond	New Marlborough	Berkshire	Housatonic	Housatonic	6.9	7.4	16.0	-73.1933	42.0636	ARM	Low
Farnham Reservoir	Washington	Berkshire	Housatonic	Housatonic	6.3	2.9	1.3	-73.2042	42.3889	ARM	Low
Felton Lake	Washington	Berkshire	Housatonic	Housatonic	6.0	-	2.7	-73.2228	42.3625	ARM	Low
Fiske Pond	Wendell	Franklin	Connecticut	Connecticut	5.3	-	0.1	-72.4320	42.5155	ARM	Low
Five Mile Pond	Springfield	Hampden	Connecticut	Connecticut	7.5	6.5	16.6	-72.5093	42.1398	2010	Low
Forge Pond	Granby	Hampshire	Connecticut	Connecticut	7.3	-	-	-72.4705	42.2753	2010	Low
Garnet Lake	Peru	Berkshire	Connecticut	Westfield	6.4	4.3	6.4	-73.0475	42.4083	ARM	Low
Goose Pond	Lee/Tyringham	Berkshire	Housatonic	Housatonic	7.3	6.0	13.0	-73.1808	42.2874	2009	Low
Greenwood Pond	Templeton	Worcester	Connecticut	Millers	5.1	3.2	0.8	-72.0410	42.5542	ARM	Low
Guilder Pond	Mount Washington	Berkshire	Hudson	Babish	4.3	-	-3.1	-73.4375	42.1083	ARM	Low
Hammond Pond	Chesterfield	Hampshire	Connecticut	Westfield	6.9	-	-	-72.7995	42.4105	2010	Low
Harts Pond	Agawam	Hampden	Connecticut	Connecticut	8.0	26.5	44.2	-72.7105	42.0391	ARM	High
Hawley Reservoir	Pelham	Hampshire	Connecticut	Connecticut	6.1	2.5	2.2	-72.4431	42.3751	ARM	Low
Hay Meadow Pond	New Marlborough	Berkshire	Connecticut	Farmington	7.3	-	18.9	-73.2198	42.0498	ARM	Low
Hayes Pond	Otis	Berkshire	Housatonic	Housatonic	6.4	3.9	4.0	-73.1472	42.2089	ARM	Low
Hill Reservoir	Pelham	Hampshire	Connecticut	Connecticut	6.1	-	2.4	-72.4404	42.3816	ARM	Low
Horn Pond	Becket	Berkshire	Connecticut	Westfield	6.8	5.2	10.4	-73.0250	42.2825	ARM	Low
Housatonic River	Lenox	Berkshire	Housatonic	Housatonic	7.9	32.0	131.0	-73.2405	42.3939	2009	High
Housatonic River	Lenox	Berkshire	Housatonic	Housatonic	7.9	35.0	131.0	-73.2447	42.3475	2009	High
Housatonic River	Lee	Berkshire	Housatonic	Housatonic	8.0	35.0	135.0	-73.2752	42.2781	2009	High
Housatonic River	Stockbridge	Berkshire	Housatonic	Housatonic	8.2	40.0	139.0	-73.3324	42.2870	2009	High
Housatonic River	Stockbridge	Berkshire	Housatonic	Housatonic	8.3	43.0	141.0	-73.3654	42.2513	2009	High
Knights Pond	Belchertown	Hampshire	Connecticut	Chicopee	5.5	-	0.3	-72.4128	42.3516	ARM	Low
Lake Averic	Stockbridge	Berkshire	Housatonic	Housatonic	7.2	18.9	35.1	-73.3425	42.3167	ARM	Medium
Lake Buel	Monterey	Berkshire	Housatonic	Housatonic	8.4	32.0	132.0	-73.2750	42.1678	2009	High
Lake Denison	Winchendon	Worcester	Connecticut	Millers	6.0	5.2	1.7	-72.0871	42.6442	ARM	Low
Lake Garfield	Monterey	Berkshire	Housatonic	Housatonic	7.8	14.0	46.0	-73.2088	42.1899	2009	Medium
Lake Lorraine	Springfield	Hampden	Connecticut	Chicopee	6.9	3.1	7.8	-72.5127	42.1439	ARM	Low
Lake Mansfield	Great Barrington	Berkshire	Housatonic	Housatonic	8.6	19.0	-	-73.3675	42.2018	2009	High
Lake Mattawa	Orange	Franklin	Connecticut	Millers	7.3	-	-	-72.3275	42.5704	2010	Low
Lake Pleasant	Montague	Franklin	Connecticut	Connecticut	6.4	2.5	2.3	-72.5133	42.5606	ARM	Low
Lake Rohunta	Orange	Franklin	Connecticut	Millers	6.6	3.0	4.0	-72.2731	42.5656	2010	Low
Lake Warner	Hadley	Hampshire	Connecticut	Connecticut	7.3	10.0	22.0	-72.5811	42.3858	2010	Low
Lake Watatic	Ashburnham	Worcester	Connecticut	Millers	5.6	-	1.6	-71.9379	42.6884	ARM	Low
Lake Wyola	Shutesbury	Franklin	Connecticut	Connecticut	6.2	5.0	2.0	-72.4283	42.4967	2010	Low
Laurel Lake	Erving	Franklin	Connecticut	Millers	5.9	2.0	4.0	-72.3779	42.6221	2010	Low
Laurel Lake	Lee/Lenox	Berkshire	Housatonic	Housatonic	8.1	44.0	162.0	-73.2620	42.3219	2009	High
Lee Pond	Mount Washington	Berkshire	Hudson	Babish	4.3	-	-2.9	-73.4556	42.0803	ARM	Low
Littleville Lake	Chester	Hampden	Connecticut	Westfield	7.2	5.0	10.0	-72.8995	42.2936	2010	Low
Long Pond	Great Barrington	Berkshire	Housatonic	Housatonic	7.7	20.1	67.6	-73.3917	42.2317	ARM	High
Lovewell Pond	Hubbardston	Worcester	Connecticut	Chicopee	5.9	-	1.3	-71.9569	42.5107	ARM	Low
Lower Highland Lake	Goshen	Hampshire	Connecticut	Connecticut	7.0	3.0	6.0	-72.7985	42.4546	2010	Low
Lower Spectacle Pond	Sandisfield	Berkshire	Connecticut	Farmington	6.5	4.8	6.3	-73.1186	42.1667	ARM	Low
Mauserts Pond	Clarksburg	Berkshire	Hudson	Hoosic	6.6	-	10.6	-73.0792	42.7367	ARM	Low
Mcleod Pond	Colrain	Franklin	Connecticut	Deerfield	7.4	13.2	21.5	-72.7492	42.6514	ARM	Medium
Mill Pond	Sheffield	Berkshire	Housatonic	Housatonic	7.9	-	88.5	-73.3714	42.1203	ARM	High
Minott Pond South	Westminster	Worcester	Connecticut	Millers	4.9	2.2	-0.3	-71.9604	42.5313	ARM	Low
Mohawk Lake	Stockbridge	Berkshire	Housatonic	Housatonic	7.5	17.3	55.3	-73.3569	42.2958	ARM	Medium
Moores Pond	Warwick	Franklin	Connecticut	Millers	6.1	-	2.0	-72.3473	42.6564	ARM	Low
Newell Pond	Greenfield	Franklin	Connecticut	Deerfield	6.8	-	21.0	-72.5749	42.6356	ARM	Low
North Pond	Florida	Berkshire	Connecticut	Deerfield	6.1	3.3	2.3	-73.0539	42.6514	ARM	Low
Onota Lake	Pittsfield	Berkshire	Housatonic	Housatonic	7.7	20.0	75.0	-73.2695	42.4760	2009	High
Otis Reservoir	Otis/Tolland	Berkshire	Connecticut	Farmington	6.8	6.0	-	-73.0432	42.1447	2009	Low
Pelham Lake	Rowe	Franklin	Connecticut	Deerfield	6.5	-	-	-72.8917	42.7022	2010	Low
Pequot Pond	Westfield	Hampden	Connecticut	Connecticut	7.7	20.0	39.0	-72.6944	42.1846	2010	High

Appendix 2. (continued)

Name	Town	County	Major Watershed	Watershed	pH	Calcium	Alkalinity	Longitude	Latitude	Source	Risk
Plainfield Pond	Plainfield	Hampshire	Connecticut	Deerfield	6.9	-	-	-72.9582	42.5398	2010	Low
Plantain Pond	Mount Washington	Berkshire	Housatonic	Housatonic	5.3	0.9	0.0	-73.4444	42.0708	ARM	Low
Plunkett Reservoir	Hinsdale	Berkshire	Housatonic	Housatonic	7.8	12.0	32.0	-73.1311	42.4259	2009	Medium
Pontoosuc Lake	Pittsfield	Berkshire	Hudson	Hoosic	7.8	38.0	106.0	-73.2472	42.4851	2009	High
Porter Lake	Springfield	Hampden	Connecticut	Connecticut	8.1	27.0	51.0	-72.5690	42.0743	2010	High
Prospect Lake	Egremont	Berkshire	Housatonic	Housatonic	8.4	21.5	84.0	-73.4521	42.1955	2009	High
Quabbin Reservoir	Belchertown	Worcester	Connecticut	Chicopee	6.6	2.0	2.8	-72.2993	42.4035	ARM	Low
Richmond Pond	Richmond	Berkshire	Housatonic	Housatonic	8.3	37.5	120.0	-73.3315	42.4158	2009	High
Robin Hood Lake	Becket	Berkshire	Connecticut	Westfield	7.0	8.5	20.8	-73.0625	42.2458	ARM	Low
Round Pond	Great Barrington	Berkshire	Housatonic	Housatonic	7.7	15.3	54.0	-73.3917	42.2486	ARM	Medium
Rudd Pond	Becket	Berkshire	Connecticut	Westfield	7.1	5.3	9.6	-73.0811	42.2958	ARM	Low
Sandwash Reservoir	Washington	Berkshire	Housatonic	Housatonic	6.2	3.7	3.6	-73.1667	42.3694	ARM	Low
Scarboro Pond	Belchertown	Hampshire	Connecticut	Connecticut	6.4	-	4.5	-72.4347	42.3511	ARM	Low
Shaw Pond	Otis/Becket	Berkshire	Connecticut	Farmington	7.6	10.5	31.0	-73.1242	42.2518	2009	Low
Sibley Swamp Pond	Wendell	Franklin	Connecticut	Chicopee	5.3	1.4	0.4	-72.3778	42.5072	ARM	Low
Silver Lake	Agawam	Hampden	Connecticut	Connecticut	7.6	17.7	32.7	-72.6361	42.0652	ARM	Medium
Sportsmans Pond	Athol	Worcester	Connecticut	Millers	6.1	2.8	2.3	-72.2305	42.6095	ARM	Low
Stockbridge Bowl	Stockbridge	Berkshire	Housatonic	Housatonic	8.4	33.0	122.0	-73.3240	42.3416	2009	High
Stump Pond	Gardner	Worcester	Connecticut	Millers	5.5	-	1.0	-71.9729	42.5809	ARM	Low
Thompsons Pond	Spencer	Worcester	Connecticut	Chicopee	6.5	-	6.1	-71.9724	42.3027	ARM	Low
Thousand Acre Pond	New Marlborough	Berkshire	Housatonic	Housatonic	7.3	3.0	20.0	-73.2074	42.0693	2009	Low
Threemile Pond	Sheffield	Berkshire	Housatonic	Housatonic	7.3	-	43.0	-73.3097	42.1394	ARM	Medium
Trout Pond 2	Tolland	Hampden	Connecticut	Farmington	5.8	-	7.4	-73.0011	42.1020	ARM	Low
Tully Pond	Orange	Franklin	Connecticut	Millers	6.4	-	4.2	-72.2409	42.6366	ARM	Low
Upper Goose Pd	Lee	Berkshire	Housatonic	Housatonic	7.4	6.1	15.5	-73.1764	42.2867	ARM	Low
Upper Highland Lake	Goshen	Hampshire	Connecticut	Westfield	7.1	3.0	6.0	-72.7972	42.4573	2010	Low
Upper Naukeag Lake	Ashburnham	Worcester	Connecticut	Millers	5.7	1.0	0.0	-71.9275	42.6577	ARM	Low
Upper Reservoir	Lee	Berkshire	Housatonic	Housatonic	5.6	2.1	1.4	-73.2133	42.3297	ARM	Low
Upper Spectacle Pond	Sandisfield	Berkshire	Connecticut	Farmington	6.8	4.3	8.4	-73.1180	42.1816	ARM	Low
Watershops Pond	Springfield	Hampden	Connecticut	Connecticut	8.7	22.0	48.0	-72.5497	42.1042	2010	High
West Lake	Sandisfield	Berkshire	Connecticut	Farmington	7.2	7.1	22.9	-73.1611	42.1322	ARM	Low
West Lake	Sandisfield	Berkshire	Connecticut	Farmington	7.4	7.2	22.0	-73.1621	42.1293	2010	Low
Westfield Reservoir	Montgomery	Hampden	Connecticut	Westfield	7.1	-	-	-72.8106	42.1926	2010	Low
Westfield River	Westfield	Hampden	Connecticut	Westfield	7.3	5.0	16.0	-72.7433	42.1283	2010	Low
White Lily Pond	Otis	Berkshire	Connecticut	Farmington	6.4	2.6	8.0	-73.0406	42.2264	ARM	Low
Windsor Pond	Windsor	Berkshire	Connecticut	Westfield	6.9	7.0	5.0	-72.9844	42.5368	2009	Low
Windsor Reservoir	Hinsdale	Berkshire	Housatonic	Housatonic	7.3	12.7	31.6	-73.1069	42.4856	ARM	Medium
Woods Pond	Lenox	Berkshire	Housatonic	Housatonic	8.6	30.5	88.0	-73.2394	42.3542	ARM	High
Wright Pond	Holyoke	Hampden	Connecticut	Westfield	7.9	13.3	33.6	-72.6604	42.1747	ARM	Medium
York Lake	New Marlborough	Berkshire	Connecticut	Farmington	7.0	5.9	13.4	-73.1833	42.0992	ARM	Low

Zebra Mussel Phase II Assessment

Physical, Chemical, and Biological Evaluation of Waterbodies in the Connecticut River Watershed of Massachusetts

APPENDIX 3

Lake Profiles

Brief profiles are provided for each of the primary and secondary lakes surveyed for this report, as well as for the Connecticut River (Table 1). Profiles include orthophotos showing locations of survey sites (see Appendix 1 for coordinates and methods employed at each), and summaries of habitat and water chemistry.

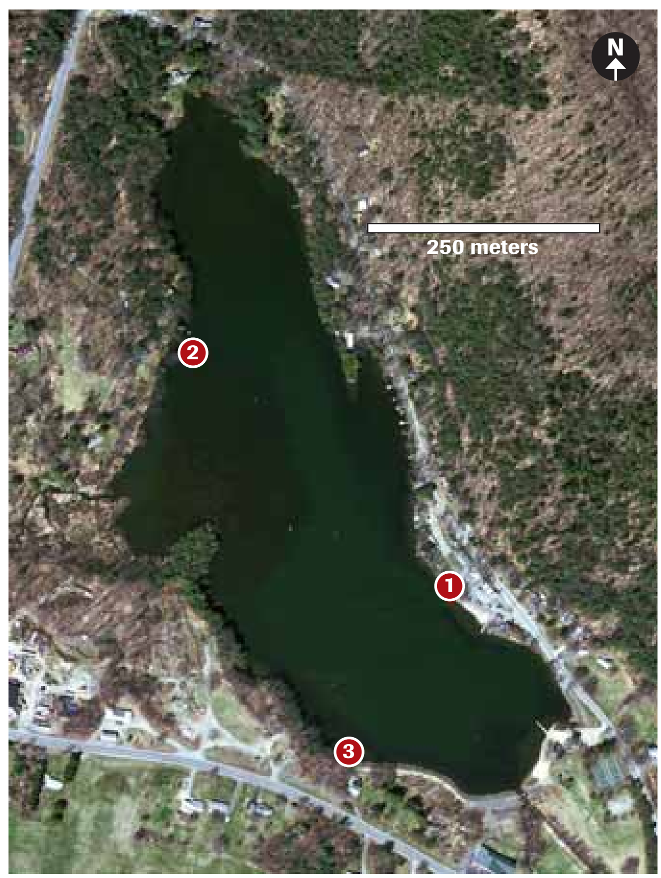
Aldrich Lake
Granby

- Surveyed: June 1, 2010
- Survey Site: The survey site was located at the boat access point at the Amherst Road Bridge. Methods included a SCUBA survey in deep water, D-net sampling while wading, a single plankton tow, and both laboratory and field measurements of water chemistry parameters.
- Description: Aldrich Lake is a 66-acre lake in Granby formed by damming Bachelor Brook. The approximately 0.8-mile long lake runs in a generally east to west direction, with a deeper western basin and a shallow weedy eastern basin. The eastern basin is moderately eutrophic. Macrophyte abundance was low to moderate within the survey area at the time of the survey. Substrate was mucky silt in the shallows, grading to a combination of sand/gravel/cobble in the old stream channel. Secchi depth was seven feet. Dissolved oxygen was 7.2 mg/L at the surface, and 0.2 mg/L at 11 feet. Shoreline development is low, with a wooded buffer separating all but one of the eleven residential properties near the lake. Recreation is primarily fishing, generally from non-motorized boats or boats with small motors.
- Potential for Zebra Mussels: Aldrich Lake is considered Low Risk because of suboptimal water chemistry [pH 7.36, calcium 11.0 mg/l, and alkalinity 32 mg/l]. Its suboptimal physical habitat, near lack of thermal stratification, and eutrophic state also reduce its potential to support zebra mussels.

Aldrich Lake survey site.

Ashfield Lake
Ashfield

- Surveyed: June 22, 2010
- Survey Sites: Three locations were surveyed, including the public boat ramp. Methods included a SCUBA survey in deep water, D-net sampling while wading, a single plankton tow, and both laboratory and field measurements of water chemistry parameters.
- Description: Ashfield Lake is a 37-acre lake located in the town of Ashfield. Its maximum depth is only 20 feet and probably barely stratifies. The lake is formed by an earthen dam at its southern end. Aquatic macrophyte abundance was moderate, except for one shallow cove where floating species such as *Nymphaea odorata* formed a relatively dense patch. The substrate near shore was generally a combination of sand and gravel, grading to deep muck at greater depths. Approximately 200 meters of shoreline substrate is riprap near the earthen dam. Secchi depth was 13.5 feet. Dissolved oxygen was 9.5 mg/L at the surface, and 0.3 near the bottom. Approximately 40 percent of the shoreline is residential property, with the remainder of the lakeshore wooded.
- Potential for Zebra Mussels: Ashfield Lake is considered Medium Risk because of marginally suitable pH (7.63), calcium (14 mg/l), and alkalinity (34 mg/l). Its small size and limited physical habitat reduce its vulnerability to zebra mussels. Boating activity is relatively light, which may also reduce the risk of zebra mussel introduction.



Ashfield Lake survey sites.

Congamond Lakes
Southwick

- Surveyed: June 18, 2010
- Survey Sites: Five locations in two basins were surveyed, including boat access points and a former public beach were surveyed. Methods included SCUBA (four locations), snorkeling (five locations) and D-net sampling while wading (five locations), three plankton tows, and both laboratory and field measurements of water chemistry parameters.
- Description: The three basins of the Congamond Lakes comprise 465 acres of surface area in the towns of Southwick, MA and West Suffield, CT. Macrophyte abundance was generally high throughout the lake, with a decline in plant densities in deep water. Substrate in shallow areas was primarily sand and gravel with some areas of cobble, while deeper areas contained mostly organic muck or gyttja. Secchi depth ranged from 4.5 to 6 feet. Average dssolved oxygen was 12.7 mg/L at the surface and 0.4 mg/L at 13 feet. Shoreline development and recreation are very high, with multiple boat ramps and many private docks.
- Potential for Zebra Mussels: The Congamond Lakes are considered Medium Risk, with a pH readings ranging from 7.7 to 8.2, calcium between 14-16 mg/L, and alkalinity of 42-46 mg/l. The size, depth, and substrate make it among the more suitable physical habitats among the 2010 survey lakes. High boating activity increases the risk of zebra mussel introduction.

Congamond Lake survey sites.

Cranberry Pond
Sunderland

- Surveyed: June 3, 2010
- Survey Site: One survey site near the dam and boat ramp was surveyed. Methods included snorkeling, D-net sampling while wading, a single plankton tow, and both laboratory and field measurements of water chemistry parameters.
- Description: Cranberry Pond is a 27-acre coldwater pond in the town of Sunderland. Aquatic macrophyte abundance is high throughout the shallow portions of the pond. Most of the pond is shallow, with a maximum depth of 26 feet but an average depth of only four feet. Substrate ranged from sand and gravel near shore to organic muck in deeper water. The shoreline is entirely undeveloped and recreation is primarily fishing from non-motorized boats or boats with small motors.
- Potential for Zebra Mussels: Cranberry Pond is considered Low Risk due to suboptimal physical and chemical conditions including low pH (6.96), low calcium (5 mg/l) and low alkalinity (12 mg/l).

Cranberry Pond survey site.

Five-Mile Pond

Springfield

- Surveyed: June 11, 2010
- Survey Site: One general area centered on the public boat ramp was surveyed. Methods included SCUBA diving in deeper areas, D-net sampling while wading, a single plankton tow, and both laboratory and field measurements of water chemistry parameters.
- Description: Five-Mile Pond is a 48-acre pond near urban Springfield with an average depth of 12 feet and a maximum depth of 35 feet. Aquatic macrophyte abundance was high within the survey area, but declined in deeper water. Secchi depth was beyond the deepest point in the survey area (9.5 feet) and generally quite clear. Dissolved oxygen ranged from 8.6 mg/L at the surface to 2.4 at nine feet. Although Five-mile Pond is within a highly developed area, approximately 50 percent of the lakeshore is wooded. The pond is heavily used for fishing, boating and swimming. Asian clams are established in the pond.
- Potential for Zebra Mussels: Five-mile Pond is considered Low Risk because of suboptimal conditions including marginal pH (7.48), low calcium (6.5 mg/l) and low alkalinity (16.6 mg/l). Its calcium and alkalinity are very low compared to other nearby urban waterbodies (Porter Lake, Watershops Pond).

Five-mile Pond survey site.

Littleville Lake

Chester/Huntington

- Surveyed: June 15, 2010
- Survey Sites: Three areas were surveyed, including the areas around each of the public boat ramps, and the Westfield River in the deep pool immediately downstream of the dam. Methods included SCUBA diving, snorkeling, D-net sampling while wading, three plankton tows, and both laboratory and field measurements of water chemistry parameters..
- Description: Littleville Lake is a 275-acre, deep (max depth = 86 feet), coldwater lake in the towns of Chester and Huntington. The lake was formed by damming the Middle Branch Westfield River. Aquatic macrophyte abundance was low at all three survey sites. Substrate ranged from exposed ledge, boulder and cobble with areas of sand and gravel, to areas with silt and detritus. Secchi depth was 14 feet. Dissolved oxygen remained relatively constant at depth, 9.5 mg/L at the surface to 9.1 mg/L at 30 feet. Because this is a flood control lake, the shoreline is entirely undeveloped. The excellent fishery supports high recreational use of the lake, although the 10-horsepower limit on motors limits boat traffic.
- Potential for Zebra Mussels: Although its physical habitat would be nearly ideal for zebra mussels, Littleville Lake has unsuitable chemical conditions including low pH (7.3), low calcium (5 mg/l), and low alkalinity (10 mg/l). Zebra mussels could not become established in Littleville Lake.

Littleville Lake survey sites.

Lower Highland Lake
Goshen

- Surveyed: June 6, 2010
- Survey Site: One site was surveyed, starting at the public boat ramp and extending out to the northern end of the main lake. Methods included SCUBA diving, D-net sampling while wading, a single plankton tow, and both laboratory and field measurements of water chemistry parameters.
- Description: Lower Highland Lake is an 88-acre lake in the town of Goshen. The upper half of the lake lies within the DAR State Forest. This lake is one of two impoundments of the west branch of the Mill River, separated by a quarter mile from Upper Highland Lake. Aquatic macrophyte abundance was low throughout the survey area. Substrate was primarily muck, with some boulders and sand/gravel. Secchi depth was beyond the maximum surveyed depth (7.5'). Dissolved oxygen did not decline with depth. Approximately 60 percent of the shoreline is developed, and recreational use is relatively high during the summer months.
- Potential for Zebra Mussels: Lower Highland Lake not at risk based on suboptimal chemical conditions, including low pH (6.99), low calcium (3 mg/l) and low alkalinity (6 mg/l).

Lower Highland Lake survey site.

Upper Highland Lake
Goshen

- Surveyed: June 6, 2010
- Survey Site: One site was surveyed in Upper Highland Lake, Methods included SCUBA diving, D-net sampling while wading, a single plankton tow, and both laboratory and field measurements of water chemistry parameters.
- Description: Upper Highland Lake is a 53-acre lake in the town of Goshen, entirely within the DAR state forest. This lake is the northern of two impoundments on the west branch of the Mill River, separated by a quarter mile from Lower Highland Lake. Macrophyte abundance was low within the study area. Substrate was a combination of sand, gravel, cobble and boulder throughout the survey area, with soft muck covering the firmer substrate at greater depths. Secchi depth was ten feet. Dissolved oxygen did not decline with depth. There is no shoreline development, aside from the state forest and Camp Holy Cross.
- Potential for Zebra Mussels: Upper Highland Lake not at risk based on suboptimal chemical conditions, including low pH (7.05), low calcium (3 mg/l) and low alkalinity (6 mg/l).

Upper Highland Lake survey site.

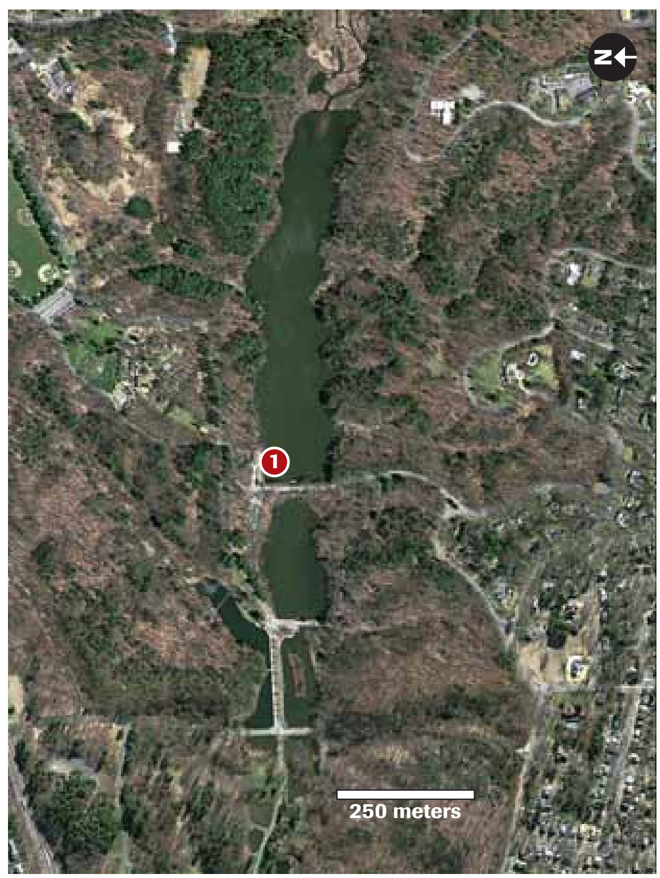
Pequot Pond
Westfield

- Surveyed: June 15, 2010
- Survey Sites: Four locations were surveyed, including the public boat ramp and three other shoreline areas. Methods included SCUBA diving, snorkeling, D-net sampling while wading, four plankton tows, and both laboratory and field measurements of water chemistry parameters.
- Description: The 198-acre Pequot Pond is located in the town of Westfield. Aquatic macrophyte abundance ranged from low to high, with the highest density near the public boat ramp. Substrate was generally sand/gravel with occasional cobble in the shallower waters, grading into organic muck in the deeper sections of the pond. Secchi depth was 12.5 feet. Dissolved oxygen did not decline between the surface and 10 feet but was 0.09 mg/L at 29 feet. Residential development comprises approximately 60 percent of the shoreline. Recreational use of the pond is very high due to residential development, a boat ramp, and a public beach.
- Potential for Zebra Mussels: Pequot Pond is considered High Risk (although its really on the line between Medium and High) based on marginally suitable pH (7.67), high calcium (20 mg/l), and marginally suitable alkalinity (39 mg/l). Its large size, deep water, suitable substrate, and fair water quality contribute to its susceptibility to zebra mussels. In addition, the high amount of boat traffic may increase the chances of zebra mussel introduction, even though source populations of zebra mussels are currently quite far away.

Pequot Pond survey sites.

Porter Lake
Springfield

- Surveyed: June 11, 2010
- Survey Site: A single survey site near the Forest Park Nature Center was surveyed. Methods included D-net surveys while wading and kayaking, a single plankton tow, and both laboratory and field measurements of water chemistry.
- Description: Porter Lake is a 21-acre lake located in Forest Park in Springfield. The lake was formed by damming Pescousic Brook. Submerged aquatic macrophytes were moderately abundant and probably limited by high turbidity during the summer. The substrate was primarily organic muck, with some sand close to shore. Secchi depth was only 4.5 feet, and dissolved oxygen dropped sharply from 11.22 mg/L at the surface to 0.28 mg/L near the bottom (11'). Approximately 11 percent of the shoreline is very close to roads or manicured lawns. The remaining shoreline is undeveloped. Recreational use of the pond is very low.
- Potential for Zebra Mussels: Porter Lake is considered Low Risk because of the very low recreational use of the lake and poor habitat conditions. Its water chemistry was among the most suitable for zebra mussels in the entire Connecticut River watershed, with high pH 8.11, high calcium levels (27 mg/l), and high alkalinity of (51 mg/l). Its chemistry is likely strongly influenced by urban runoff, wastewater effluents or leaky septic/sewer systems in urban Springfield.



Porter Lake survey site.

Lake Warner

Hadley

- Surveyed: June 1, 2010.
- Survey Site: Areas near the bridge and boat ramp at the southwest end of the lake were surveyed. Methods included SCUBA diving, snorkeling, D-net sampling while wading, one plankton tow, and both laboratory and field measurements of water chemistry.
- Description: Lake Warner is a relatively shallow 68-acre warmwater lake. The 1.2-mile long lake was created by damming the Mill River. Although macrophyte abundance was low at the survey site, Lake Warner has abundant aquatic and emergent vegetation throughout most of the lake during the summer, and is typically covered with a layer of duckweed (*Lemna* and *Wolffia* spp.). Secchi depth was nine feet during the time of the survey. The substrate at the survey site was primarily sand and gravel, with some silt. Dissolved oxygen ranged from 8.8 mg/L at the surface to 1.1 mg/L at a depth of ten feet. Residential development and agriculture occur near the northwest side of the lake, and the southeast side of the lake is less developed with some agriculture. Recreational use of the lake is generally limited to fishing and paddling.
- Potential for Zebra Mussels: Lake Warner is considered Low Risk because of suboptimal chemical conditions, including low pH (7.27), low calcium (10 mg/l), and low alkalinity (22 mg/l). Its poor habitat and highly eutrophic conditions contribute to its low potential to support zebra mussels.

Lake Warner survey site.

Lake Wyola

Shutesbury

- Surveyed: June 3, 2010
- Survey Sites: Three areas were surveyed including the areas around the public boat ramp at the southern end and the dam and swimming area at the northern end. Methods included SCUBA diving, snorkeling, D-net sampling while wading, two plankton tows, and both laboratory and field measurements of water chemistry parameters.
- Description: Lake Wyola is a 129-acre lake in the town of Shutesbury. This is a raised Great Pond that is periodically lowered to control aquatic plants. Macrophyte abundance was high in the general area of the boat ramp at the southern end of the pond, and moderate near the dam. Substrate was sand and gravel with cobble in shallower areas and mostly gyttja in deeper areas. Secchi depths were beyond the depths of the surveyed areas (8 feet). Although the lake is located in a relatively undeveloped portion of the state, approximately 80 percent of the shoreline is developed with seasonal and year-round homes. Recreational use of the lake is high, especially for boating, swimming, and fishing.
- Potential for Zebra Mussels: Lake Wyola is considered Low Risk due to suboptimal conditions, including low pH (6.17), low calcium (5 mg/l), and low alkalinity (<2 mg/l). Among the waterbodies surveyed in 2010, it was among the least suitable for zebra mussels based on water chemistry.

Lake Wyola survey sites.

Connecticut River

Chicopee, Easthampton, Gill, Hatfield, Northampton, Northfield

- Surveyed: June 7-8, 10, 2010
- Survey Sites: Six areas were surveyed, including the areas around the boat ramps in Chicopee, Easthampton, Gill (Bartons Cove), Hatfield, Northampton (the Oxbow Marina), and Northfield. Methods included SCUBA diving, snorkeling, D-net surveys while wading, plankton tows at each site, and field and laboratory measurements of water chemistry parameters.
- Description: Native mussels were typically common to abundant at most locations, especially the eastern elliptio (*Elliptio complanata*), and the only non-native bivalve encountered was the Asian clam (*Corbicula fluminea*). Habitat conditions were variable among the six survey sites. Macrophyte abundance was low at all sites except for Bartons Cove where macrophyte abundance was generally high. Areas near the Easthampton, Gill, and Northfield boat ramps generally had silty-muck and sand substrates. Substrate at the Oxbow was mostly sand and gravel with some cobble. Substrate at the Chicopee boat ramp was primarily fine sand and silt with embedded boulders, and near the Hatfield boat ramp was a combination of sand and ledge. Secchi depth in the Oxbow was only six feet, but was typically much deeper at the other sites, generally reaching the bottom (~7-12'). The surrounding landscapes ranged from rural to suburban, providing a full range of development conditions. Recreational use of the Connecticut River is generally quite high, with much boat traffic (both motor boat and paddling) and fishing.
- Potential for Zebra Mussels: The Connecticut River is considered Low Risk primarily due to low calcium (8-10 mg/L), even though pH (7.36-7.63) and alkalinity (22-29 mg/L) are both in the "Medium" risk range. Habitat conditions are ideal for zebra mussels in many locations throughout the Connecticut River in Massachusetts, as well as in areas to the north and south of Massachusetts. The large number of boats that visit the river each year, potentially from zebra mussel-infested waters of western New England and eastern New York, makes transport of zebra mussels seem likely. However, the likelihood that zebra mussels can survive and reproduce in the Connecticut River appears low based on calcium levels in the river.

Watershops Pond
Springfield

- Surveyed: May 19, 2010
- Survey Site: Laboratory and field measurements of water chemistry parameters were taken at a single location.
- Description: This 186-acre warmwater pond has just under seven miles of heavily developed shoreline. Watercolor is brown with a transparency of only three feet. The bottom is muck, with some limited areas of sand and rock. Maximum depth is 21 feet and aquatic vegetation is heavy. This pond is an impoundment of the Mill River and is also fed by Schneelock Brook and numerous street drains. During the summer months there is severe deoxygenation below a depth of five feet. There is no formal boat launching or parking area, but access is possible off Alden Street for car top boats and canoes only.
- Potential for Zebra Mussels: Although Watershops Pond was the most urban and degraded waterbody surveyed in 2010, its water chemistry was the most suitable for zebra mussels, including a pH of 8.72, calcium of 22.0 mg/L, and akalinity of 48.0 mg/L. Its water chemistry is thought to be strongly influenced by the surrounding urban environment, and it is unlikely that zebra mussels could survive in such a eutrophic and poorly oxygenated pond with such poor physical habitat.