Quality of Massachusetts Waters: Regulation, Improvement and Challenges

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SWCS SNEC Winter Conference

Amherst, MA

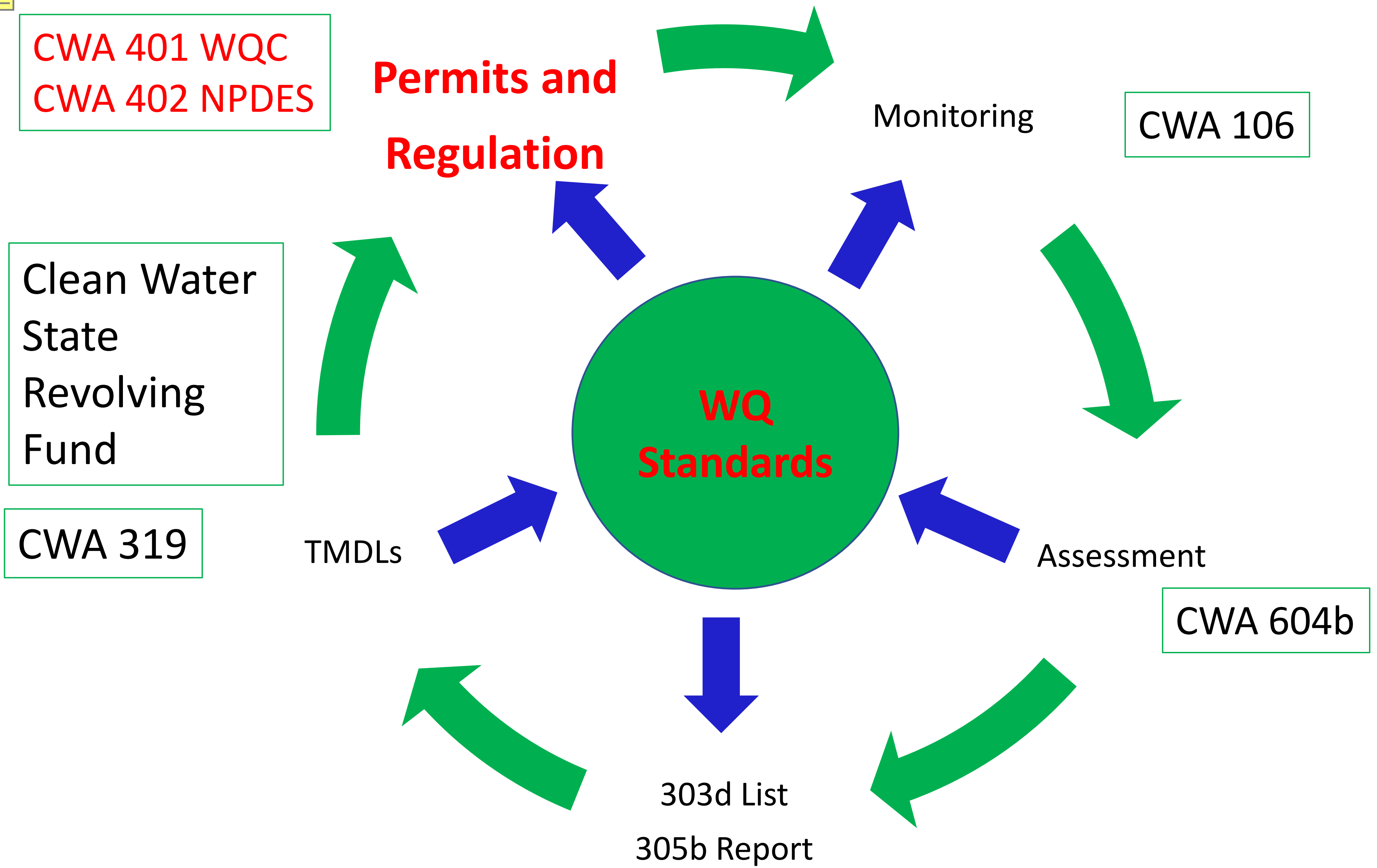
March 30, 2023

Massachusetts Surface Water

Excluding Drinking Water/Ground Water

Outline

- MA Surface Water Regulation: Clean Water Act (CWA)
- Improvement of Surface Water Quality
- Challenges of MA Surface Water Quality
  - Nutrient Enrichment (Eutrophication)
  - Climate Change
  - PFAS (Per- and Polyfluoroalkyl Substances)
  - Plastics
  - Road Salt


CWA 401 WQC
CWA 402 NPDES
Permits and Regulation
Monitoring
CWA 106
Clean Water State Revolving Fund
WQ Standards
CWA 319
TMDLs
Assessment
CWA 604b
303d List
305b Report

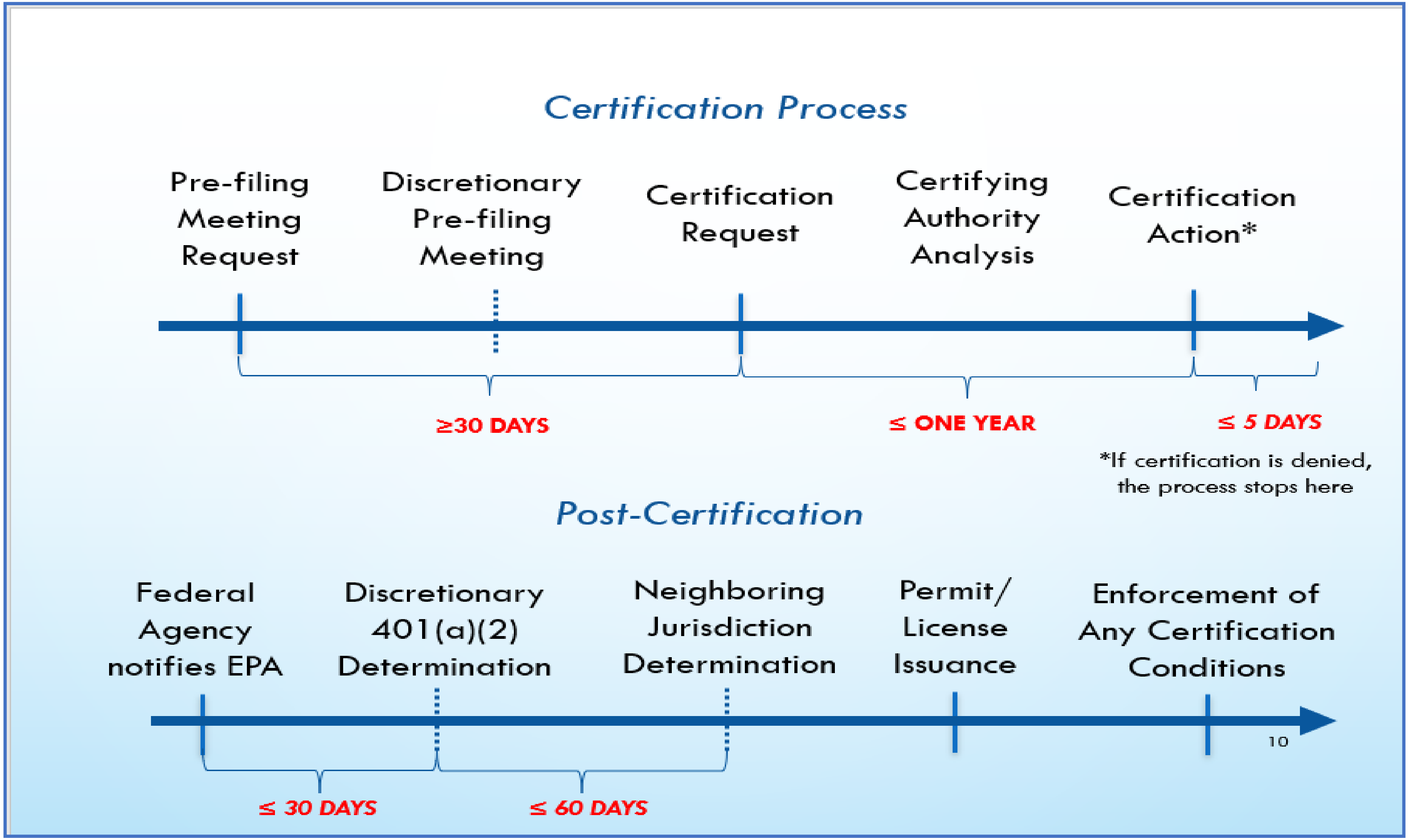
Clean Water Act (CWA) Section 401

- Section 401 water quality certifications for activities that may affect water quality and require a federal license or permit

Under Section 401 of the CWA, a federal agency may not issue a permit or license to conduct any activity that may result in any discharge into waters of the United States unless a Section 401 water quality certification (WQC) is issued, or waived.

Some of the major federal licenses and permits subject to Section 401 include:
•Clean Water Act Sections 402 and 404 permits issued by EPA or the Corps,
•Federal Energy Regulatory Commission (FERC) licenses for hydropower facilities and natural gas pipelines, and
•Rivers and Harbors Act Sections 9 and 10 permits
https://www.epa.gov/cwa-401/overview-cwa-section-401-certification

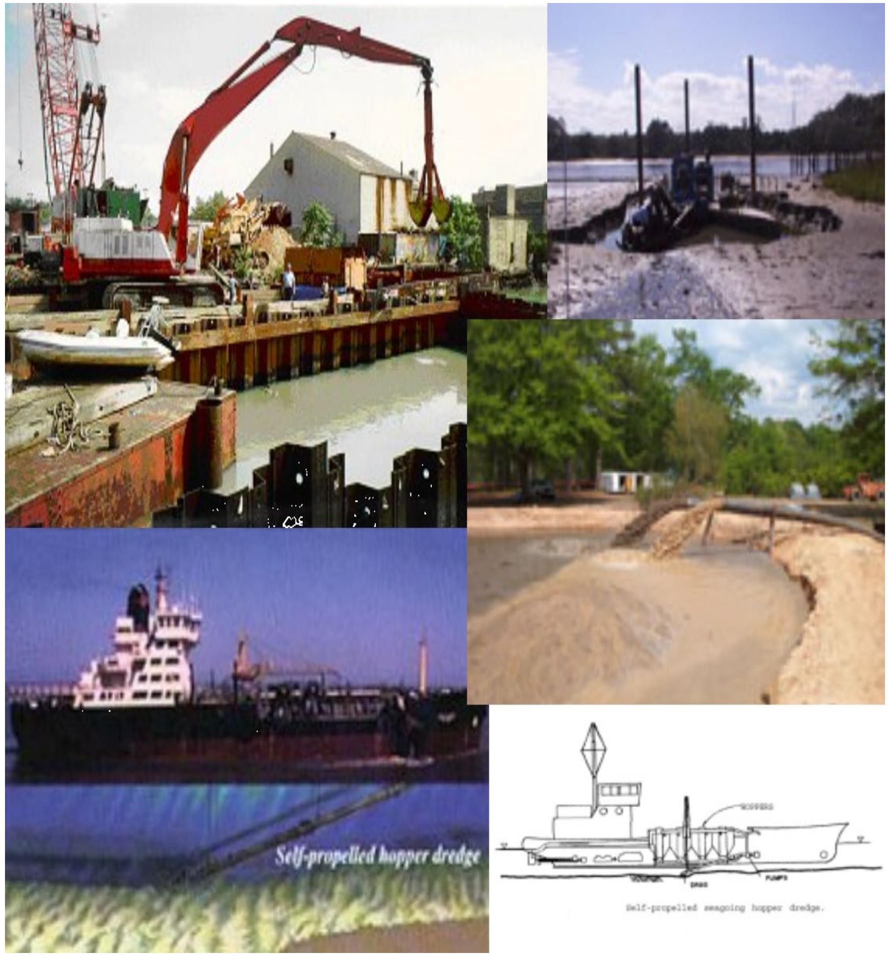
1. MA Surface Water Regulation: 401 Water Quality Cert.



314 CMR 9.00

401 Water Quality Certification for discharge of dredged or fill material, dredging, and dredged material disposal in waters of the United States within the Commonwealth

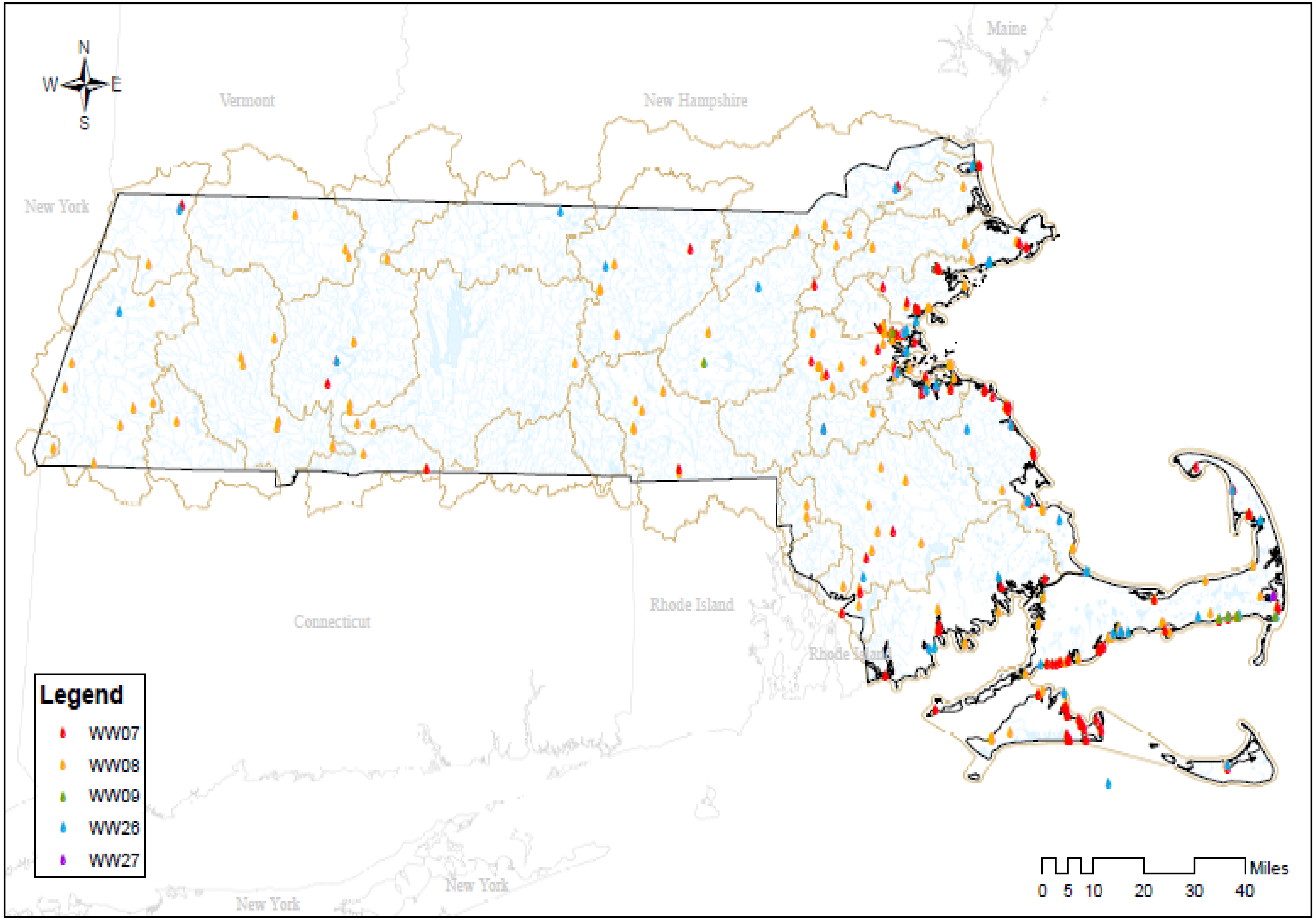
314 CMR 9.00 implements and supplements State Water Quality Standards 314 CMR 4.00



MassDEP 401 Water Quality Certification (WQC) Program

- **No fill or dredging shall be permitted unless appropriate and practicable steps have been taken which will first avoid, and if avoidance is not possible then minimize, or if neither avoidance or minimization are possible, then mitigate, potential adverse impacts to land under water or ocean, intertidal zone and special aquatic sites.**

MA 401 Water Quality Certifications (WQCs)



Sampling and Analysis Requirements (314 CMR 9.07(2))

- **The applicant shall submit the results of all relevant sampling with the application, unless an alternative schedule is specifically authorized by the Department in writing.**
- **As part of sampling and analysis, the applicant shall perform a "due diligence" review to determine the potential for the sediment proposed to be dredged to have concentrations of oil or hazardous materials, as defined in 310 CMR 40.0000: Massachusetts Contingency Plan (MCP)**

CONTAMINANT		RCS-1 (mg/kg, dry weight)
Total Arsenic		20
Total Cadmium		70
Total Chromium		100
Total Lead		200
Total Mercury		20
Total Petroleum Hydrocarbons (TPH)		
Total PCBs		1
Total PAHs		
Total VOCs		
Listed or Characteristic Hazardous Waste (TCLPs)		

*TCLP testing should be performed for metals or organic compounds when the total concentrations in the sediments are above the theoretical levels at which the TCLP criteria may be met or exceeded. For the above metals such levels (mg/kg) are: As > 100, Cd > 20, Cr > 100, Pb > 100, Hg > 4

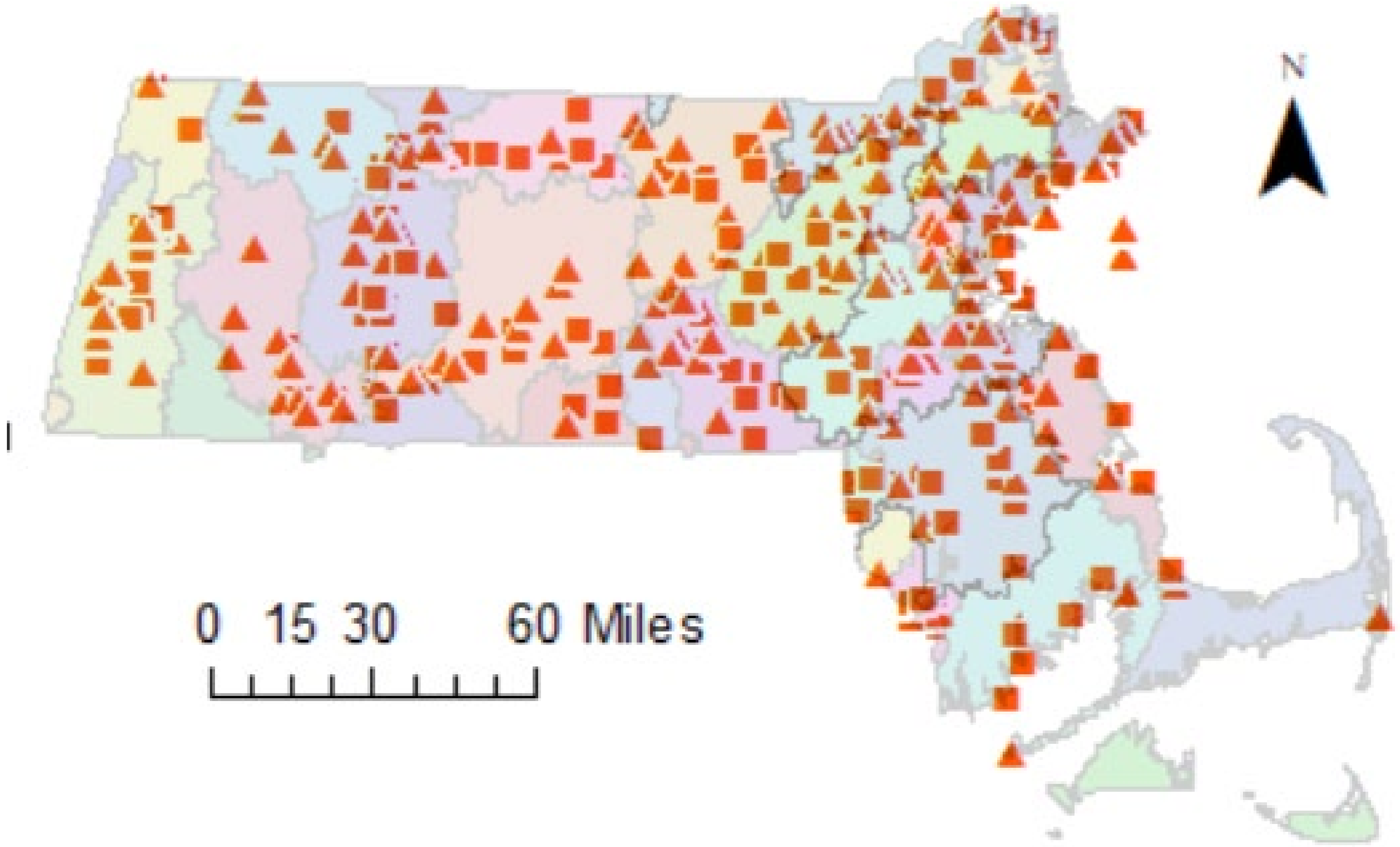
TCLP
Toxicity Characteristics Leaching Procedure

	RCS-1	TCLP Threshold (mg/L)	20x Rule Screening Threshold	Units
Metals, Total				
Arsenic	20	5	100	mg/Kg
Cadmium	70	1	20	mg/Kg
Chromium	100	5	100	mg/Kg
Copper	1000			mg/Kg
Lead	200	5	100	mg/Kg
Mercury	20	0.2	4	mg/kg
Nickel	600			mg/Kg
Zinc	1000			mg/Kg

Sampling and Analysis Requirements (314 CMR 9.07(2))

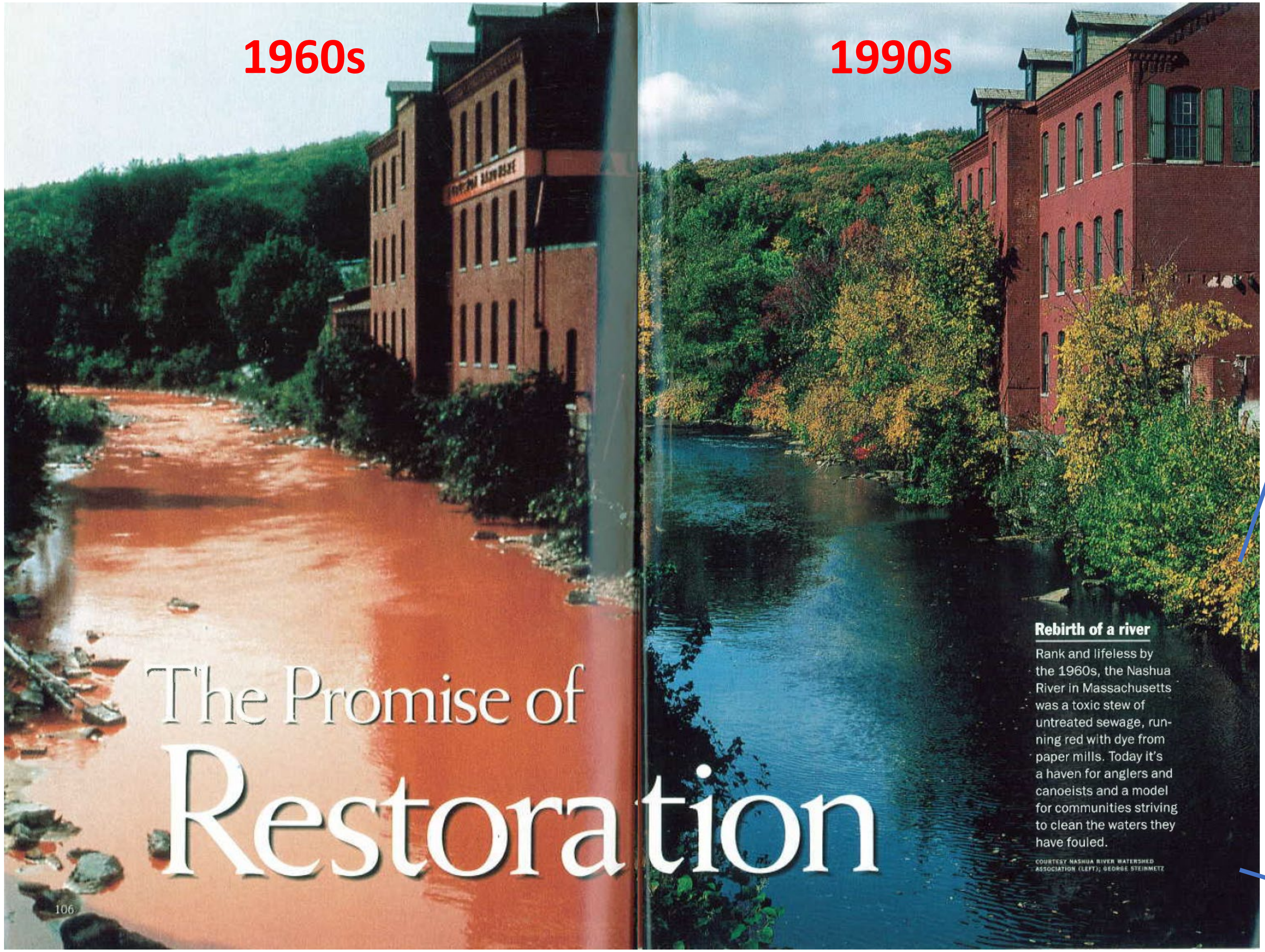
- No chemical testing shall be required if the sediment to be dredged contains less than 10% by weight of particles passing the No. 200 U.S. Standard Series Testing Sieve (nominal opening 0.0029 inches), **and** if the required “due diligence” review demonstrates, to the Department’s satisfaction, that the area is unlikely to contain anthropogenic concentrations of oil or hazardous materials (314 CMR 9.07(2)(a)).
- In all other instances, chemical and physical testing shall be conducted and the information provided in writing to the Department.

CWA 402 NPDES Surface Water Discharge Permits



2. MA Water Quality Improvement

The Nashua River



Rebirth of a river

Rank and lifeless by the 1960s, the Nashua River in MA was a toxic stew of untreated sewage, running red with dye from paper mills. Today it's a haven for anglers and canoeists and a model for communities striving to clean the waters they have fouled (***National Geographic* 1993** by George Steinmetz)

The Nashua River

The Assabet River

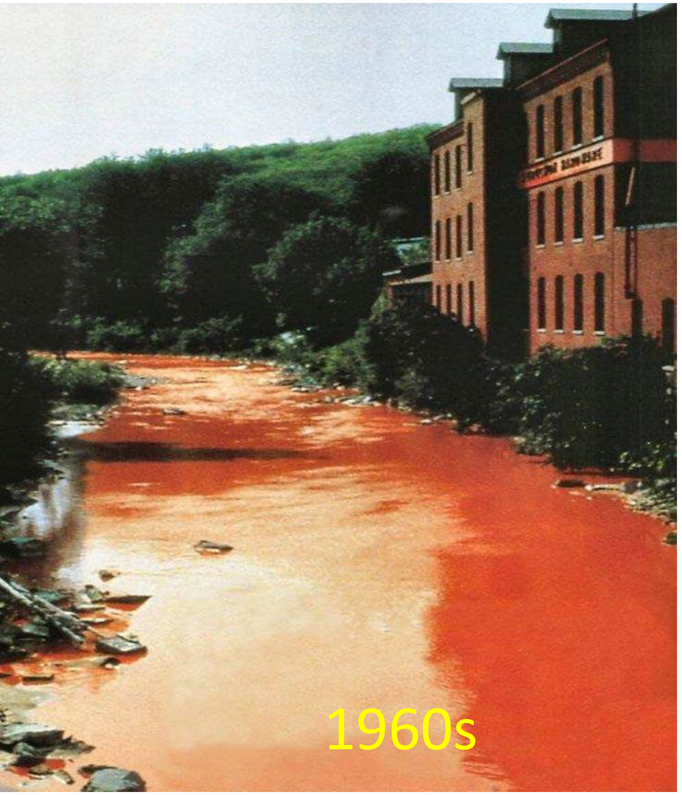


Photo by NRWA

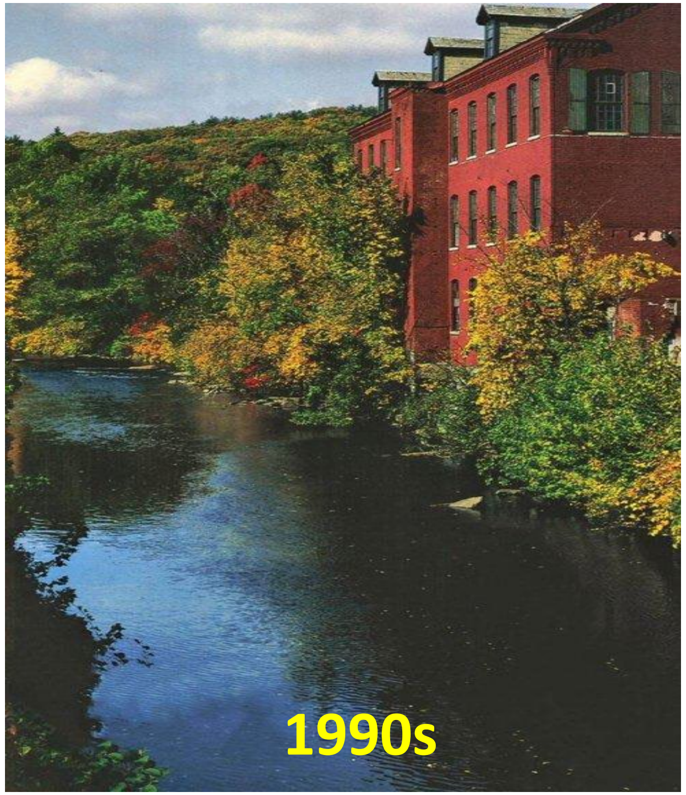


Photo by George Steinmetz

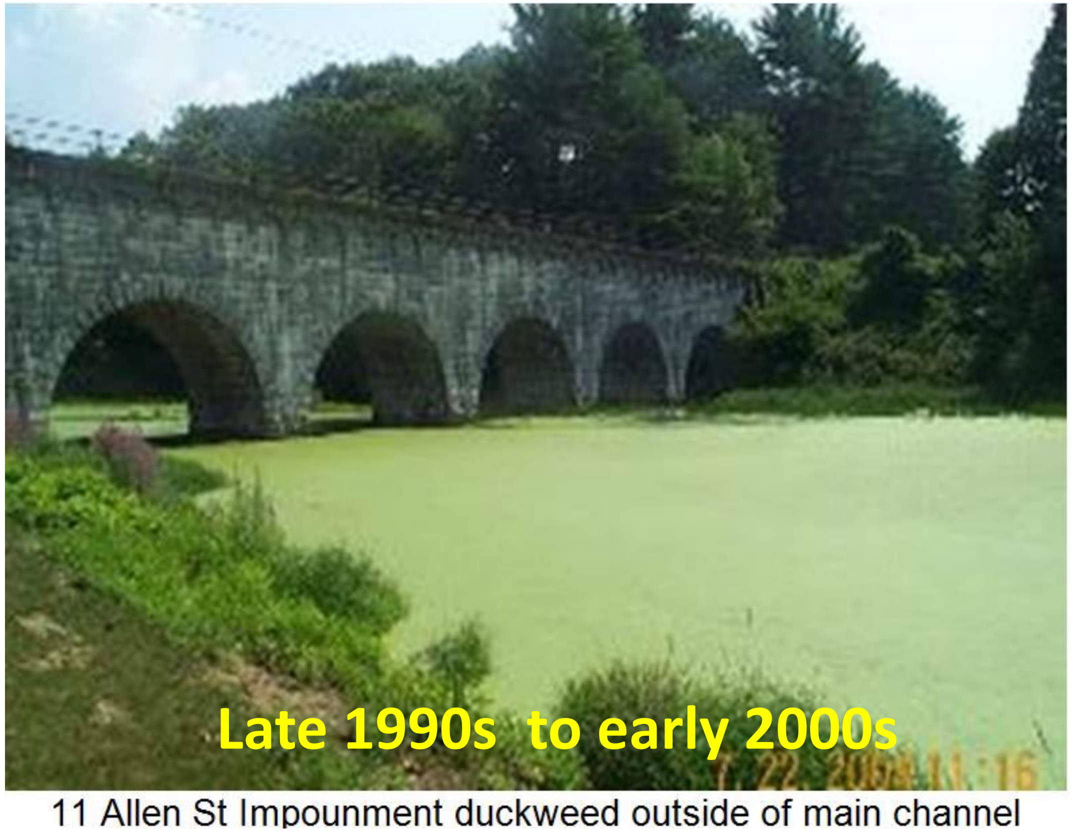
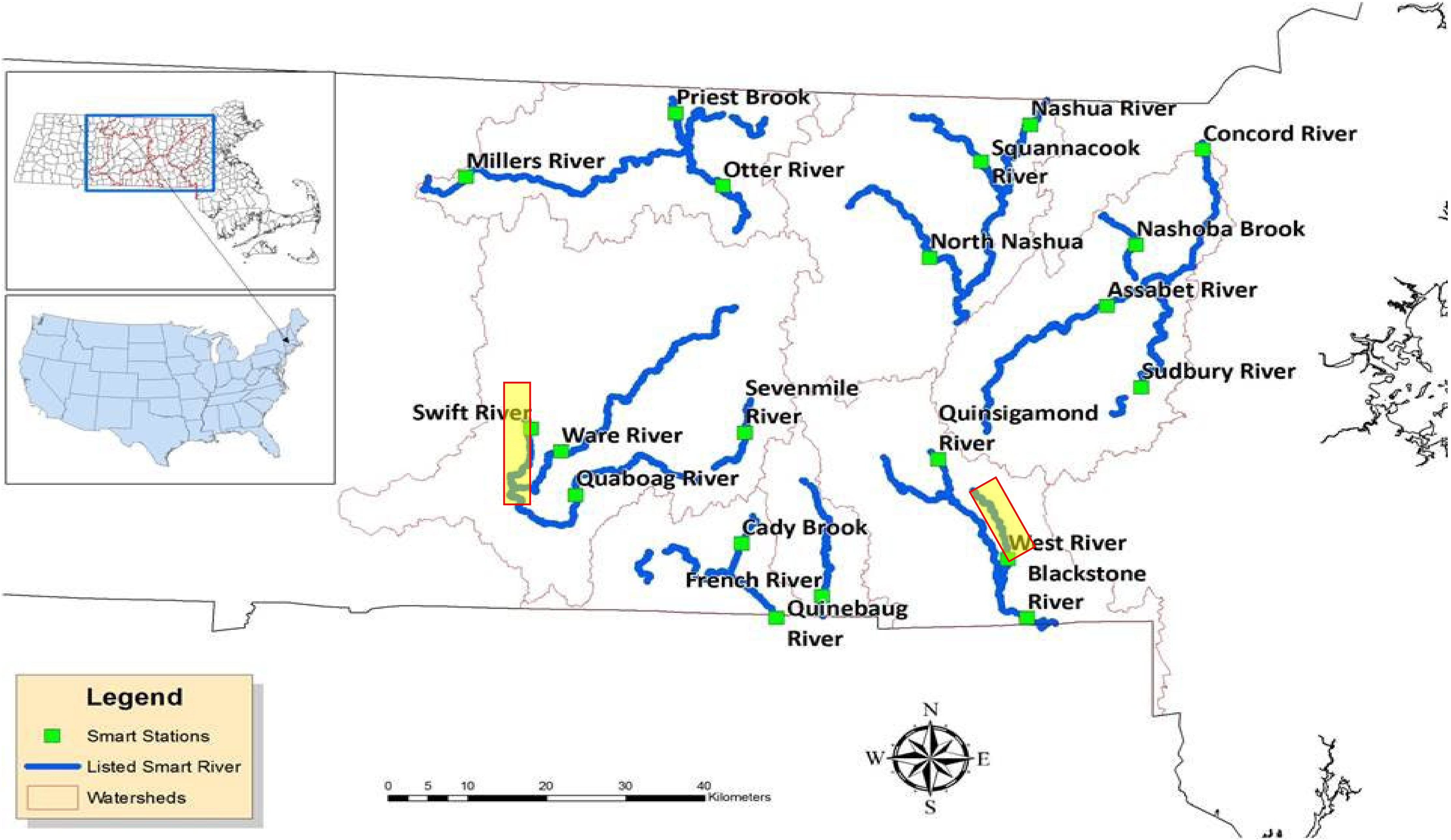


Photo by Therese Beaudoin

Aquatic Plants in Assabet River



1999 to 2013

Figure 1. Bi-monthly sampling station locations of the 20 rivers in central Massachusetts.

20-River Summary statistics and trend analysis (1999-2013): Total Phosphorus concentrations and sampling years

River	Measured TP concentrations							
	N	Median	Mean	Standard Deviation	Min	Max	Kendall Tau b Correlation Coefficients	P value
ASSABET RIVER	73	0.078	0.098	0.092	0.025	0.690	-0.4901	<0.0001
BLACKSTONE RIVER	70	0.185	0.213	0.154	0.020	0.890	-0.3159	0.0001
CADY BROOK	54	0.028	0.038	0.025	0.005	0.130	-0.3714	<0.0001
CONCORD RIVER	58	0.072	0.090	0.053	0.021	0.260	-0.4624	<0.0001
FRENCH RIVER	75	0.021	0.023	0.009	0.009	0.049	-0.3169	<0.0001
MILLERS RIVER	73	0.032	0.037	0.023	0.011	0.180	-0.5374	<0.0001
NASHOBA BROOK	72	0.051	0.058	0.041	0.013	0.220	-0.1623	0.0456
NASHUA RIVER	80	0.047	0.059	0.047	0.017	0.360	-0.6153	<0.0001
NORTH NASHUA RIVER	80	0.086	0.131	0.114	0.023	0.570	-0.3029	<0.0001
OTTER RIVER	73	0.071	0.110	0.120	0.020	0.920	-0.5326	<0.0001
PRIEST BROOK	73	0.019	0.022	0.014	0.000	0.063	-0.2369	0.0033
QUABOAG RIVER	77	0.043	0.055	0.045	0.016	0.300	-0.3952	<.0001
QUINEBAUG RIVER	74	0.027	0.034	0.018	0.009	0.091	-0.4933	<0.0001
QUINSIGAMOND RIVER	71	0.018	0.023	0.032	0.009	0.280	-0.1645	0.0462
SEVENMILE RIVER	78	0.015	0.018	0.012	0.005	0.077	-0.2241	0.0043
SQUANNACOOK RIVER	74	0.018	0.021	0.013	0.007	0.086	-0.3594	<0.0001
SUDBURY RIVER	73	0.020	0.022	0.008	0.012	0.046	-0.1722	0.0341
SWIFT RIVER	78	0.003	0.004	0.003	0.000	0.011	0.0444	0.5994
WARE RIVER	78	0.032	0.035	0.016	0.012	0.130	-0.3445	<0.0001
WEST RIVER	68	0.028	0.030	0.023	0.007	0.190	-0.1155	0.1683

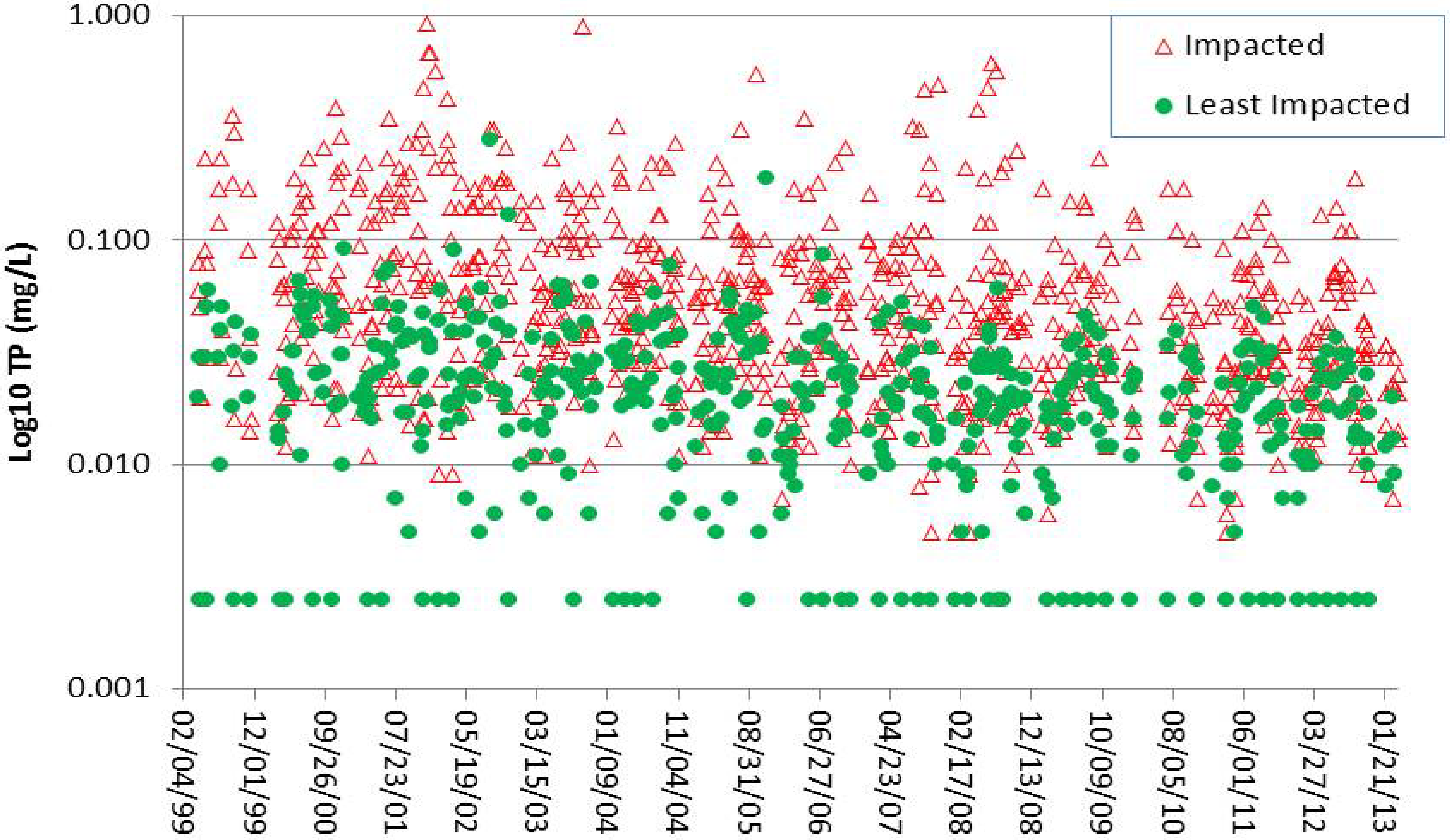
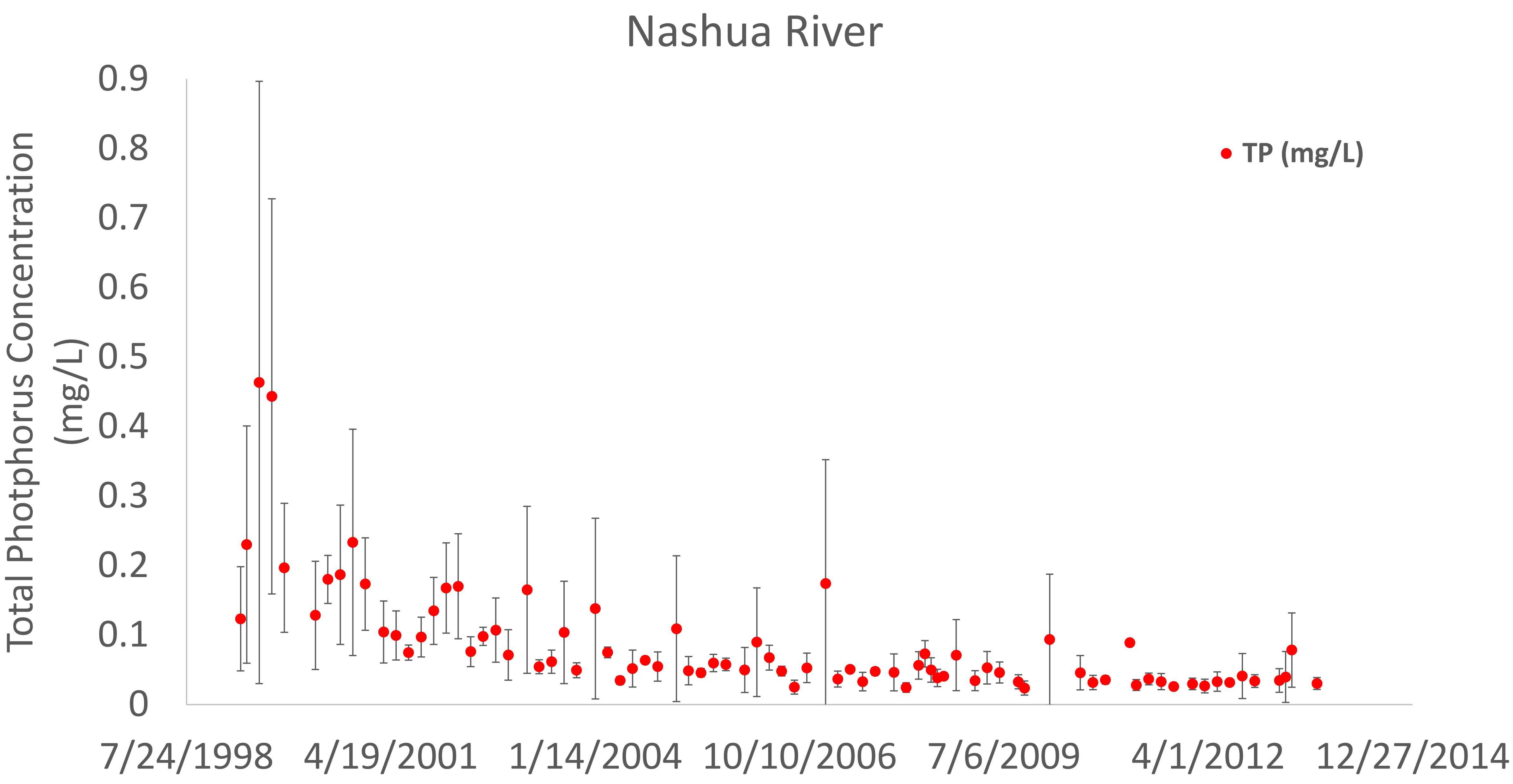
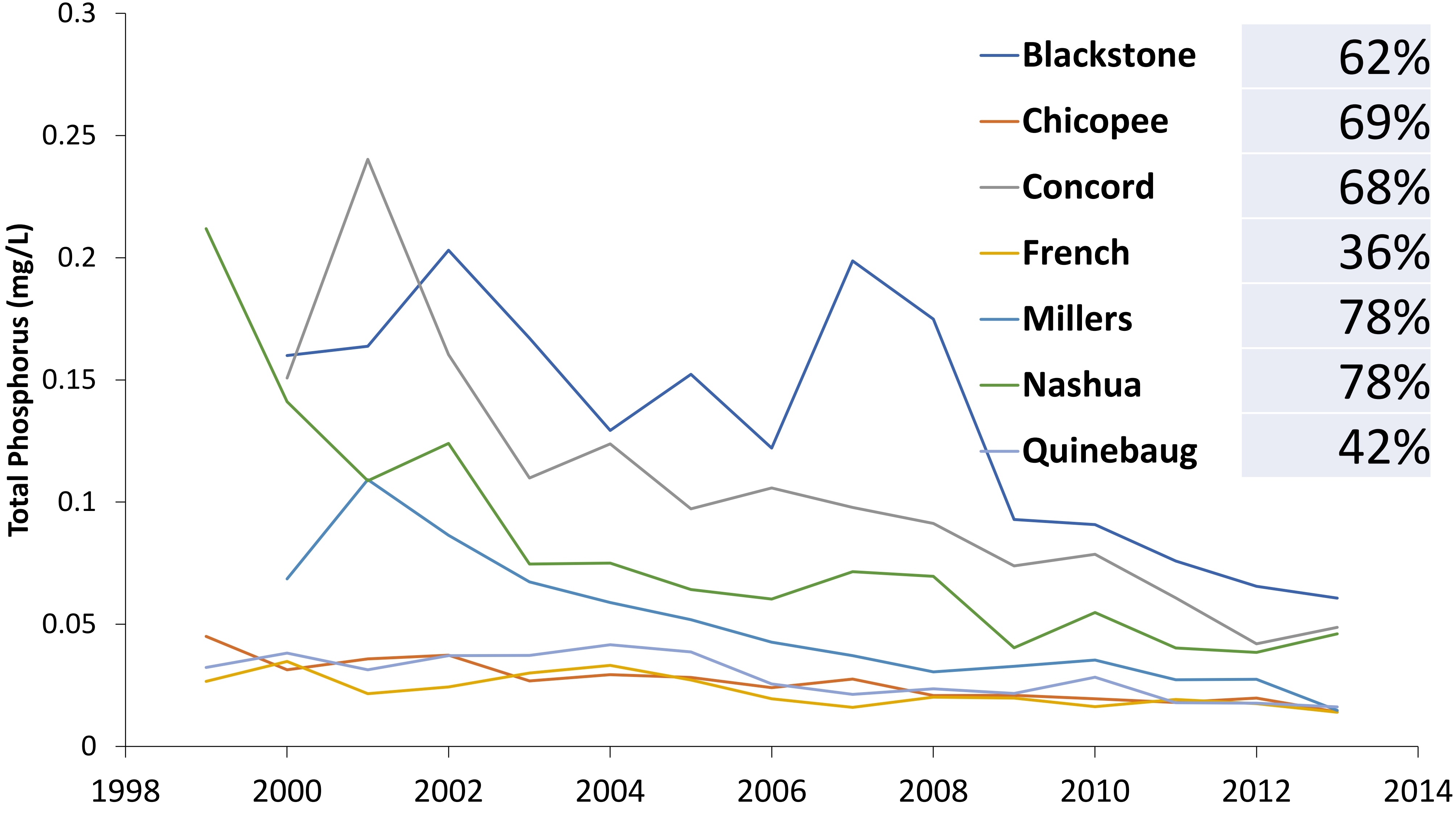


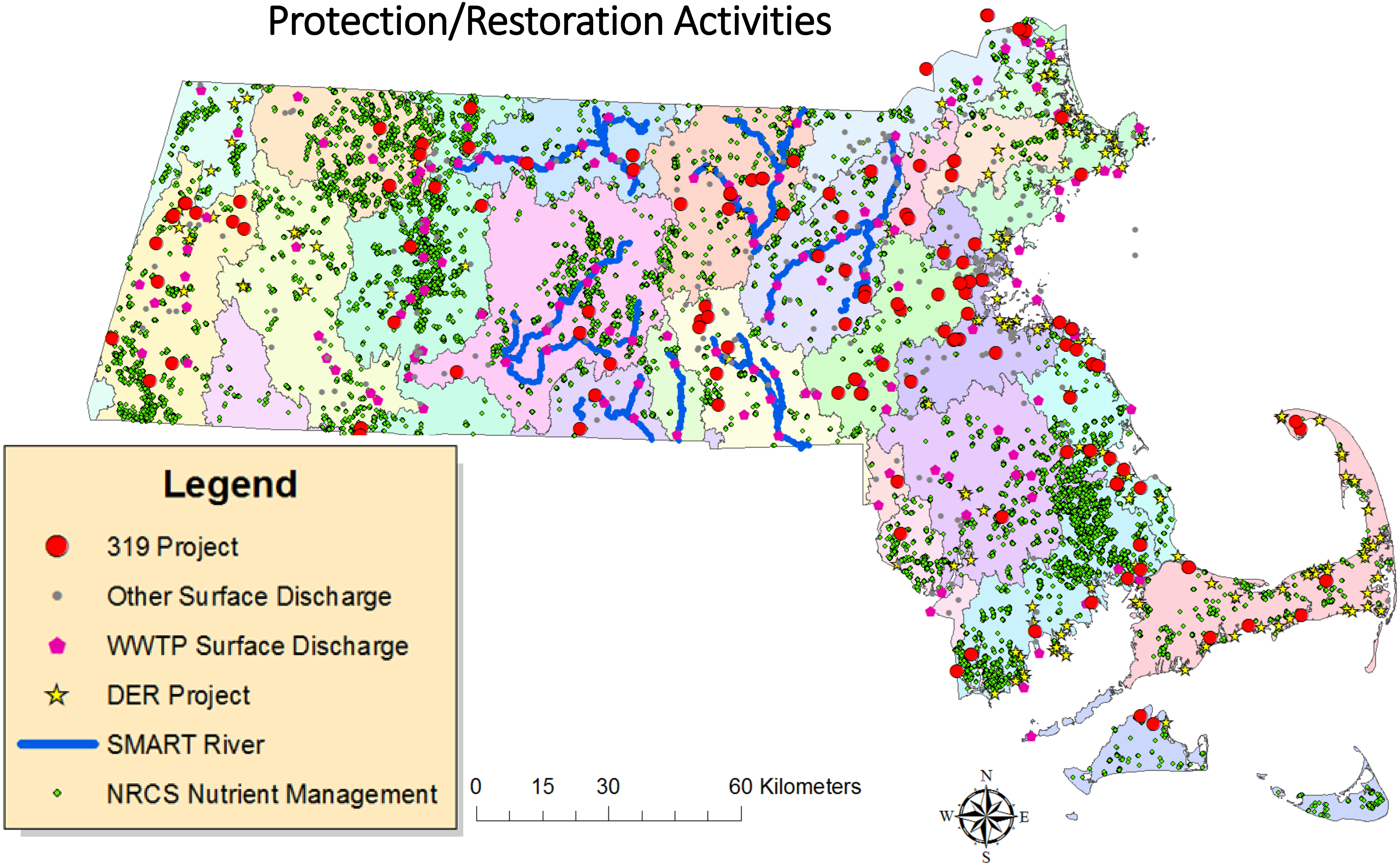
Figure 3. Trends of TP concentrations at least impacted and highly impacted rivers.

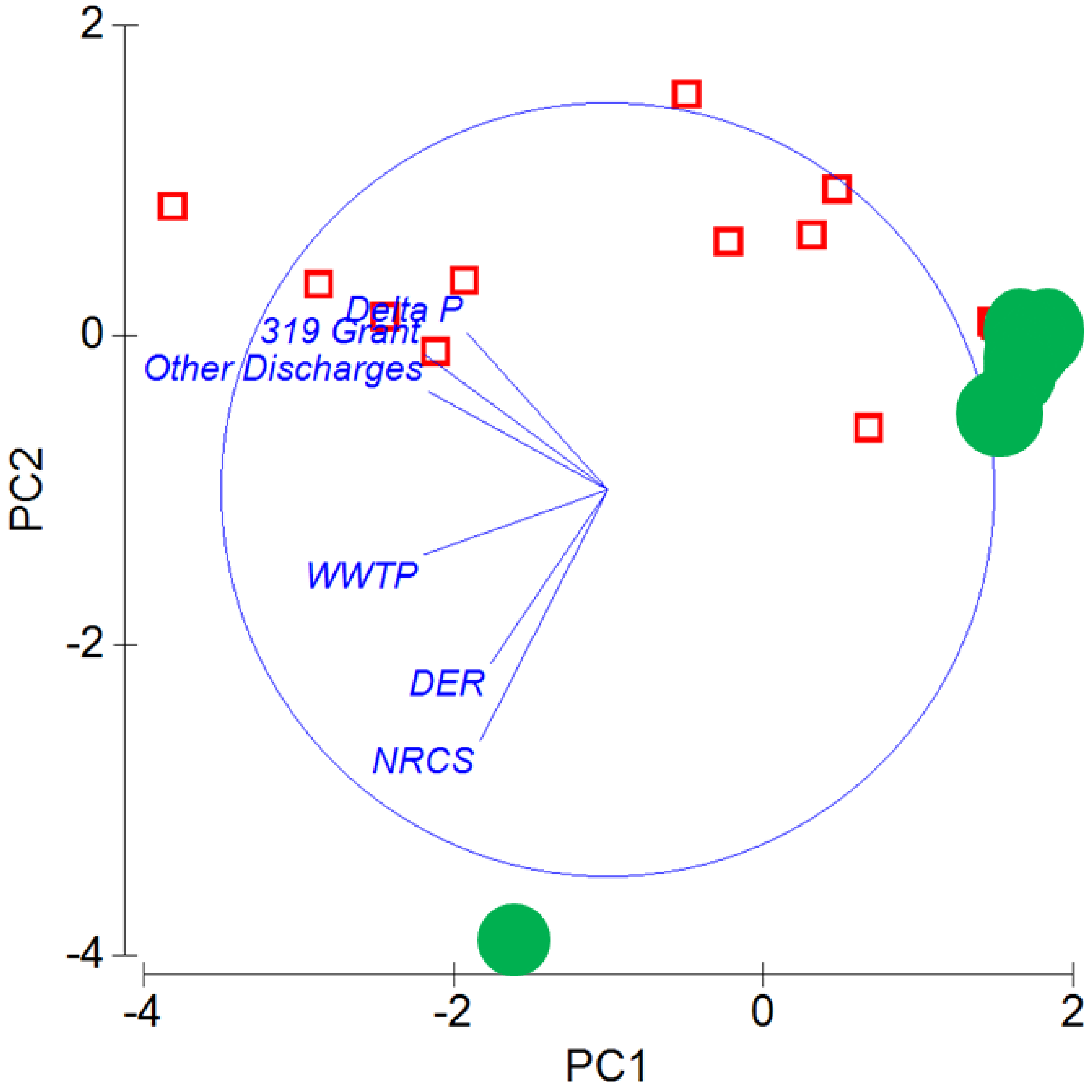

Nashua River
Total Photphorus Concentration (mg/L)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
4/1/2012
12/27/2014
TP (mg/L)



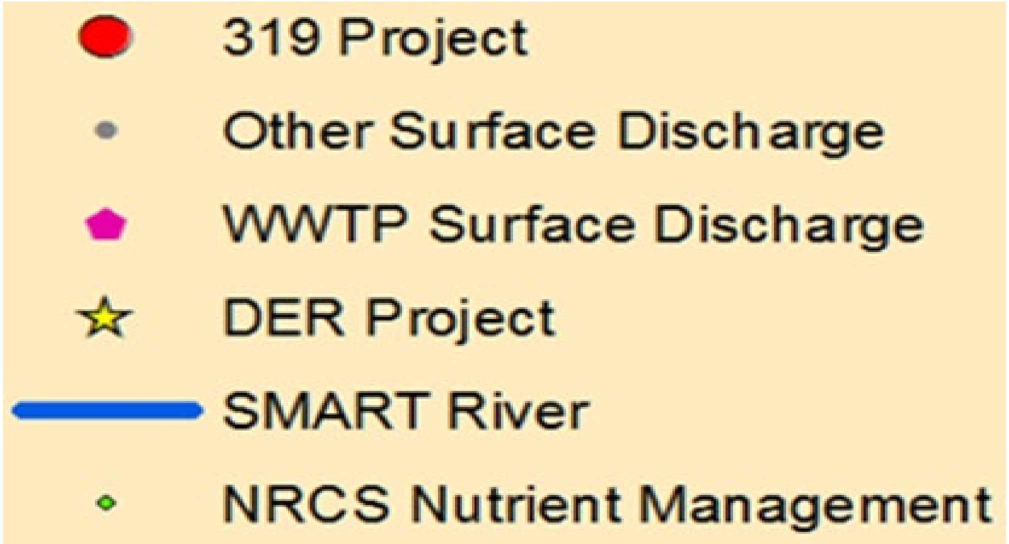
Declining Phosphorus Trends in Massachusetts Watersheds

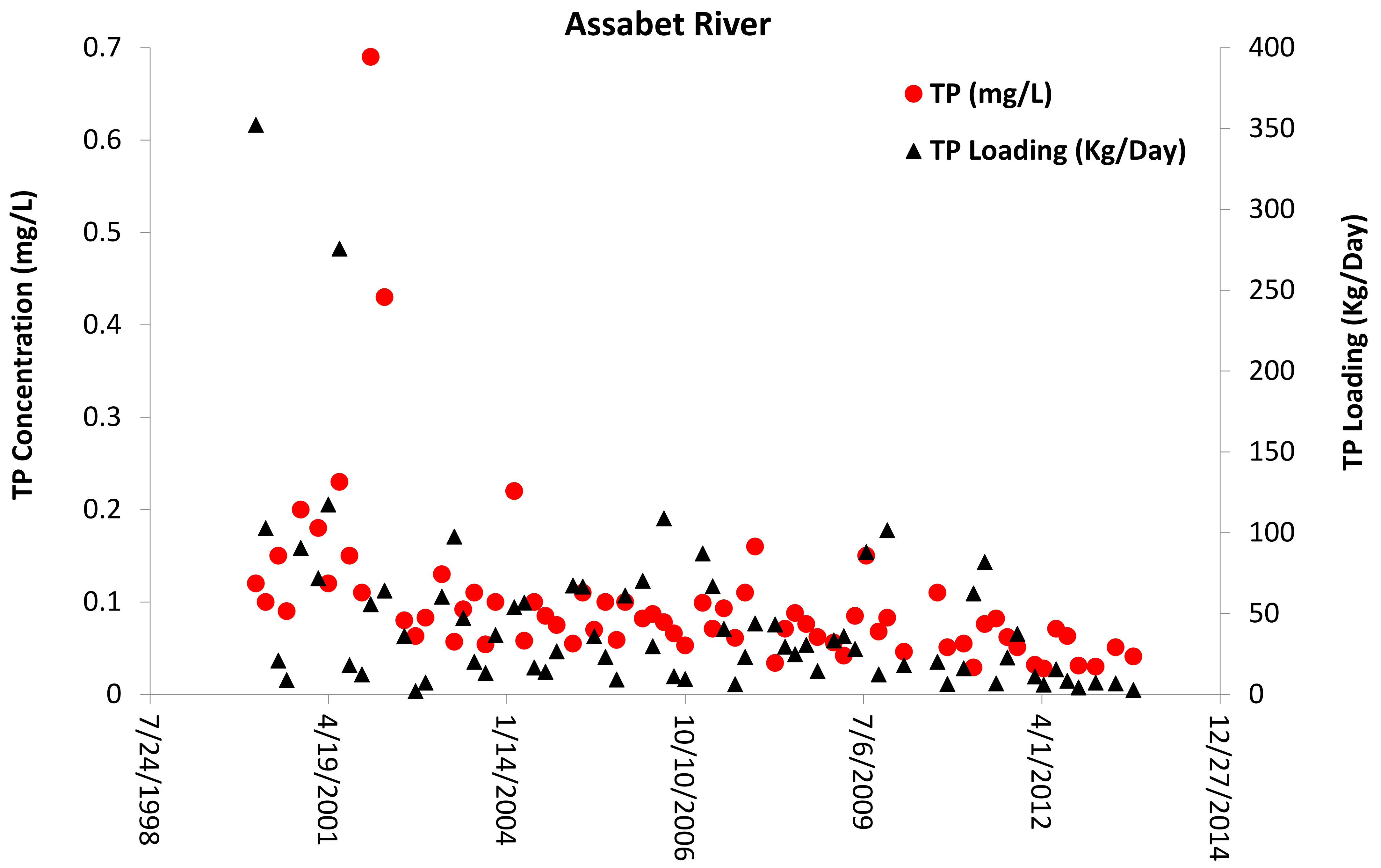
Protection/Restoration Activities





Principal Components (PC) 1 and 2 explain 54.9% and 18.8% of the variation, respectively.

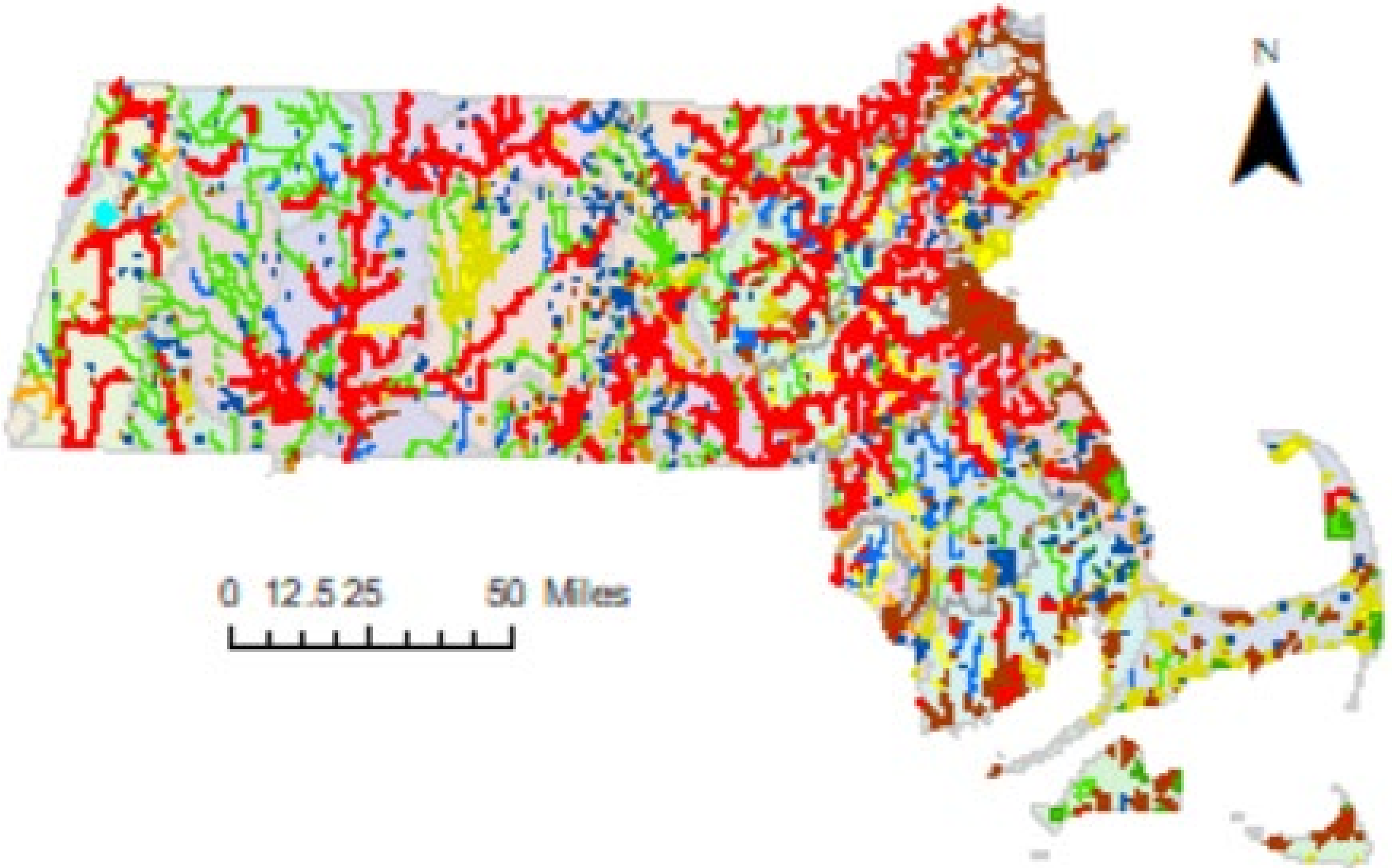




Assabet River
TP (mg/L)
TP Loading (Kg/Day)
TP Concentration (mg/L)
TP Loading (Kg/Day)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
50
100
150
200
250
300
350
400
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
4/1/2012
12/27/2014

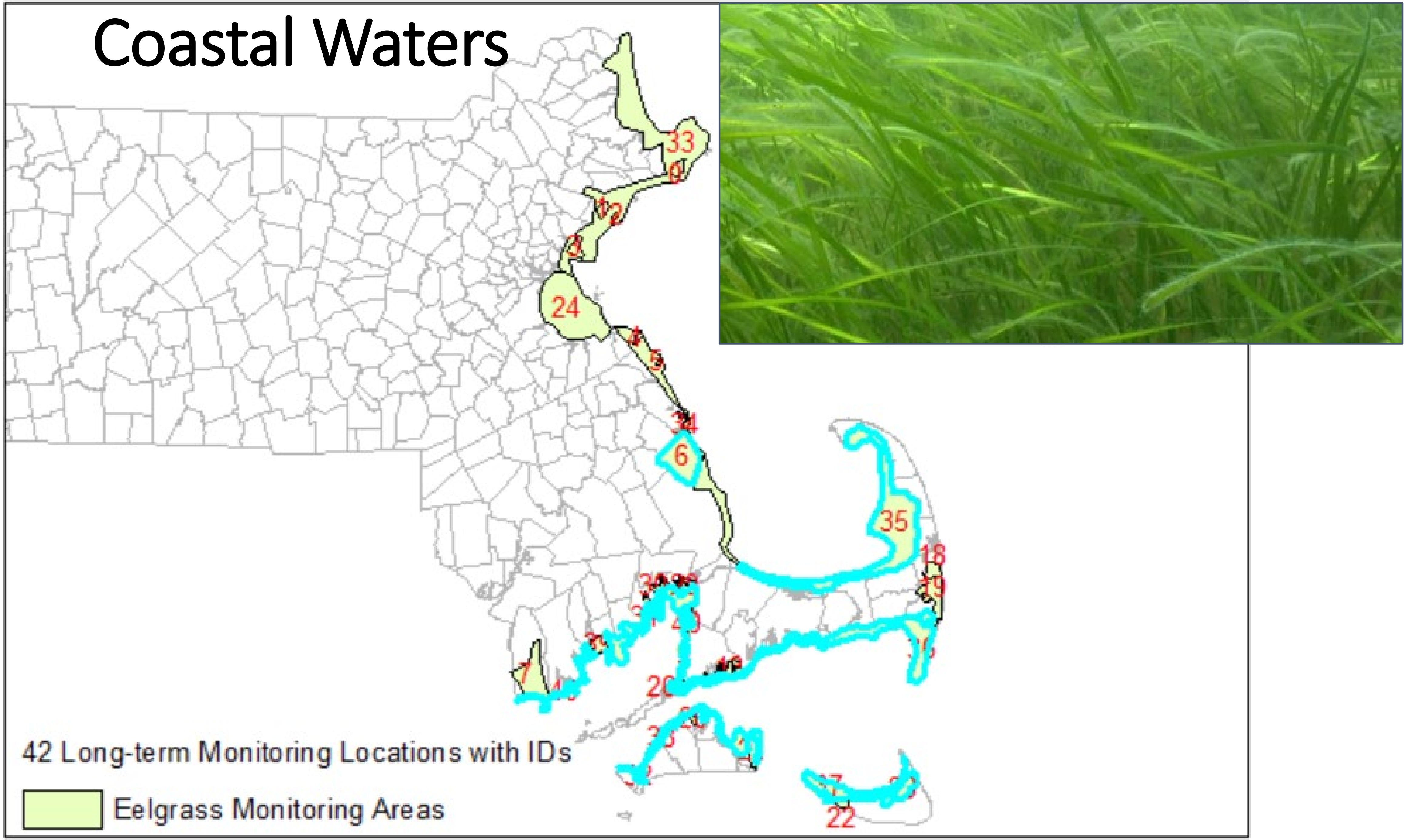
MA Water Quality Challenges

Nutrient enrichment (Eutrophication)
Climate Change
PFAS (Per- and Polyfluoroalkyl Substances)
Plastics in water
Road Salt



Freshwaters: Nutrient enrichment (mainly Phosphorus) directly or indirectly linked to approximately 48% of water quality impairments

Coastal Waters



- Secchi (water clarity)
- Shoreline isolation
- Sediment TOC%
- Sediment particle size class
- Salinity
- Depth
- Total Nitrogen Loads

Naomi E. Detenbeck and Steven Rego 2015

Fishing and Shellfishing Activities

Does scalloping impact eelgrass?...
What does the literature tell us?

<u>Bishop et al 2005 and Fonseca et al 1984</u>

Bay scallop dredging in eelgrass in North Carolina

- Both measured eelgrass effects by simulating dredging activity

<u>Results</u>:

Immediate impacts to eelgrass (both studies) but no effects 1 month later (Bishop et al)

Dredging up eelgrass in Nantucket Harbor in 1950s (MacKenzie 2008)

The Boston Globe

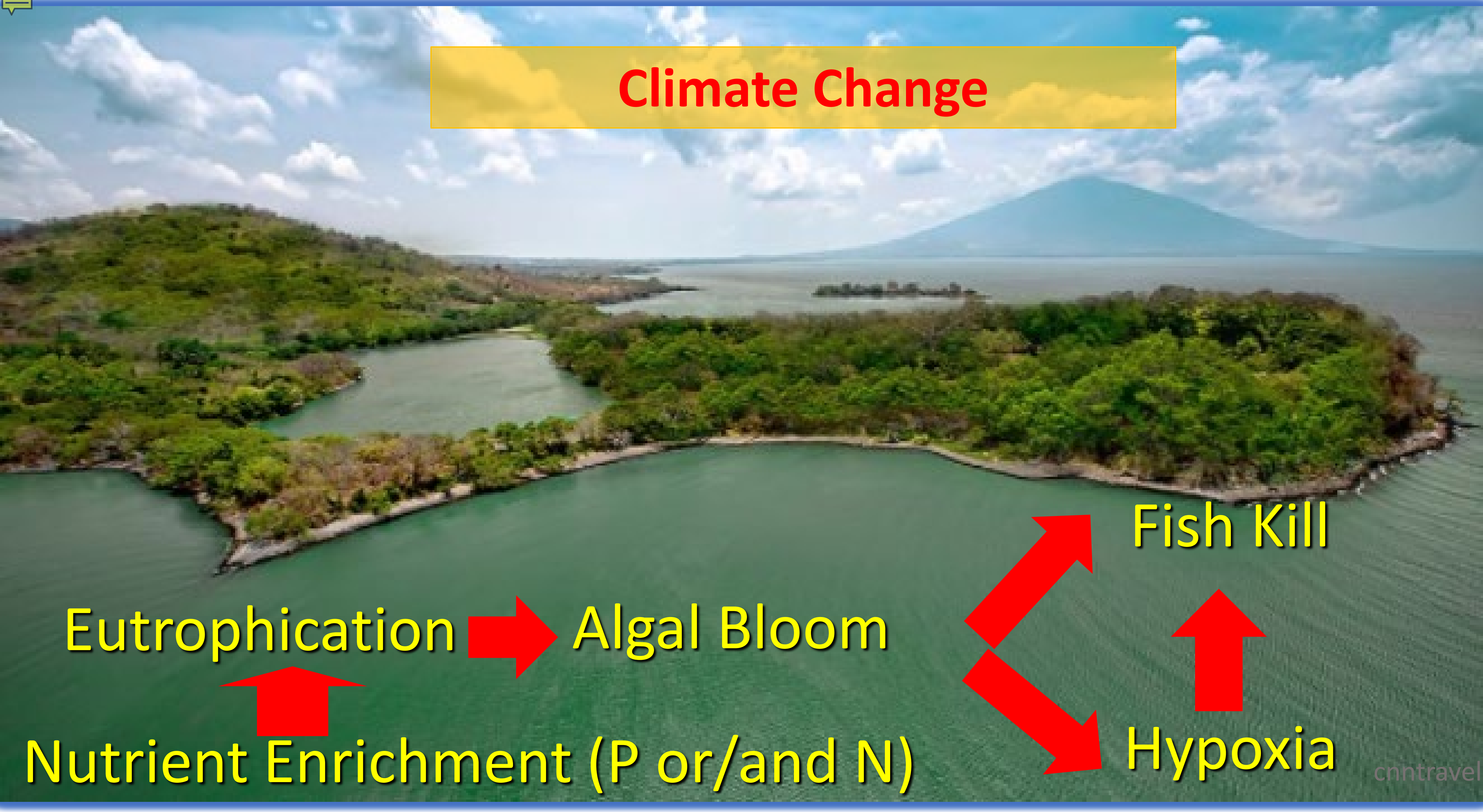
Warming winters are threatening who we are as New Englanders, and that includes our

A new study has found that winters in New England have warmed dramatically in the past 50 years, led by Burlington, Vt., which is tops in the nation with a 7.1-degree jump in average temperature.

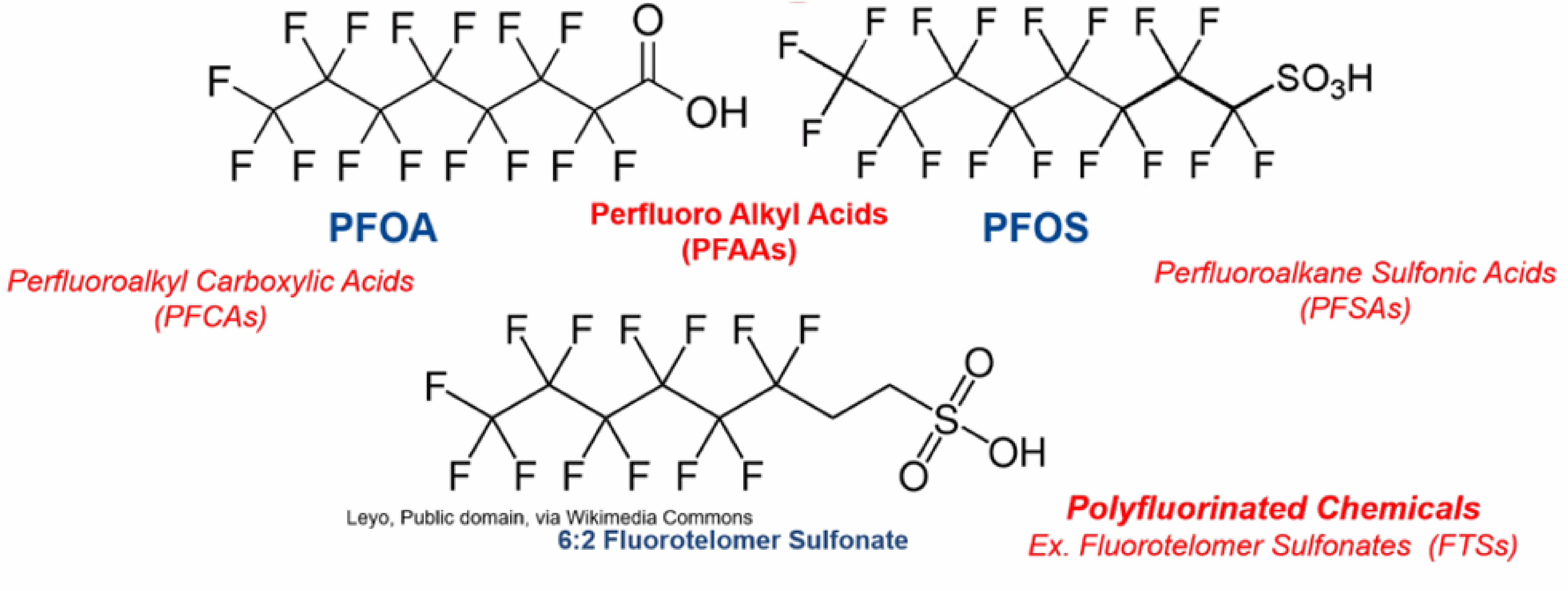
Climate Change and Harmful Algal Blooms

Scientists predict that climate change will have many effects on freshwater and marine environments. These effects, along with nutrient pollution, might cause harmful algal blooms to occur more often, in more waterbodies and to be more intense. Algal blooms endanger human health, the environment and economies across the United States.

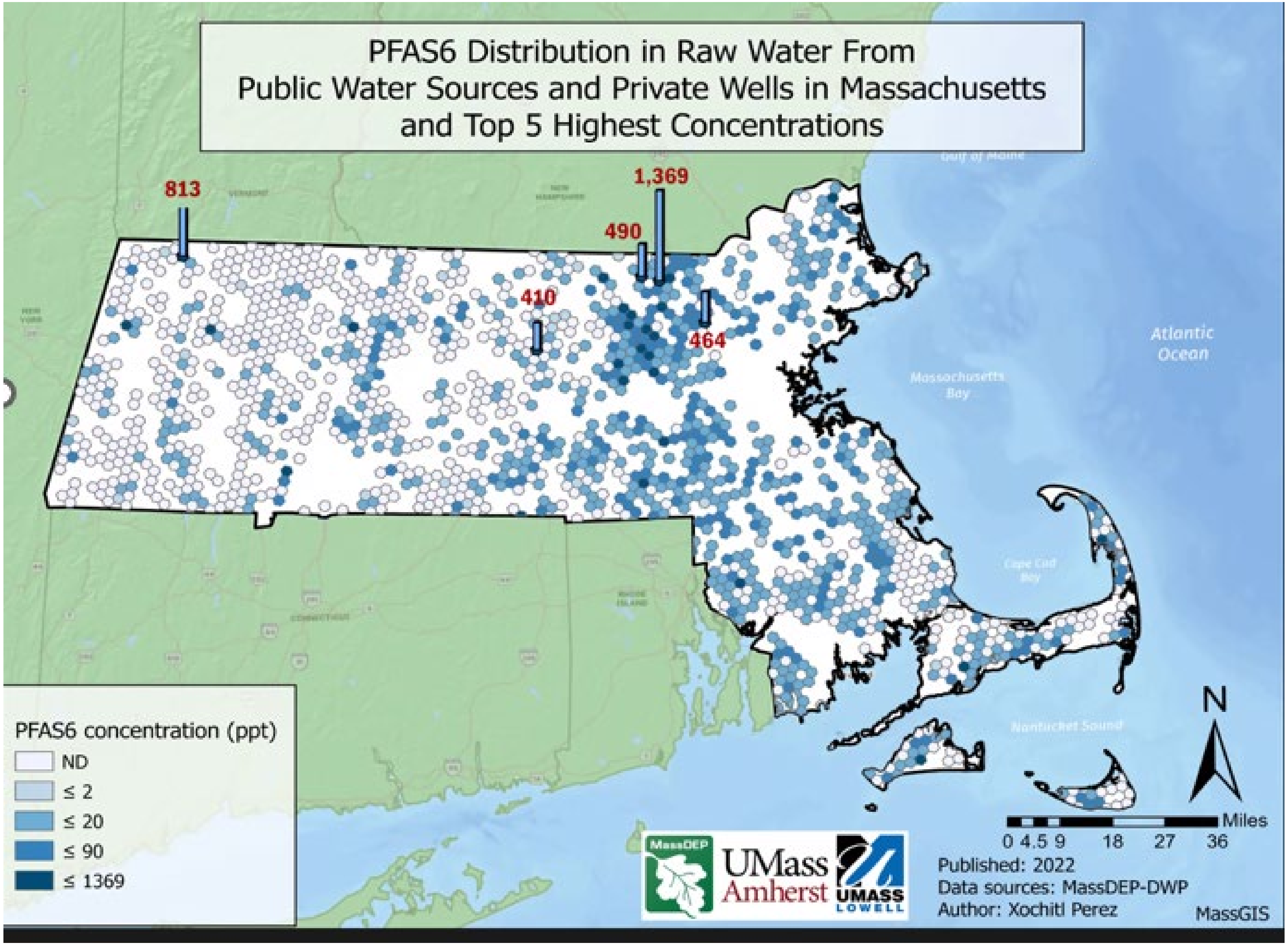
- Toxic blue-green algae prefer warmer water.
- Warmer temperatures prevent water from mixing, allowing algae to grow thicker and faster.
- Algal blooms absorb sunlight, making water even warmer and promoting more blooms.


Climate Change
Fish Kill
Eutrophication
Algal Bloom
Hypoxia
Nutrient Enrichment (P or/and N)
cnntravel

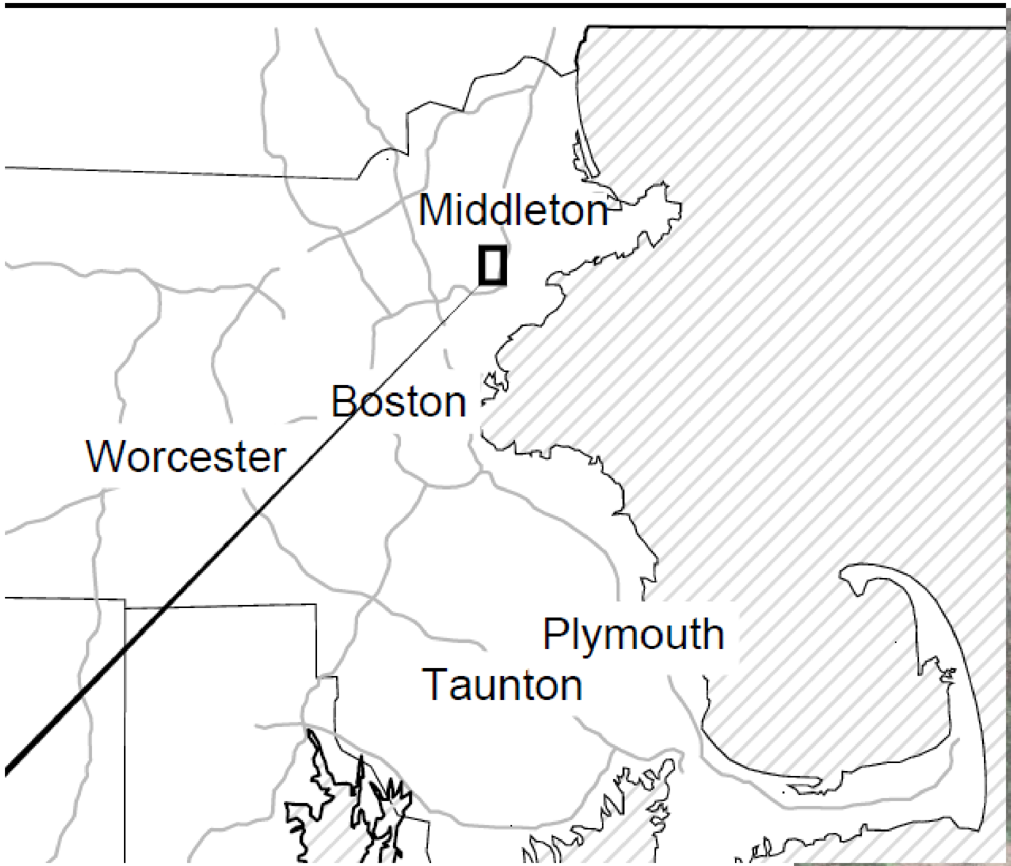
Per- and polyfluoroalkyl Substances (PFAS)



Jim Occhialini 2023



PFAS6 Distribution in Raw Water From Public Water Sources and Private Wells in Massachusetts and Top 5 Highest Concentrations
813
1,369
490
410
464
Atlantic Ocean
Massachusetts Bay
Cape Cod Bay
Nantucket Sound
PFAS6 concentration (ppt)
ND
≤ 2
≤ 20
≤ 90
≤ 1369
N
0 4.5 9 18 27 36 Miles
MassDEP
UMass Amherst
UMASS LOWELL
Published: 2022
Data sources: MassDEP-DWP
Author: Xochitl Perez
MassGIS



South Middleton Dam

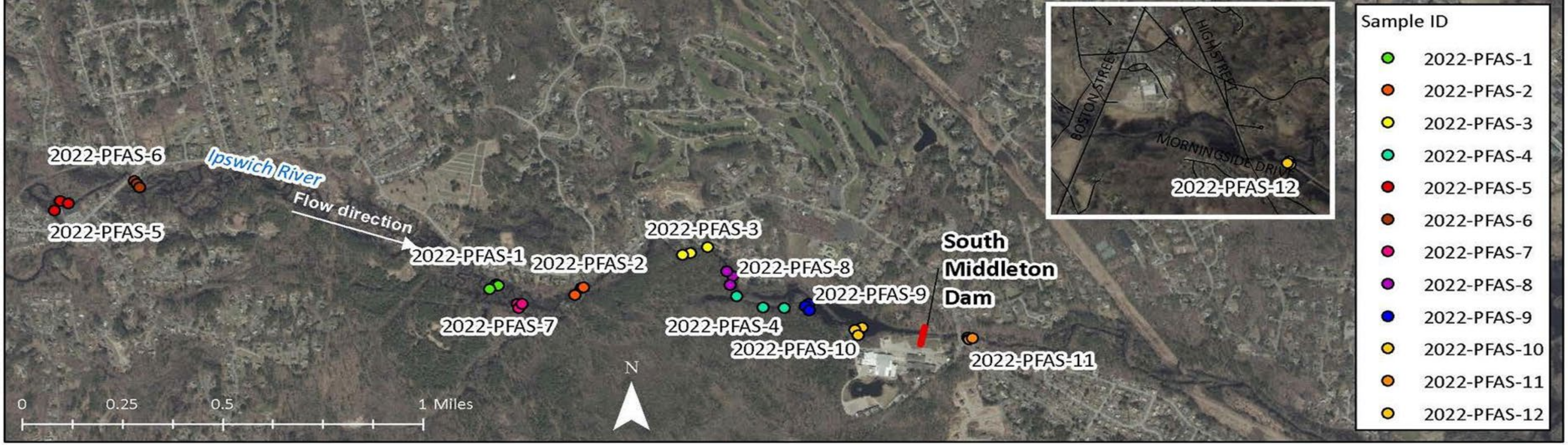
South Middleton Dam

Sediment Sampling Results
South Middleton Dam
Middleton, MA

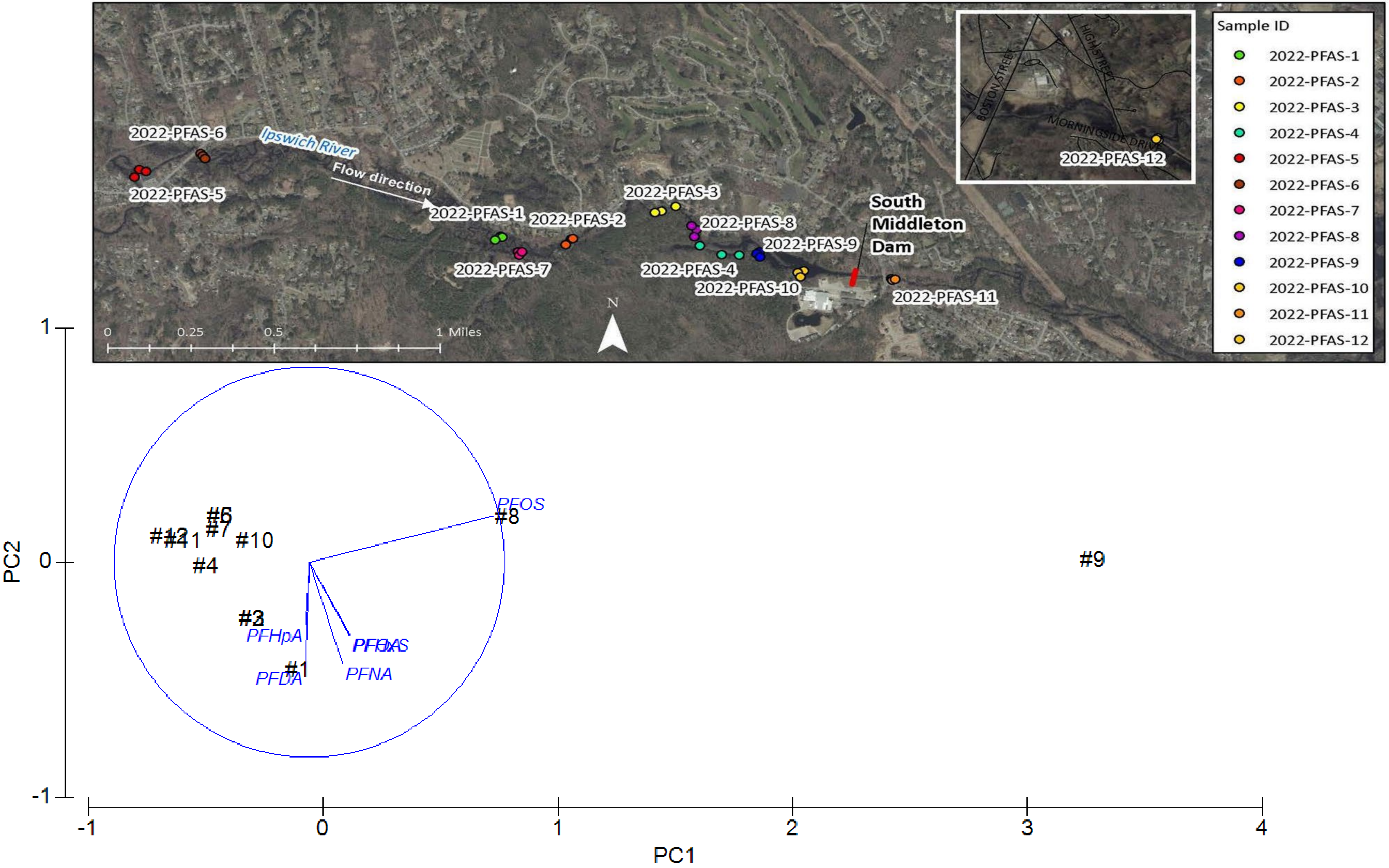
Screening Benchmarks

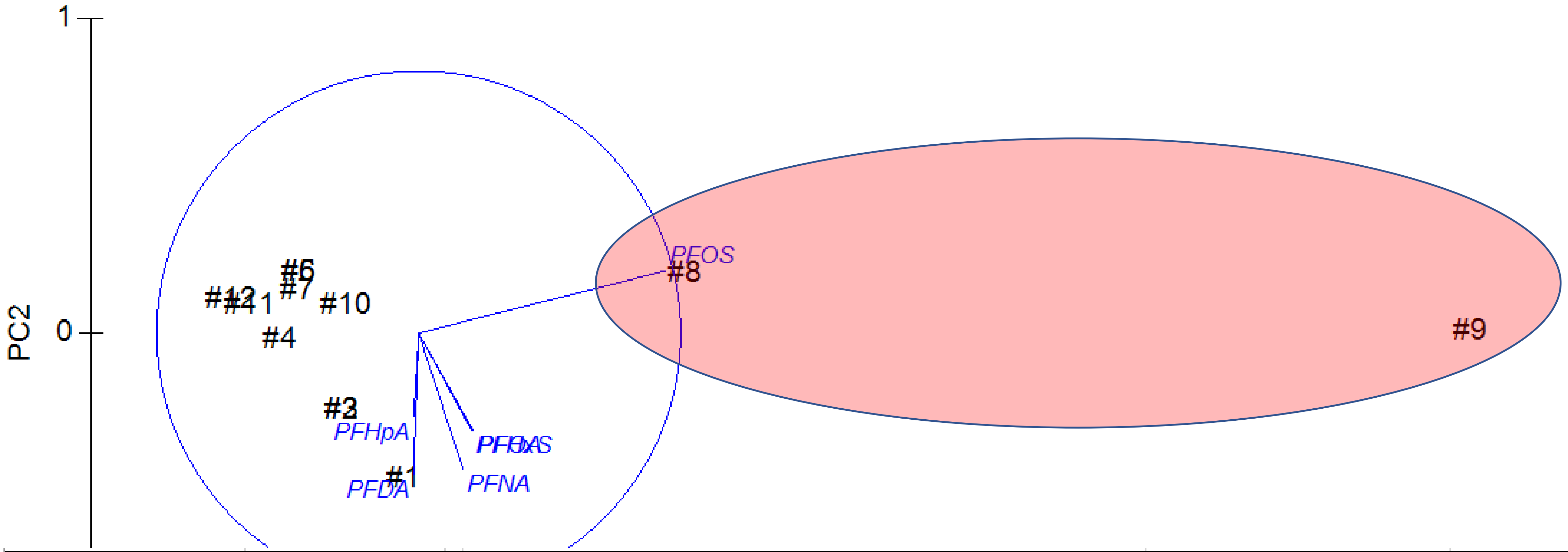
Parameter (Important: Units listed by category below)	Method	MCP S1 / GW1	TEC	PEC	TCLP	US 1	IMP 1	IMP 2	IMP 3	IMP 4	IMP 5	IMP 6 29-May-19	IMP 7 29-May-19	IMP 8 29-May-19	IMP 9 29-May-19	DS 2 29-May-19	DS 1 29-May-19
Metals [mg/kg]																	
Arsenic	6020A											5.4	2.2	3.6	4.2	4.4	3
Cadmium	6020A											< 0.47	< 0.42	< 0.47	< 0.37	< 0.47	< 0.52
Chromium	6020A											5.6	5.7	7.6	6.9	46	9.8
Lead	6020A										220	22	7.3	13	13	61	19
Nickel	6020A										9	< 4.7	< 4.2	< 4.7	4.6	7.7	7
Zinc	6020A										360	45	10	21	46	59	31
Silver	6020A										< 2.4	< 2.3	< 2.1	< 2.4	< 1.9	< 2.4	< 2.6
Mercury	7471A										1.8	0.06	< 0.03	0.04	0.04	0.09	0.13
Copper	6020A													< 4.7	3.9	23	6.4
SVOCs (PAHs)[ug/kg]																	
Acenaphthene	8270D													<7.6	<5.3	53	<8.7
Acenaphthylene	8270D													<7.6	<5.3	150	<8.7
Anthracene	8270D										110	<9.5	<6.8	<7.6	<5.3	320	<8.7
Benzo(A)Anthracene	8270D										310	41	<6.8	<7.6	14	1800	21
Benzo(A)Pyrene	8270D										350	54	8.7	<7.6	24	2000	38
Benzo(B)Fluoranthene	8270D										410	73	9.5	<7.6	22	2000	51
Benzo(G,H,I)Perylene	8270D										280	56	8.3	<7.6	18	1600	33
Benzo(K)Fluoranthene	8270D									59	280	59	<6.8	<7.6	20	1700	29
Chrysene	8270D									72	480	62	<6.8	<7.6	20	2200	39
Dibenzo(A,H)Anthracene	8270D									13	82	<9.5	<6.8	<7.6	5.7	490	11
Dibenzofuran	8270D									<12	29	<9.5	<6.8	<7.6	<5.3	36	<8.7
Fluoranthene	8270D									120	750	95	14	<7.6	34	3900	68
Fluorene	8270D						30	<6.4	140	<12	66	<9.5	<6.8	<7.6	<5.3	83	<8.7
Indeno(1,2,3-Cd)Pyrene	8270D						250	33	330	50	230	47	10	<7.6	17	1400	32
Phenanthrene	8270D						250	33	1800	58	540	46	13	8.6	24	1500	36
Pyrene	8270D						720	80	1300	140	620	100	14	8.2	45	3600	73
2-Methylnaphthalene	8270D						<21	<6.4	47	<12	62	<9.5	<6.8	<7.6	<5.3	18	<8.7
Naphthalene	8270D	4,000.0	176.0	561.0		<680	<5700	<1600	<770	<1700	<1300	<1700	<780	<1600	<770	<1000	<1600
Total PAHs			1,616.9	24,312.0		170.00	4263.00	472.60	8441.00	800.00	4674.00	633.00	77.50	16.80	243.70	22850.00	431.00
Pesticides (ug/kg)																	
4,4'-Ddd	8081	4,000.0	NC	NC		<5.1	29.00	<6.4	<6.5	<11	28	<9.5	<6.7	<7.6	<5.3	5.9	<8.8
4,4'-Dde	8081	3,000.0	NC	NC		<5.1	33.00	<6.4	<6.5	<11	13	<9.5	<6.7	<7.6	<5.3	6.6	<8.8

2021: The Salem-Beverly Water Supply provided comments that potential PFAS may be generated by sediment released downstream

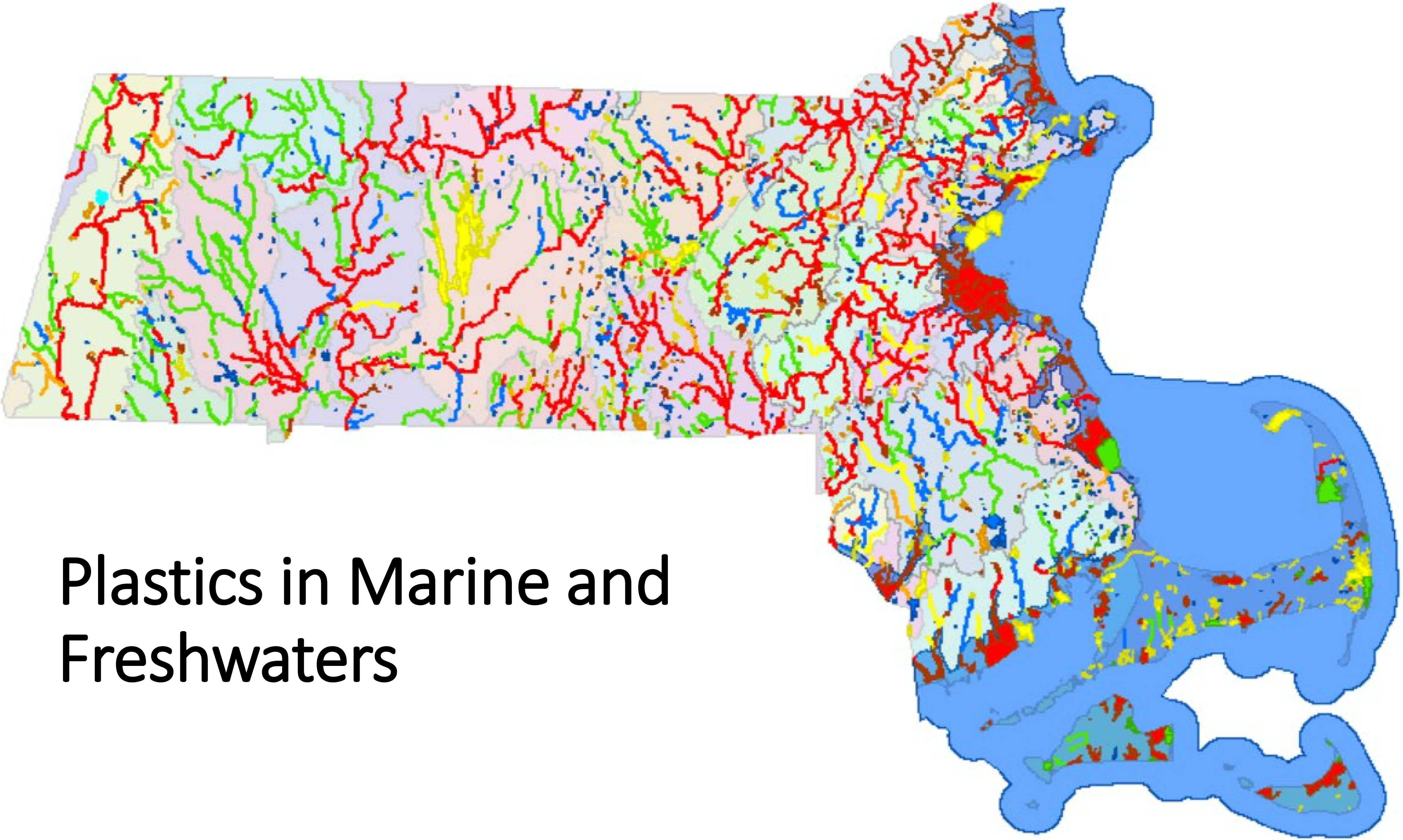


Units	Analyte		MA Contingency Plan Method 1 S-1/GW-1 standards
ug/kg (ppb)	PFHpA		0.5
ug/kg (ppb)	PFOA		0.72
ug/kg (ppb)	PFNA		0.32
ug/kg (ppb)	PFDA		0.3
ug/kg (ppb)	PFHxS		0.3
ug/kg (ppb)	PFOS		2


Sample ID
2022-PFAS-1
2022-PFAS-2
2022-PFAS-3
2022-PFAS-4
2022-PFAS-5
2022-PFAS-6
2022-PFAS-7
2022-PFAS-8
2022-PFAS-9
2022-PFAS-10
2022-PFAS-11
2022-PFAS-12
Ipswich River
Flow direction
South Middleton Dam
BOSTON STREET
HIGH STREET
MORNINGSIDE DRIVE
N
0
0.25
0.5
1 Miles
PC1
PC2
PFOS
PFHpA
PFDA
PFNA
#8
#9
#10
#4
#7
#1
-1
0
1
2
3
4



Units	Analyte	Method 1 S-1/GW-1 standards	2022-PFAS-8	2022-PFAS-9
ug/kg (ppb)	PFHpA	0.5	<0.11	<0.27 U
ug/kg (ppb)	PFOA	0.72	<0.20	0.93 J (1)
ug/kg (ppb)	PFNA	0.32	<0.20	0.80 J
ug/kg (ppb)	PFDA	0.3	<0.12	<0.30 U
ug/kg (ppb)	PFHxS	0.3	0.64 J (1)	0.81 J (1)
ug/kg (ppb)	PFOS	2	**1.4**	**3.7**

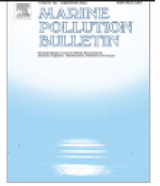


Plastics in Marine and Freshwaters

Plastistone

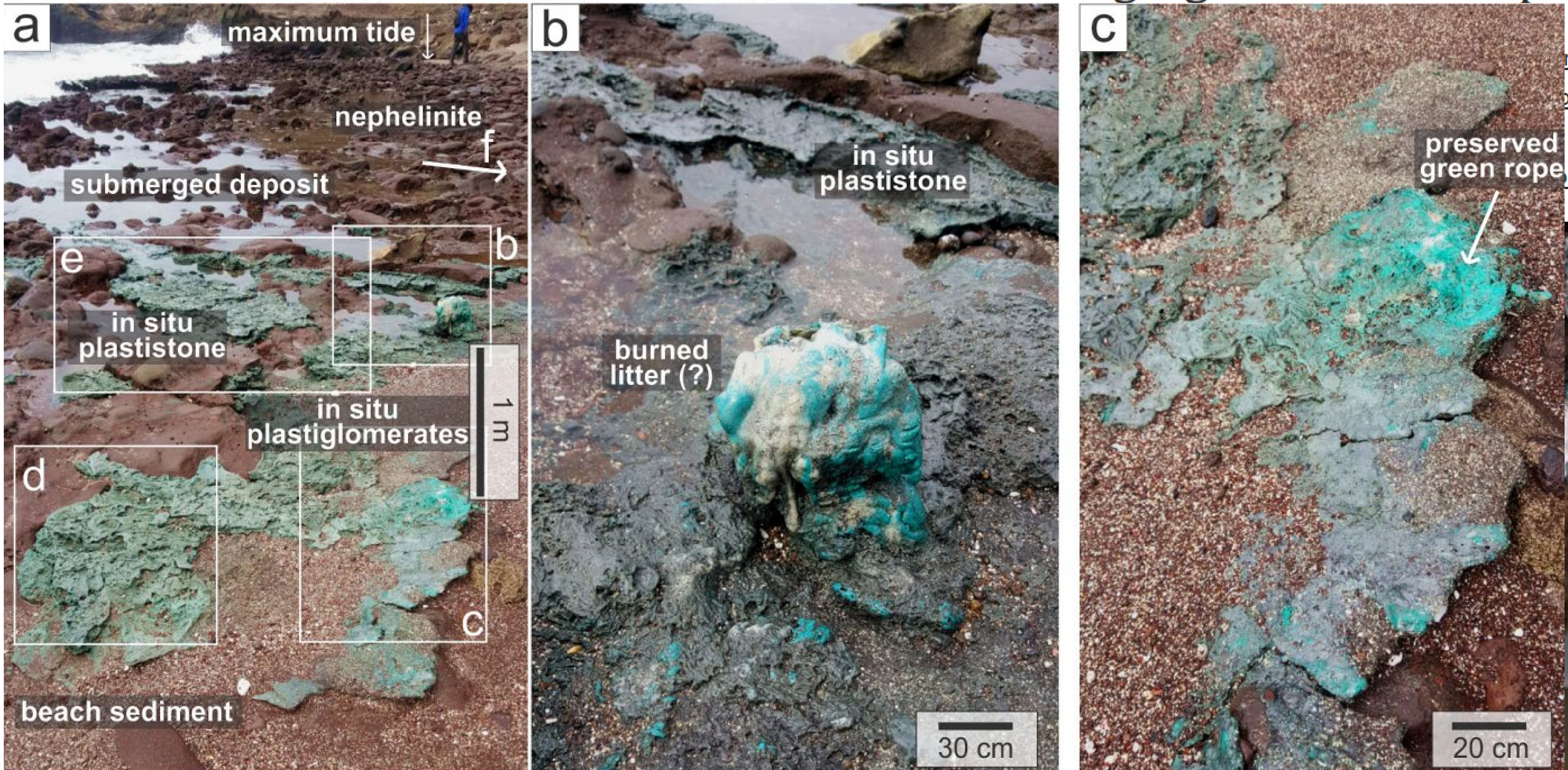
- a novel plastic debris form

Marine Pollution Bulletin
Volume 182, September 2022, 114031



Plastic debris forms: Rock analogues emerging from marine pollution

rio [b],
[c], Paulo C.F. Giannini [d],
erto dos Santos Oliveira [e]

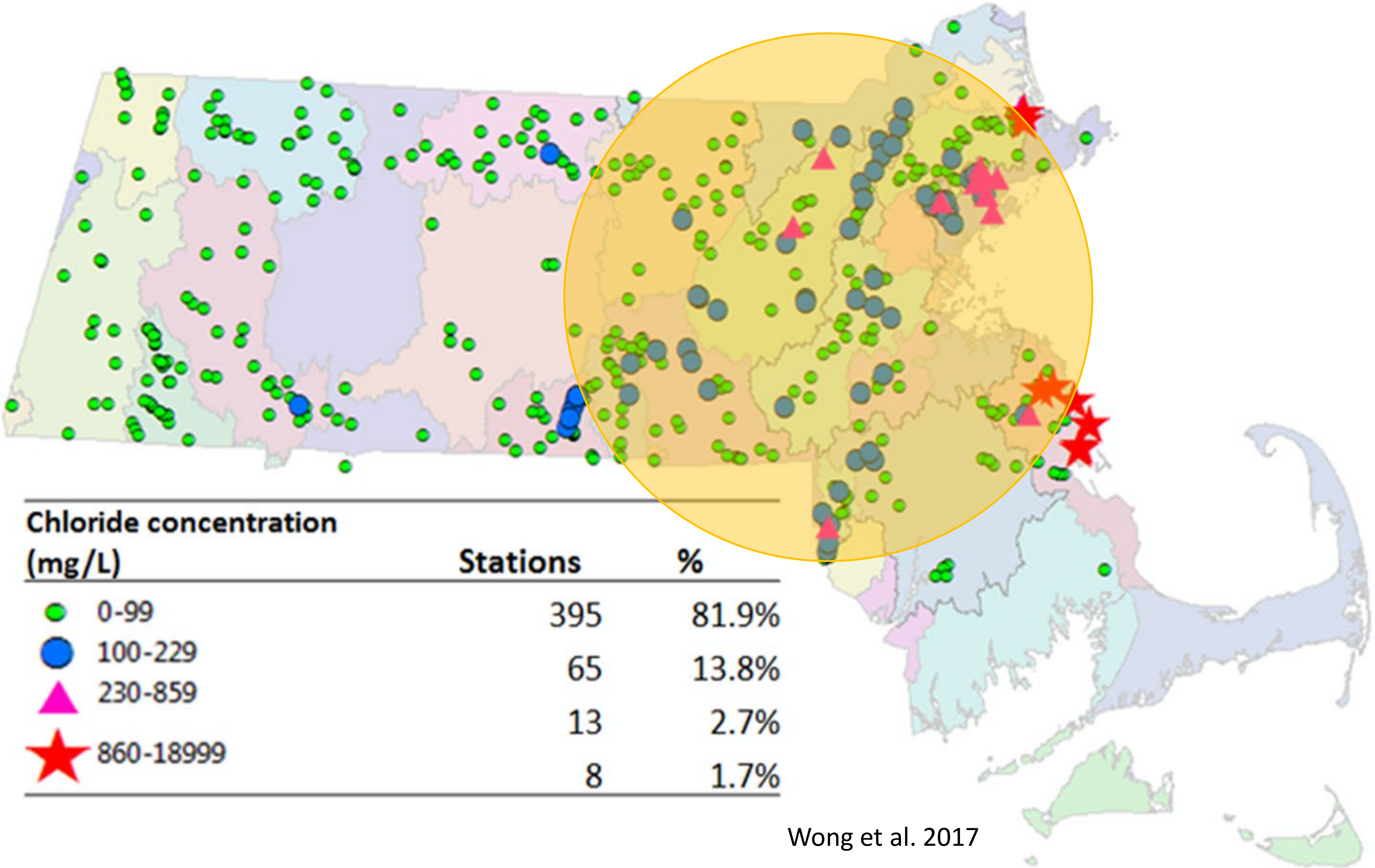


Microplastics

Road Salt

The Boston Globe 2015

Chloride levels in MA surface waters

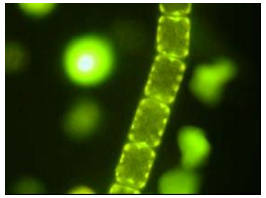
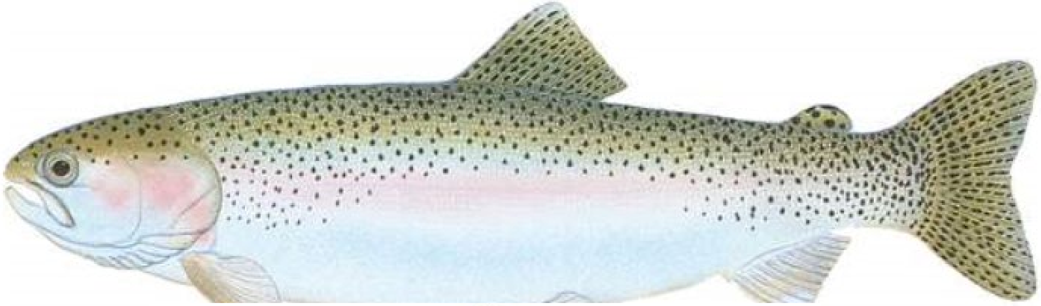
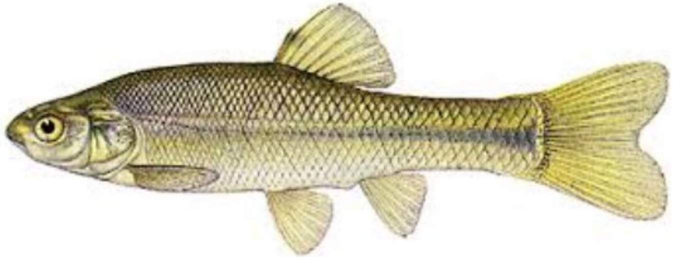


Chloride concentration (mg/L)	Stations	%
0-99	395	81.9%
100-229	65	13.8%
230-859	13	2.7%
860-18999	8	1.7%

Wong et al. 2017

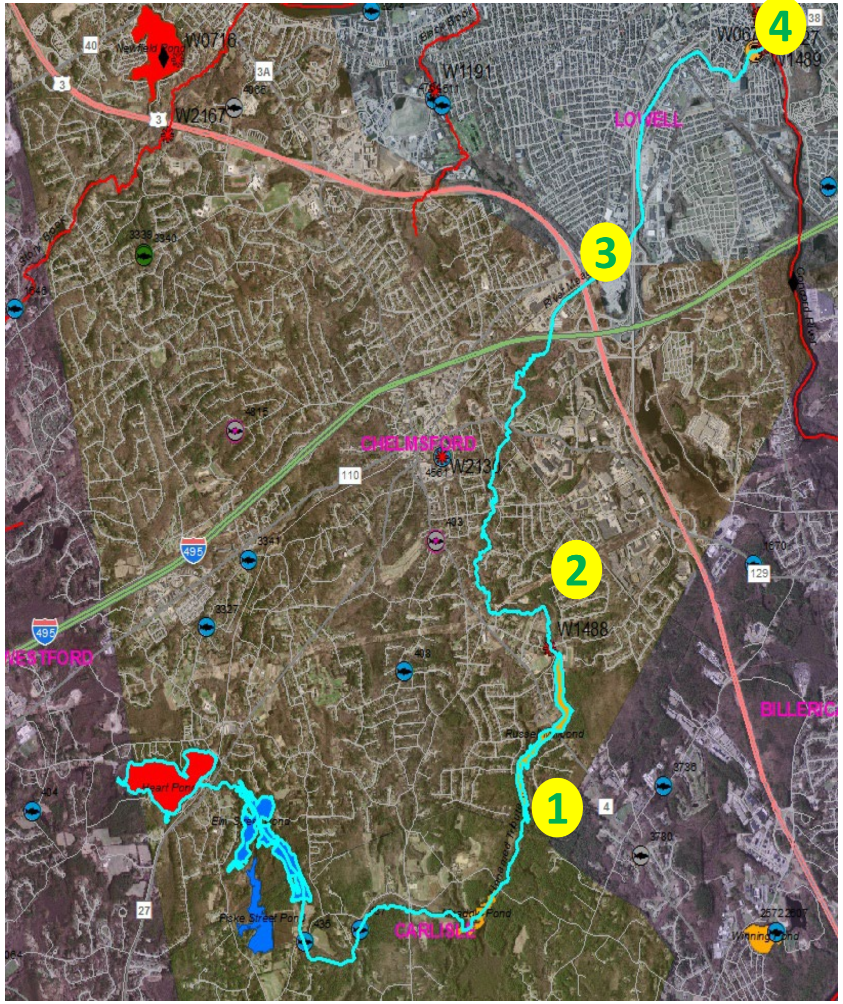
EPA Chloride Criteria

- Aquatic Life: The acute (1-hour average) standard is 860 mg/L; the chronic (four-day average) standard is 230 mg/l: These criteria should not be exceeded more than once every three years

David Wong and http://www.lake-link.com/fish/id.cfm/25/

River Meadow Brook



Site 4: Forest 32%

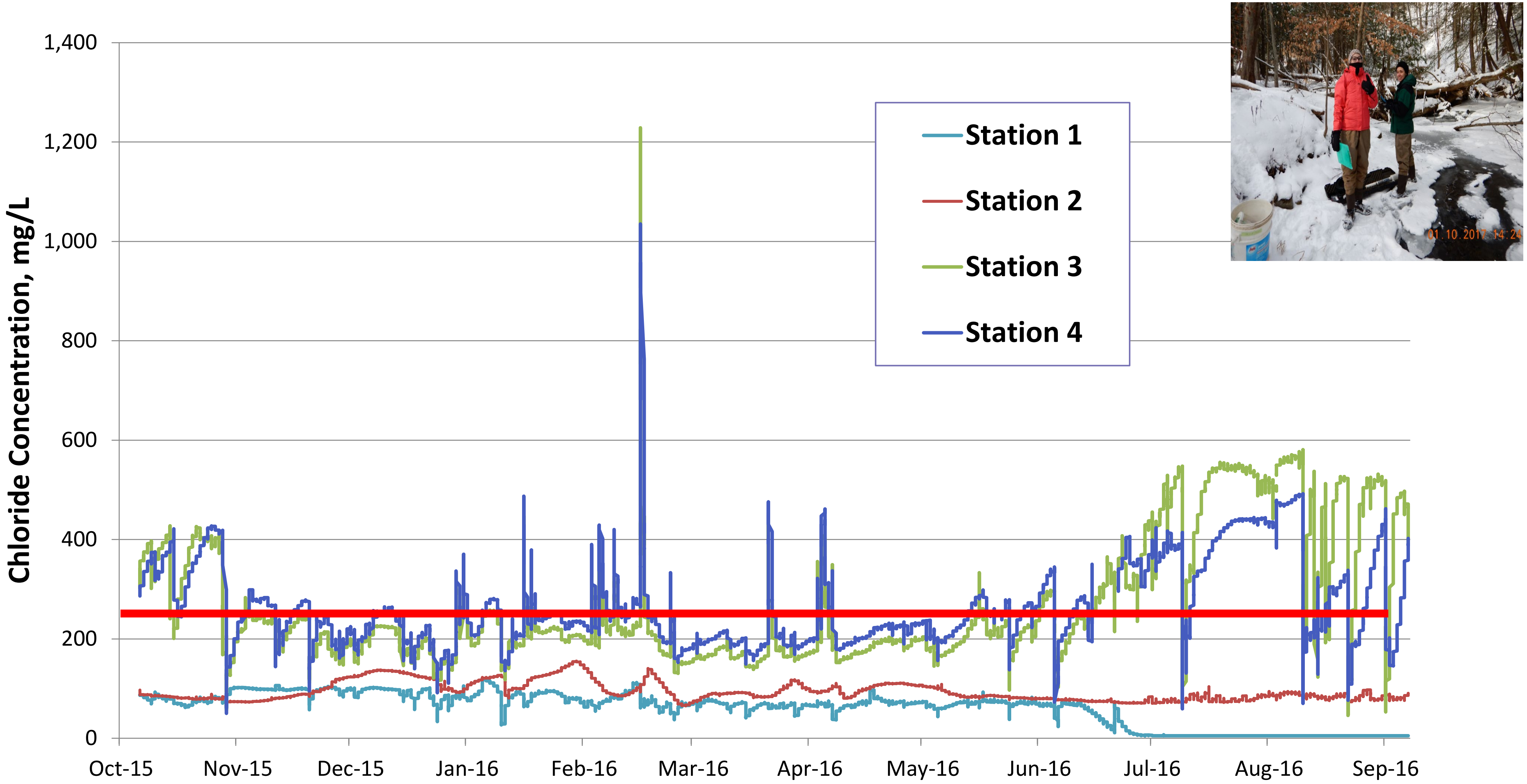
Site 3: Forest 36%

Site 2: Forest 54%

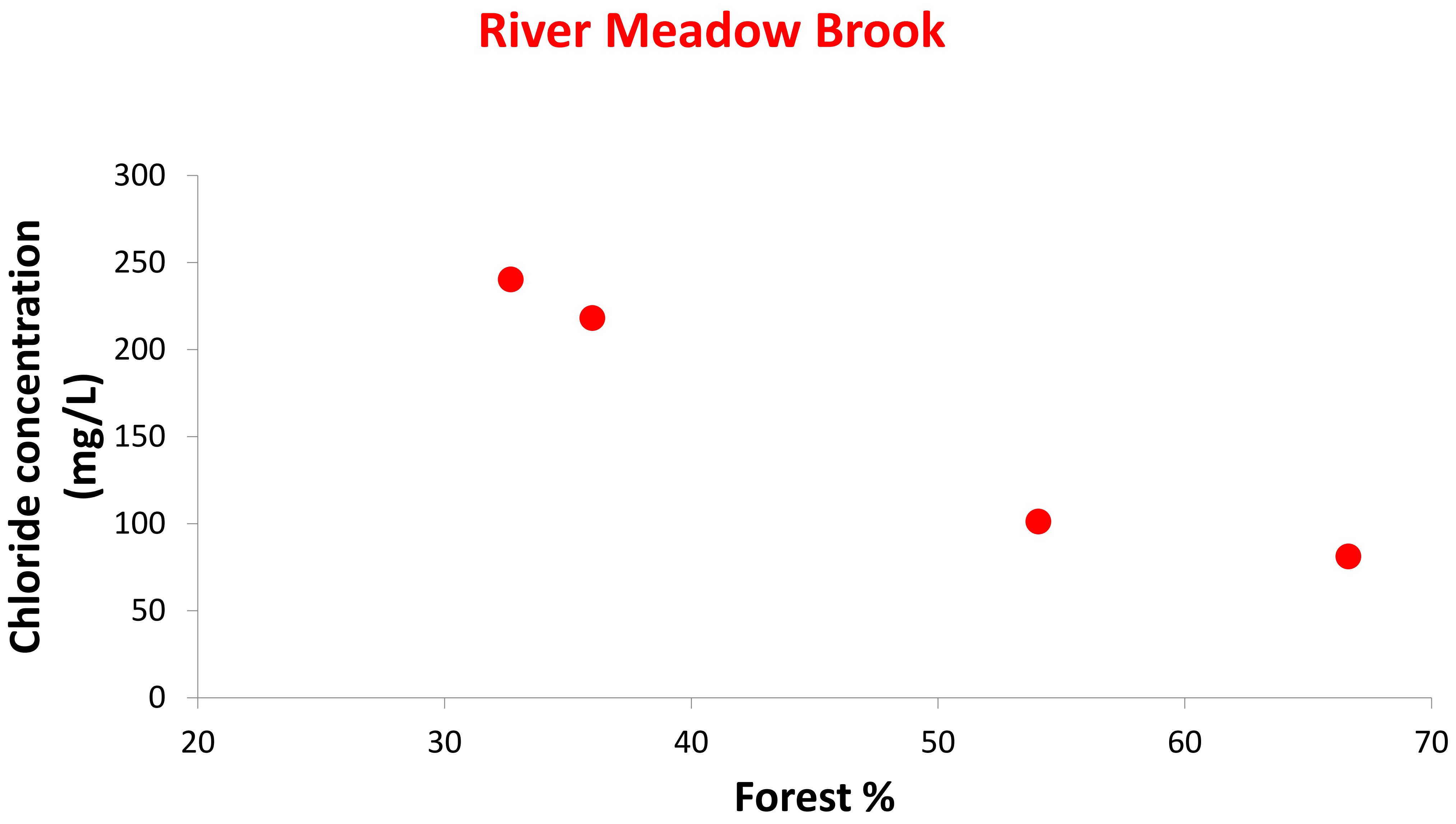
Site 1: Forest 67%

Increasing urbanization

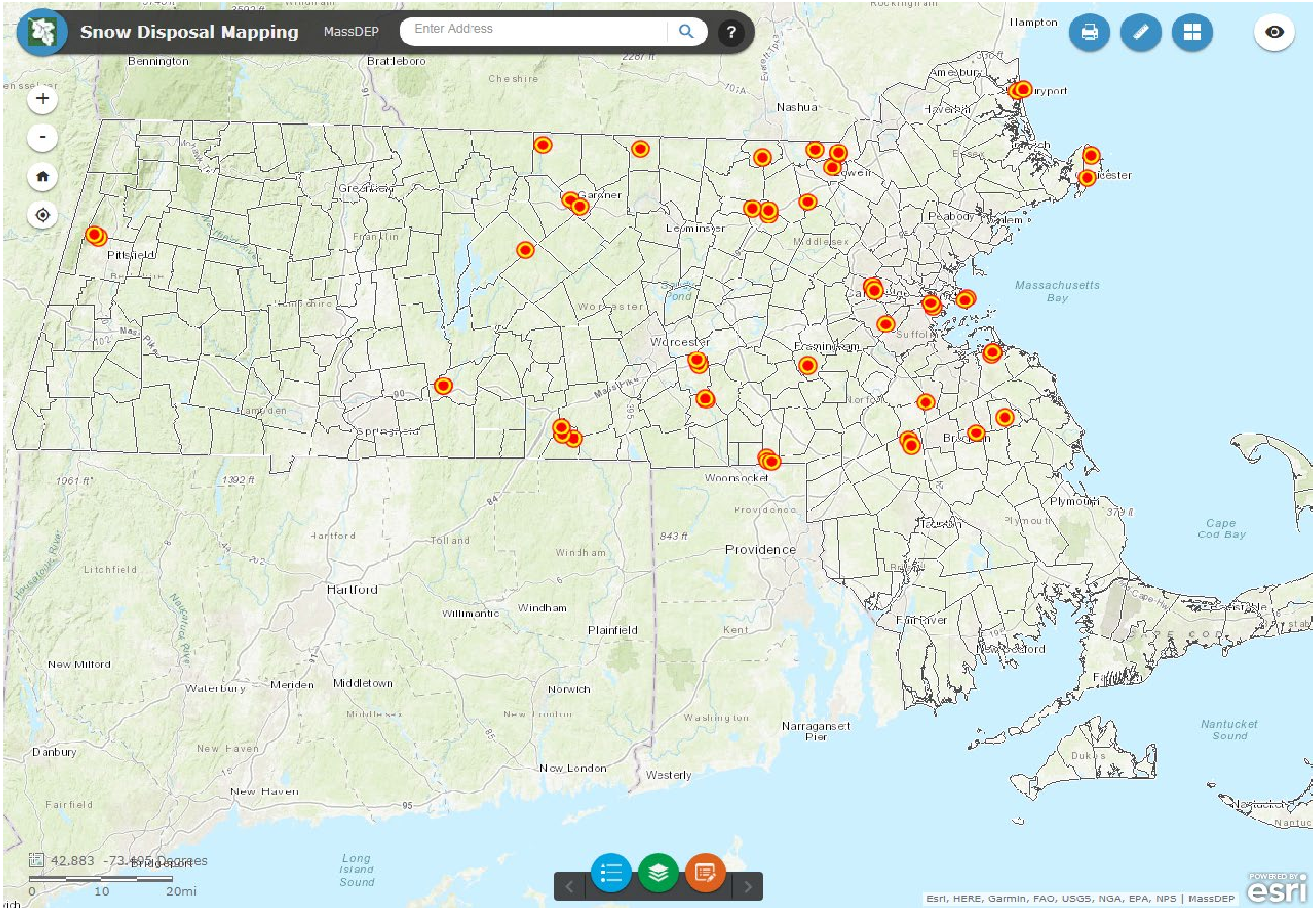
Chloride Concentrations in River Meadow Brook



Average Chloride Concentrations in River Meadow Brook



MassDEP Snow Disposal Guidance



Questions?

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ELSEVIER

Declining ambient water phosphorus concentrations in Massachusetts' rivers from 1999 to 2013: Environmental protection works

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A B S T R A C T

Over the last century, nutrient concentrations in streams, rivers, lakes and ponds have increased substantially in the United States. Elevated phosphorus levels are a concern due to their ability to cause changes in freshwater ecosystems that are detrimental to humans and wildlife. In the present study, long-term trends in total phosphorus (TP) concentrations from 20 rivers in central Massachusetts from 1999 to 2013 were investigated. Kendall's correlation coefficients were used to demonstrate that 18 of the 20 rivers had significant reductions in TP concentrations ($P < 0.05$). A similar trend was found when flow-adjusted TP concentrations were analyzed. At the beginning of monitoring activities, the average TP concentration in 9 of the 20 rivers was greater than 0.05 mg/L and 6 of these 9 rivers contained TP concentrations greater than 0.1 mg/L; about fifteen years later, only 3 rivers contained TP greater than 0.05 mg/L and none had concentrations> 0.1 mg/L. TP decreases were greater in rivers with more anthropogenic inputs. Principal component analysis (PCA) revealed that the decline of TP in these Massachusetts streams is likely the result of advancements in wastewater treatment and implementation of effective non-point source management practices.