Missisquoi River Basin Association
Water Quality Monitoring Program
Summary of Results 2005-2011

Submitted for the Missisquoi River Basin Association
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Missisquoi River Basin Overview:

The Missisquoi River runs across the northwestern part of Vermont and into southern Quebec. The river begins in Lowell and flows approximately 80 miles into the Missisquoi Bay. The Missisquoi River watershed is comprised of forests, agricultural land, and some urban and suburban developments. At 25%, agriculture is the dominant non-forested land use land cover. The water quality in Missisquoi Bay is at risk due to the enrichment of nutrients from the watershed and the toxic algae blooms that result. The Missisquoi River watershed is currently the focus of several monitoring and restoration efforts to identify nutrient sources and minimize nutrient input to the river and bay.

Program Overview:

The Missisquoi River Basin Association (MRBA) is a non-profit organization focused on the restoration of the Missisquoi River and its tributaries. The Water Quality Monitoring program is a volunteer-run sampling program that takes place each summer throughout the basin. Through partnership with the Vermont Department of Environmental Conservation LaRosa Analytical Services Partnership Program, the MRBA has access to the State of Vermont's analytical laboratory to process and analyze the water samples taken in the field.

The goal of the monitoring project is multifaceted. This volunteer program allows community members to learn about the environment of the Missisquoi River Basin, about conservation and restoration of the environment, and how to take water quality samples and interpret the results. In addition, the program collects valuable data that may eventually aid in the determination of specific problem areas at which to focus restoration efforts.

Methods:

Trained citizen volunteers collected water samples biweekly at between 19 and 21 sites depending on the year. These sites were located throughout the Missisquoi River Basin, along the mainstem of the Missisquoi River and its tributaries. Refer to Table 1 for a list of sample sites and their corresponding site codes and sample years. Figures 1-3 show the location of each site labeled by their corresponding site code.

Table 1: List of mainstem and tributary sample sites with identifying code and sampling years.

Mainstem Sites	Code	Years
Westfield - Loop Rd - Below Mineral Springs Brook	M-WL	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
Troy - Citizens Dam	M-TCD	2005, 2006, 2007
North Troy - Below Big Falls	M-NTBF	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
East Richford - Near QC Border	M-ER	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
Richford – below town, Davis Park	M-RDP	2005
Richford - Below North Branch Marvin Rd	M-RM	2006, 2007
East Berkshire - Below Trout River	M-EB	2005, 2006, 2007
Enosburg Falls - Lawyers Landing	M-ELL	2005
Enosburg Falls - Below Town	M-EF	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
N.Sheldon - Above Black Creek - Kane Road	M-NS	2005, 2006, 2007
Sheldon Junction - Bridge	M-SJ	2005
Highgate - Dam at Highgate Falls	M-HD	2005, 2006, 2007
Swanton – above town Johns Bridge	M-SJB	2005
Swanton - Marble Mill - Below Dam	M-SMM	2005
Swanton - Monument Road	M-SMR	2005, 2006, 2007, 2008, 2009, 2010, ***2011***

Tributary Sites	Code	Years
Lowell - Burgess Branch Route 58	T-LBB	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
Troy - Jay Branch - Vielleux Road	T-TJB	2006, 2007, 2008, 2009, 2010, ***2011***
Newport Center - Mud Creek - Route 105	T-NCMC	2006, 2007, 2008, 2009, 2010, ***2011***
Newport Center – trib. to Mud Creek	T-NCTM	2008, 2009, 2010
North Troy - Mud Creek - Bear Mountain Road	T-NTMC	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
Richford - North Branch - Pinnacle Road	T-RNB	2006, 2007, 2008, 2009, 2010, ***2011***
East Berkshire - Trout River - Near Mouth - Route 118	T-EBTR	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
Enosburgh - Tyler Branch, Duffy Hill Road	T-ETBDH	2006, 2007, 2008, 2009, 2010, ***2011***
Enosburgh – Tyler Branch, Boston Post Rd.	T-ETYB	2008, 2009, 2010, ***2011***
Enosburgh – below Tyler Branch	T-EBTB	2005
Enosburgh – The Branch (Rt. 108)	T-ETB	2008, 2009, 2010, ***2011***
East Fairfield - Black Creek Ryan Rd.	T-EFBC	2007, 2008, 2009, 2010, ***2011***
Fairfield – Wanzer Brook	T-FFWZ	2008, 2009, 2010, ***2011***
Sheldon - Mouth of Black Creek - Bouchard Road	T-SBC	2005, 2006, 2007, 2008, 2009, 2010, ***2011***
Highgate - Hungerford Brook Route 207	T-HHB	2006, 2007
Sheldon – trib to Hungerford Bk Cook Rd.	T-SHCR	2008, 2009, 2010, ***2011***
Swanton – trib to Hungerford Woods Hill Rd.	T-THBW	2008, 2009, 2010, ***2011***, ***2011***
Swanton – Hungerford Bk Woods Hill Rd.	T-HBW	2008, 2009, 2010
Berkshire - Godin Brk Godin Rd	T-BGB	***2011***

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Volunteers received training in accordance with the Quality Assurance Project Plan for taking grab samples for total phosphorus, total nitrogen, total suspended solids, and turbidity. Samples were kept cold during transport and storage before analysis. Samplers also completed a field data sheet at each site noting not only who took the sample, and where and when the sample was taken, but also parameters such as flow and weather observations. The US Environmental Protection Agency provided portable conductivity meters for volunteers to measure the conductivity at each site. The results were also recorded on the data sheet. In order to interpret the results from the state laboratory it was necessary to organize and manage the data using Microsoft® Access© and Microsoft® Excel©, which allowed for further geographic analysis in ESRI® ArcGIS©.

Results and Discussion:

Figures 1-3 show sampling locations and results of the three water quality parameters measured (total phosphorus, total nitrogen and turbidity). The following graphs (figs. 4-6) represent mean values for the three parameters at each site ± standard error of the mean.

In 2011, the area of the watershed with the consistently lowest mean values for phosphorus, nitrogen and turbidity (T-LBB, M-WL, T-TJB, and M-NTBF) is the upper portion of the Missisquoi River, before it flows into Canada. None of these sites exceed the 25 µg/L phosphorus standard for Missisquoi Bay of Lake Champlain (State of Vermont, 2008). The site on the Trout River, near the confluence with the Missisquoi, also showed relatively low phosphorus levels in 2011 (10.0 ± 1.5 µg/L). It appears that these portions of the Missisquoi watershed are highly intact and support very good water quality.

The Missisquoi watershed is approximately 25% agricultural and is the largest contributor of phosphorus to Lake Champlain among the all the lake's watersheds (Troy et al., 2007). The 2011 data shows that a few tributary systems appear to contribute the bulk of nutrients (nitrogen and phosphorus) to the Missisquoi River. Hungerford Brook and its two tributary sites (T-SHCR, T-HBW and T-THBW) had the highest levels of phosphorus in the watershed, as well as high concentrations of nitrogen. Sites on Mud Creek (T-NTMC, T-NTMC), Black Creek (T-SBC, T-EFBC) and Tyler Branch (T-ETDBH) showed some of the highest nutrient levels in the watershed (Figs. 1, 2). Another area of note is the area to the north of the river in Berkshire and Richford; two sites here (T-RNB, T-BGB) showed moderate to high levels of both phosphorus and nitrogen. Nutrient concentrations in the mainstem Missisquoi were found to be lower than average concentrations in many of the tributaries.

The Vermont Water Quality Standards set a limit of 25 µg/L phosphorus in Missisquoi Bay of Lake Champlain (State of Vermont, 2008). Only nine of the 21 sites sampled in 2011 were under this concentration (M-ER, M-NTBF, M-WL, T-EBTR, T-ETB, T-ETYB, T-FFWZ, T-LBB and T-TJB). The lowest average concentration was found at site T-TJB (7.4 ±0.7 µg/L) and the site with the highest average concentration was T-SHCR (151.9 ± 55.6 µg/L). Site M-SMR, located at the mouth of the Missisquoi before it flows into Missisquoi Bay, had an average phosphorus concentration of 36.8 (±8.0) µg/L in

2011. The individual samples taken from this site varied from 17.5 µg/L (August 17, 2011) to 70.3 µg/L (June 22, 2011).

There is no state water quality standard for total nitrogen (only for Nitrates), so comparing these Missisquoi nitrogen data to established criteria is not possible. In general, portions of the watershed showing increased concentrations of total nitrogen coincide with locations showing increased levels of phosphorus (Figs. 1, 2). This result indicates that the source of nutrient enrichment in the watershed is likely agricultural runoff, rather than urban development or wastewater treatment plant effluent.

Average turbidity values in the watershed were found to be low to moderate in 2011. The three Hungerford Brook watershed sites (T-SHCR, T-HBW and T-THBW) were the only ones found to exceed the turbidity standard for cold water fisheries (10 NTU), but were still within acceptable the range for warm water fisheries (25 NTU) in the Missisquoi watershed (State of Vermont, 2008). In 2010, there was some concern regarding elevated turbidity results from a tributary to Wanzer Brook (T-FFWZ). This result was likely a one-sample anomaly; the average turbidity at this site in 2011 was quite low (1.0 ±0.2 NTU).

Figures 4-6 show the overall averages of all samples taken in the six year period from June 1, 2005 until August 17th, 2011. The graphs represent mean values for each parameter at each site ± standard error of the mean. Data from 2005-2008 are grouped together, while data from 2009, 2010 and 2011 are separate in order to observe trends in the data over last three years. These figures show that, for many sites, water quality has improved from the first years of data collection. Data from the sites T-EFBC, T-HBW, T-NTMC and T-TJB continue to show decreasing phosphorous concentrations year-to-year over the past six years. Many other sites showed higher phosphorus levels in 2005-2008, which have since become lower and appear to have stabilized over the past 2-3 years (M-ER, M-NTFB, M-WL, T-EBTR, T-ETYB, T-RNB and T-SNC).

Sites that appear to have increased phosphorus concentrations compared to recent years include M-EF, M-SMR, T-NCMC and T-SHCR. A new site this year, T-BGB, showed an average total phosphorus concentration of 69.9 ± 8.3 µg/L, which is relatively high for the watershed.

Of particular note is site M-ER, which is on the mainstem Missisquoi River in Richford, just below the U.S./Canadian border. There was concern in late summer 2011 regarding this site, as the river in this area was observed to be exceedingly murky. This is highly unusual for this section of the river, which has been designated a “High Quality Biology” site by the VT DEC Biological Monitoring Section (VT DEC, 2011). These changes in water quality were well-documented in the data collected by MRBA volunteers in 2011. The Turbidity values were consistently low through June and July (~2.5 NTU) until the sampling event on August 3rd when the level was found to be 9.9 NTU (Figure 7). The subsequent sample, taken August 17th, showed even higher turbidity (18.8 NTU). Phosphorus concentrations nearly doubled during this same time period (18.7 µg/L on July 20th to 36.4 µg/L on August 3rd; Figure 8). Total nitrogen values stayed relatively constant throughout the summer (Figure 9). Unfortunately, the aftermath of Hurricane Irene suspended further sample collection after August

17th, 2011. It's important that these changes in water quality were documented. This situation shows the importance of the samples taken by MRBA volunteers.

Conclusions:

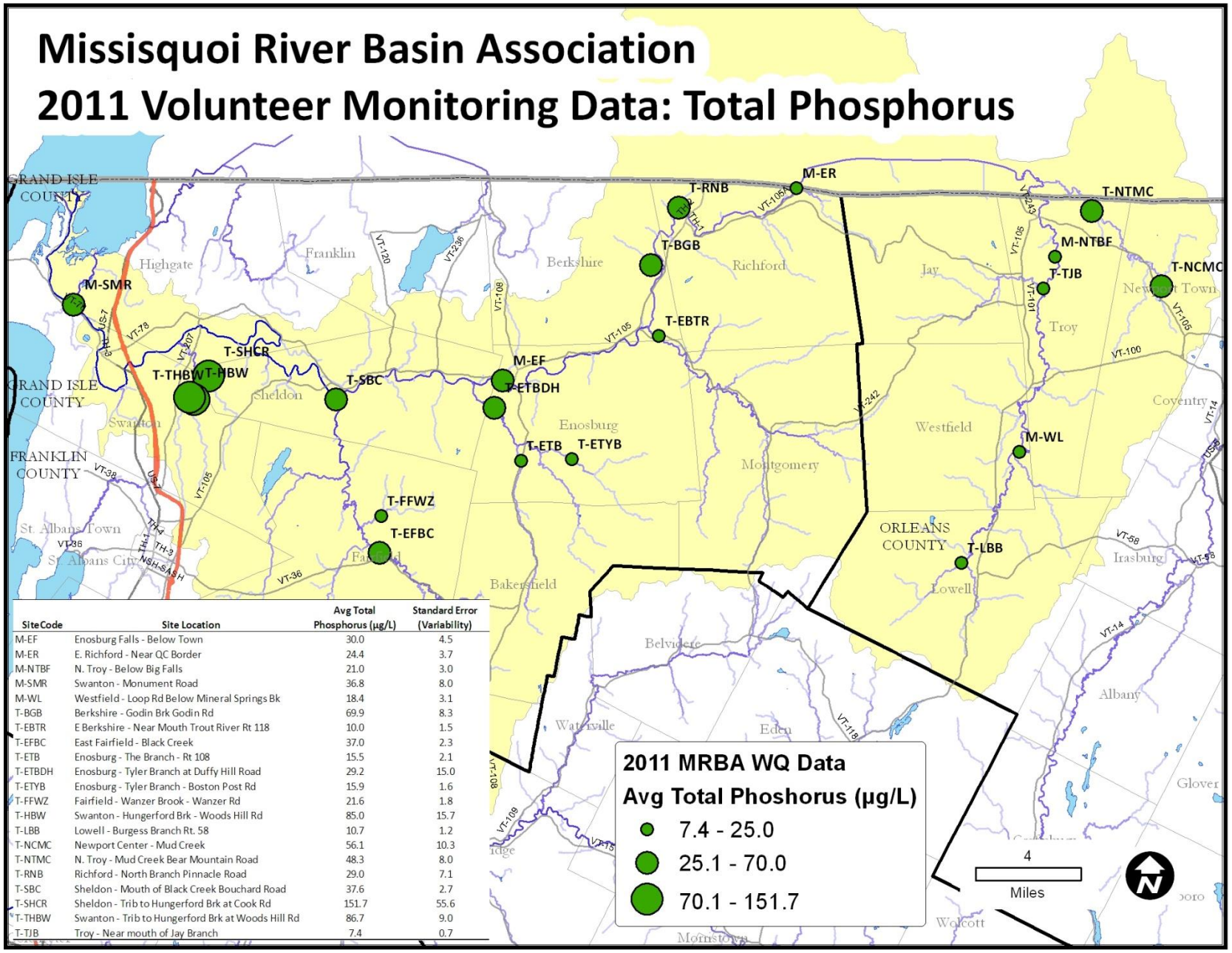
The MRBA sampling program has proven to be a great success over the past six years. With over two dozen volunteers sampling every two weeks throughout the summer, many samples have been collected and analyzed. The data have been very useful for targeting sites in need of water quality improvement projects due to high concentrations of nutrients and sediment. Some of these projects are already underway in the Missisquoi River Basin. The MRBA Water Quality Monitoring Program hopes to continue collaborations the Vermont DEC in 2012 that produce useful information for both entities.

References:

Troy, A., D. Wang, D. Capen, J. O'Neil-Dunne and S. MacFaden. 2007. Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading Lake Champlain Basin Program. Lake Champlain Basin Program, Grand Isle, VT.

Vermont Department of Environmental Concentration. Biomonitoring database. Accessed February 24, 2011.

Vermont Water Quality Standards; Vt. Code R. 12 004 052; State of Vermont Natural Resources Board, Water Resources Panel. Effective January 1, 2008. http://www.nrb.state.vt.us/wrp/rules.htm



SiteCode	Site Location	Avg Total Phosphorus (µg/L)	Standard Error (Variability)
M-EF	Enosburg Falls - Below Town	30.0	4.5
M-ER	E. Richford - Near QC Border	24.4	3.7
M-NTBF	N. Troy - Below Big Falls	21.0	3.0
M-SMR	Swanton - Monument Road	36.8	8.0
M-WL	Westfield - Loop Rd Below Mineral Springs Bk	18.4	3.1
T-BGB	Berkshire - Godin Brk Godin Rd	69.9	8.3
T-EBTR	E Berkshire - Near Mouth Trout River Rt 118	10.0	1.5
T-EFBC	East Fairfield - Black Creek	37.0	2.3
T-ETB	Enosburg - The Branch - Rt 108	15.5	2.1
T-ETBDH	Enosburg - Tyler Branch at Duffy Hill Road	29.2	15.0
T-ETYB	Enosburg - Tyler Branch - Boston Post Rd	15.9	1.6
T-FFWZ	Fairfield - Wanzer Brook - Wanzer Rd	21.6	1.8
T-HBW	Swanton - Hungerford Brk - Woods Hill Rd	85.0	15.7
T-LBB	Lowell - Burgess Branch Rt. 58	10.7	1.2
T-NCMC	Newport Center - Mud Creek	56.1	10.3
T-NTMC	N. Troy - Mud Creek Bear Mountain Road	48.3	8.0
T-RNB	Richford - North Branch Pinnacle Road	29.0	7.1
T-SBC	Sheldon - Mouth of Black Creek Bouchard Road	37.6	2.7
T-SHCR	Sheldon - Trib to Hungerford Brk at Cook Rd	151.7	55.6
T-THBW	Swanton - Trib to Hungerford Brk at Woods Hill Rd	86.7	9.0
T-TJB	Troy - Near mouth of Jay Branch	7.4	0.7

Figure 1: 2011 total phosphorus averages (µg/L).

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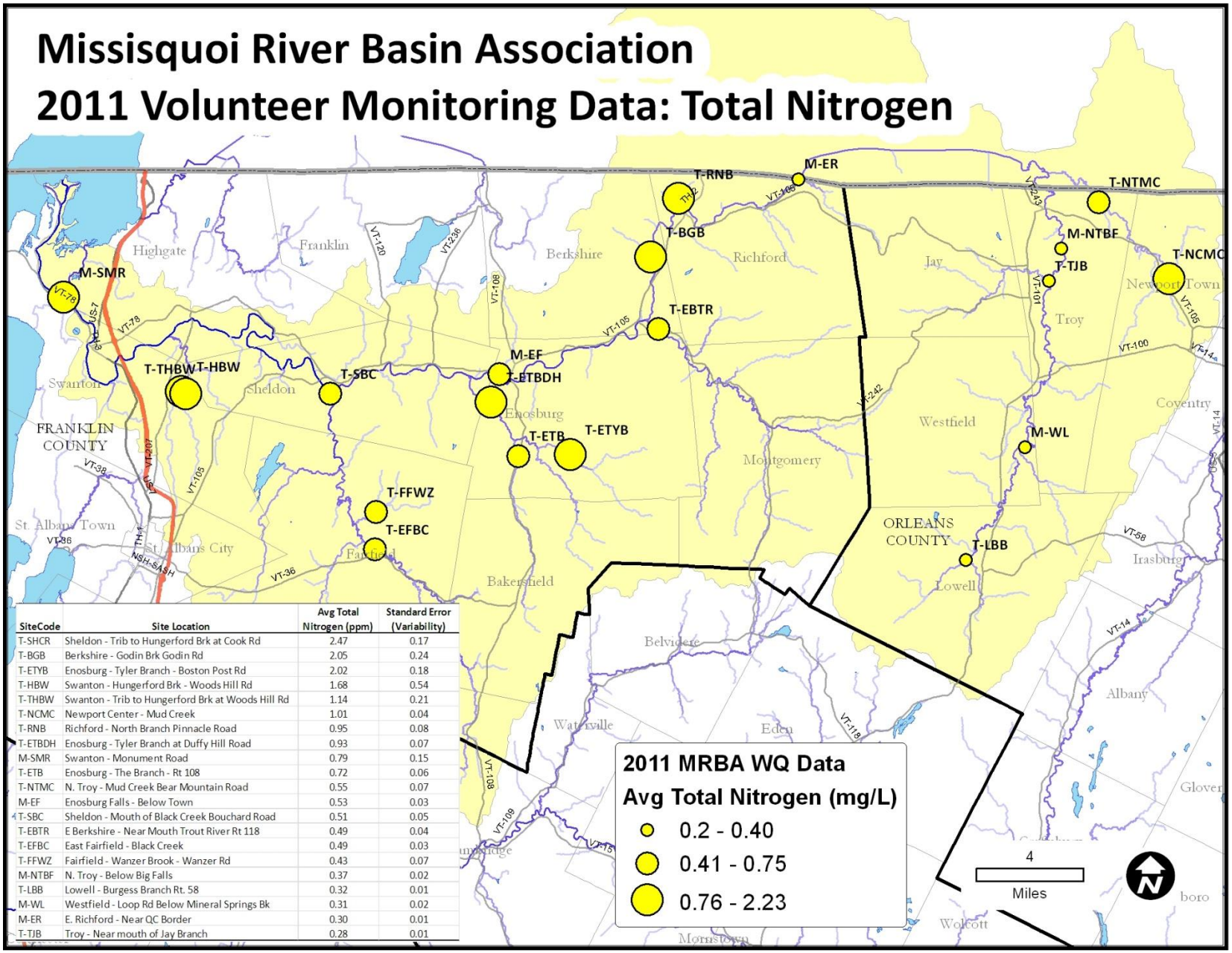
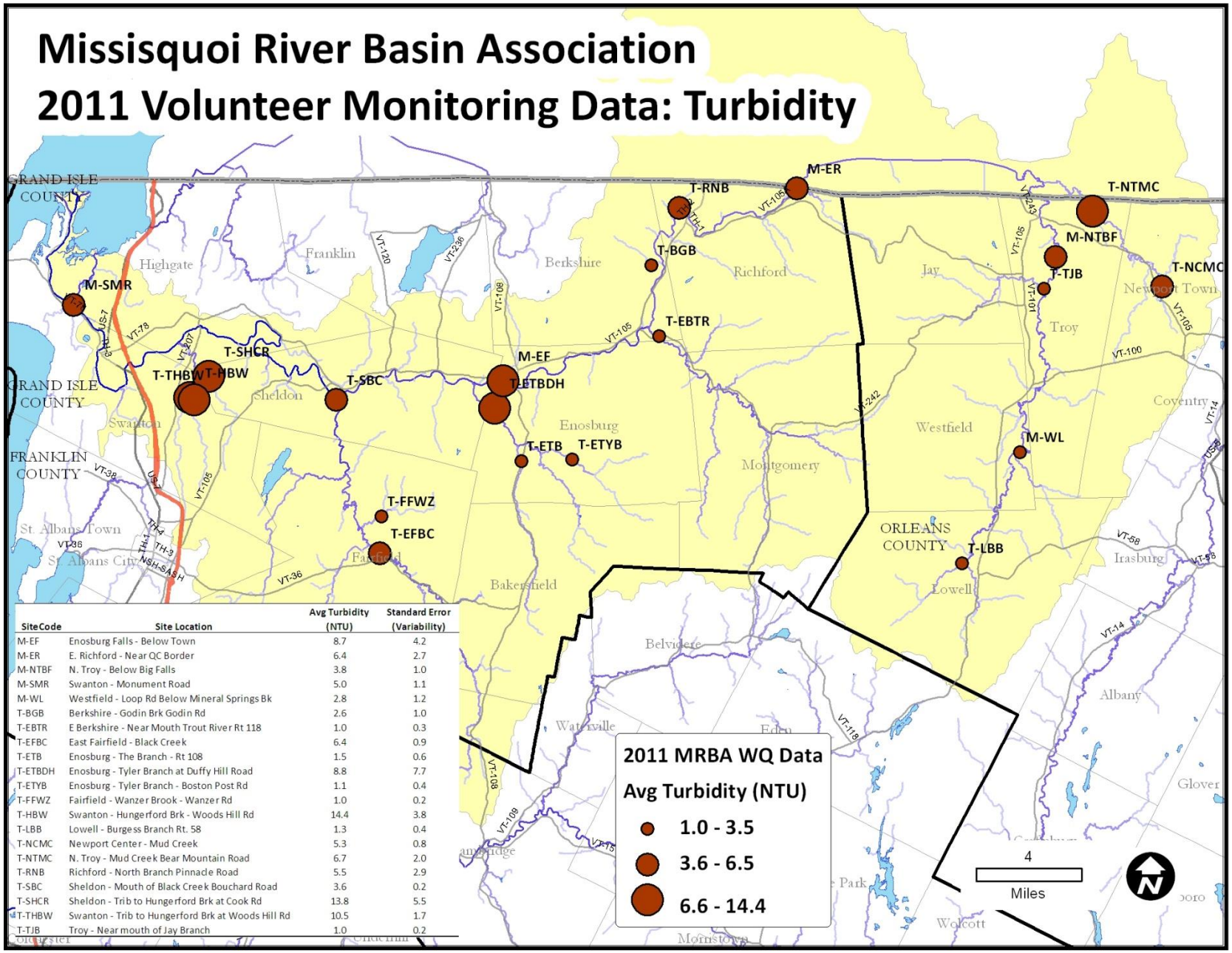


SiteCode	Site Location	Avg Total Nitrogen (ppm)	Standard Error (Variability)
T-SHCR	Sheldon - Trib to Hungerford Brk at Cook Rd	2.47	0.17
T-BGB	Berkshire - Godin Brk Godin Rd	2.05	0.24
T-ETYB	Enosburg - Tyler Branch - Boston Post Rd	2.02	0.18
T-HBW	Swanton - Hungerford Brk - Woods Hill Rd	1.68	0.54
T-THBW	Swanton - Trib to Hungerford Brk at Woods Hill Rd	1.14	0.21
T-NCMC	Newport Center - Mud Creek	1.01	0.04
T-RNB	Richford - North Branch Pinnacle Road	0.95	0.08
T-ETBDH	Enosburg - Tyler Branch at Duffy Hill Road	0.93	0.07
M-SMR	Swanton - Monument Road	0.79	0.15
T-ETB	Enosburg - The Branch - Rt 108	0.72	0.06
T-NTMC	N. Troy - Mud Creek Bear Mountain Road	0.55	0.07
M-EF	Enosburg Falls - Below Town	0.53	0.03
T-SBC	Sheldon - Mouth of Black Creek Bouchard Road	0.51	0.05
T-EBTR	E Berkshire - Near Mouth Trout River Rt 118	0.49	0.04
T-EFBC	East Fairfield - Black Creek	0.49	0.03
T-FFWZ	Fairfield - Wanzer Brook - Wanzer Rd	0.43	0.07
M-NTBF	N. Troy - Below Big Falls	0.37	0.02
T-LBB	Lowell - Burgess Branch Rt. 58	0.32	0.01
M-WL	Westfield - Loop Rd Below Mineral Springs Bk	0.31	0.02
M-ER	E. Richford - Near QC Border	0.30	0.01
T-TJB	Troy - Near mouth of Jay Branch	0.28	0.01

Figure 2: 2011 total nitrogen averages (mg/L).



SiteCode	Site Location	Avg Turbidity (NTU)	Standard Error (Variability)
M-EF	Enosburg Falls - Below Town	8.7	4.2
M-ER	E. Richford - Near QC Border	6.4	2.7
M-NTBF	N. Troy - Below Big Falls	3.8	1.0
M-SMR	Swanton - Monument Road	5.0	1.1
M-WL	Westfield - Loop Rd Below Mineral Springs Bk	2.8	1.2
T-BGB	Berkshire - Godin Brk Godin Rd	2.6	1.0
T-EBTR	E Berkshire - Near Mouth Trout River Rt 118	1.0	0.3
T-EFBC	East Fairfield - Black Creek	6.4	0.9
T-ETB	Enosburg - The Branch - Rt 108	1.5	0.6
T-ETBDH	Enosburg - Tyler Branch at Duffy Hill Road	8.8	7.7
T-ETYB	Enosburg - Tyler Branch - Boston Post Rd	1.1	0.4
T-FFWZ	Fairfield - Wanzer Brook - Wanzer Rd	1.0	0.2
T-HBW	Swanton - Hungerford Brk - Woods Hill Rd	14.4	3.8
T-LBB	Lowell - Burgess Branch Rt. 58	1.3	0.4
T-NCMC	Newport Center - Mud Creek	5.3	0.8
T-NTMC	N. Troy - Mud Creek Bear Mountain Road	6.7	2.0
T-RNB	Richford - North Branch Pinnacle Road	5.5	2.9
T-SBC	Sheldon - Mouth of Black Creek Bouchard Road	3.6	0.2
T-SHCR	Sheldon - Trib to Hungerford Brk at Cook Rd	13.8	5.5
T-THBW	Swanton - Trib to Hungerford Brk at Woods Hill Rd	10.5	1.7
T-TJB	Troy - Near mouth of Jay Branch	1.0	0.2

Figure 3: 2011 turbidity averages (NTU

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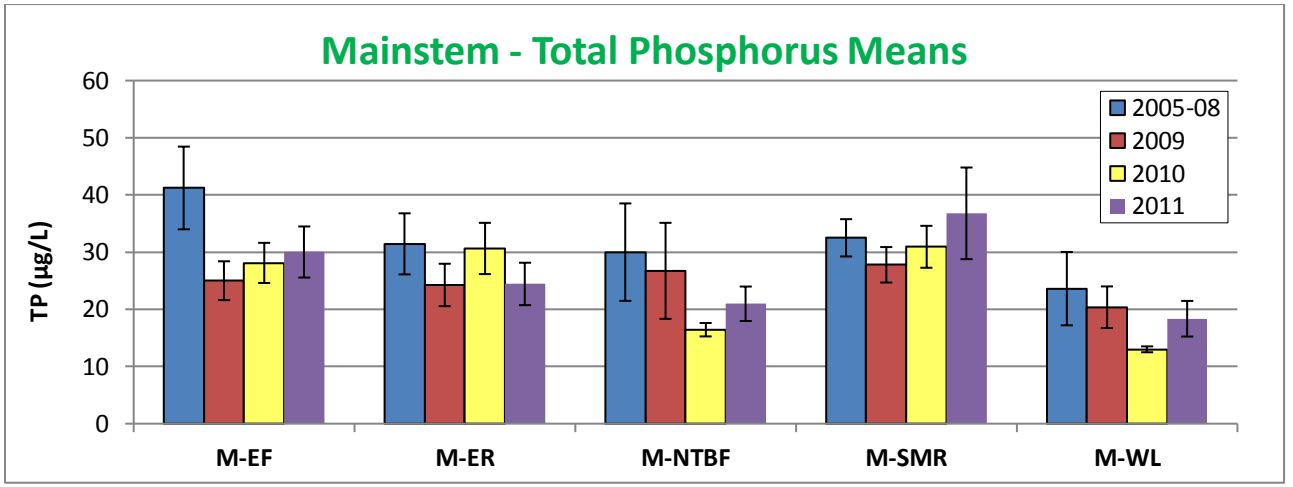

Figure 4a: Mainstem Missisquoi River averages for total phosphorus concentration in µg/L (± standard error), from 2005 to 2011.

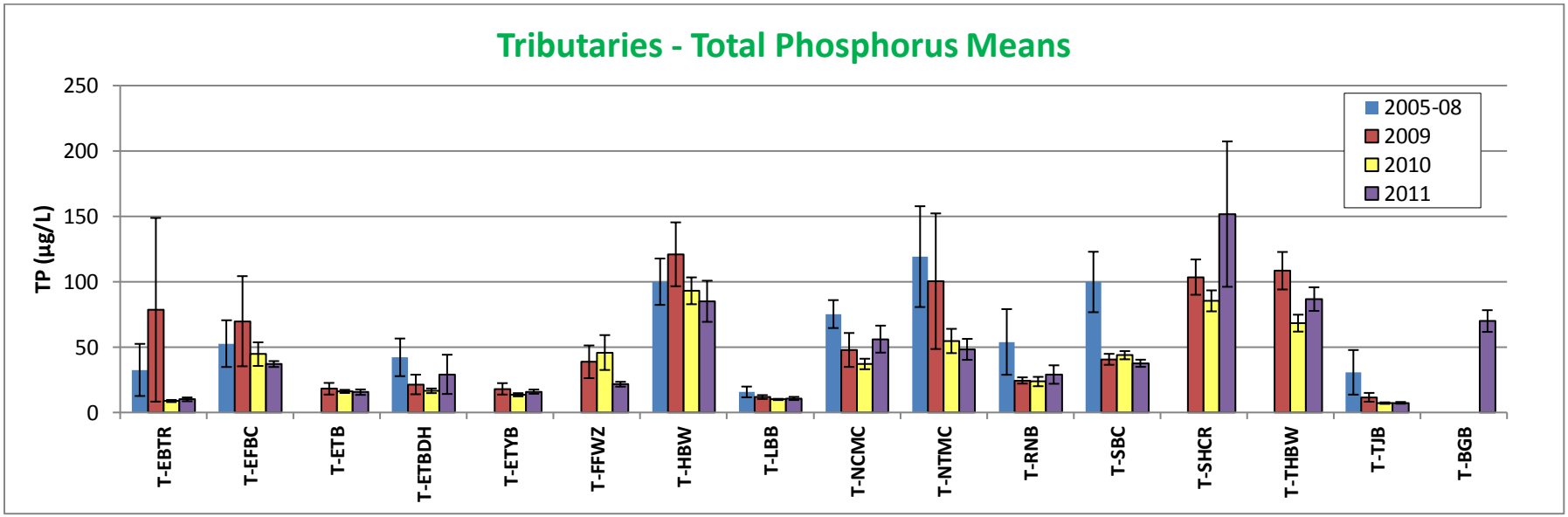

Figure 4b: Missisquoi River Tributary averages for total phosphorus concentration in µg/L (± standard error), from 2005 to 2011.

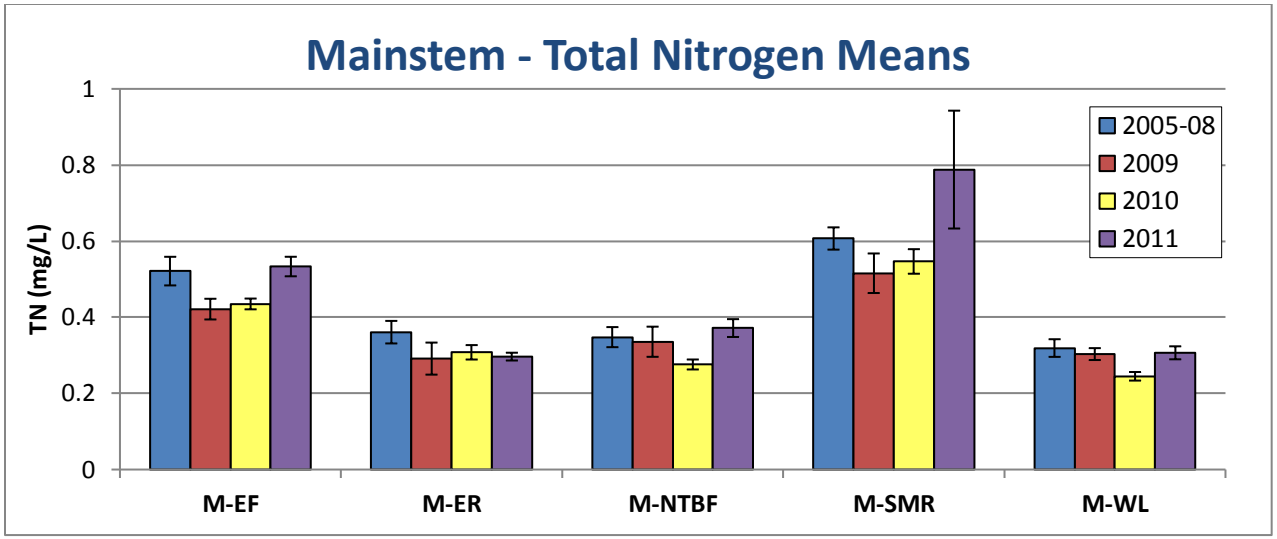

Figure 5a: Mainstem Missisquoi River averages for total nitrogen concentration in mg/L (± standard error), from 2005 to 2011.

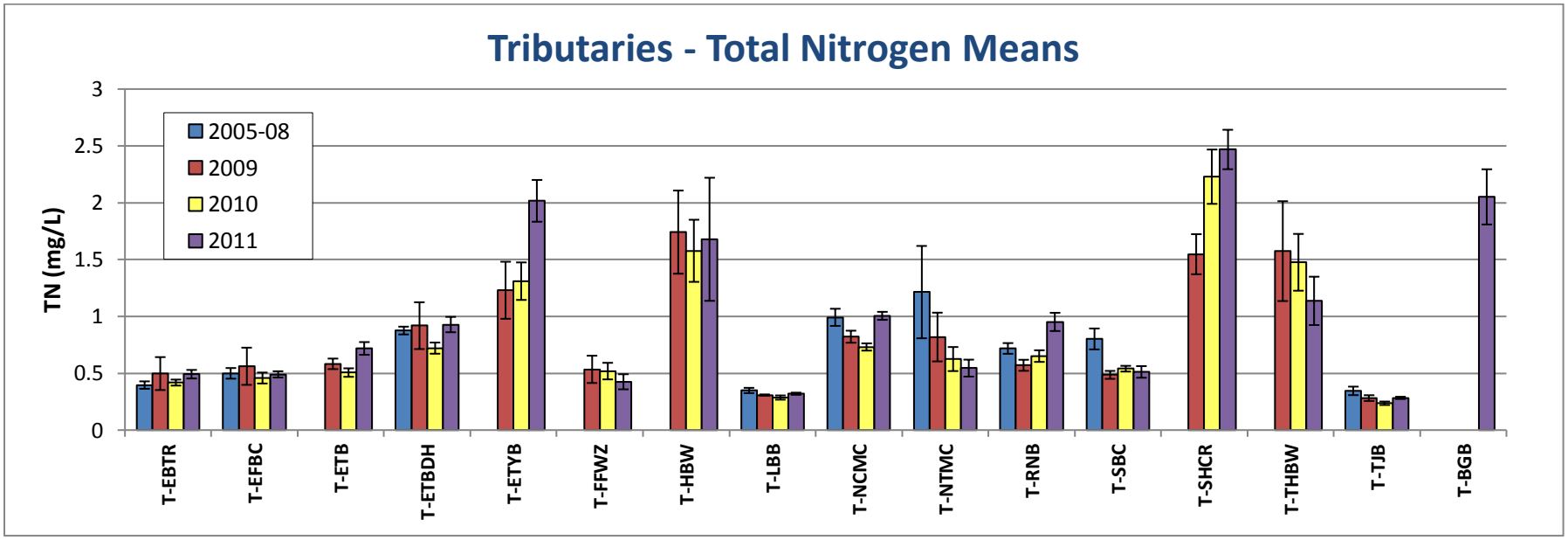

Figure 5b: Missisquoi River Tributary averages for total nitrogen concentration in mg/L (± standard error), from 2005 to 2011.

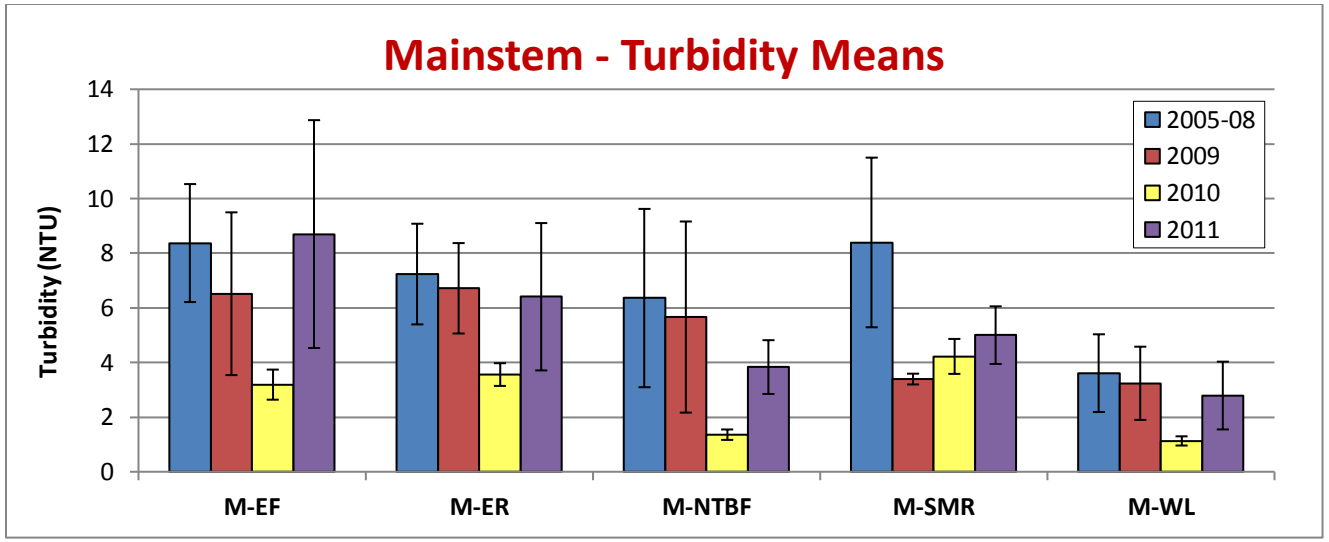

Figure 6a: Mainstem Missisquoi River averages for turbidity in NTU (± standard error), from 2005 to 2011.

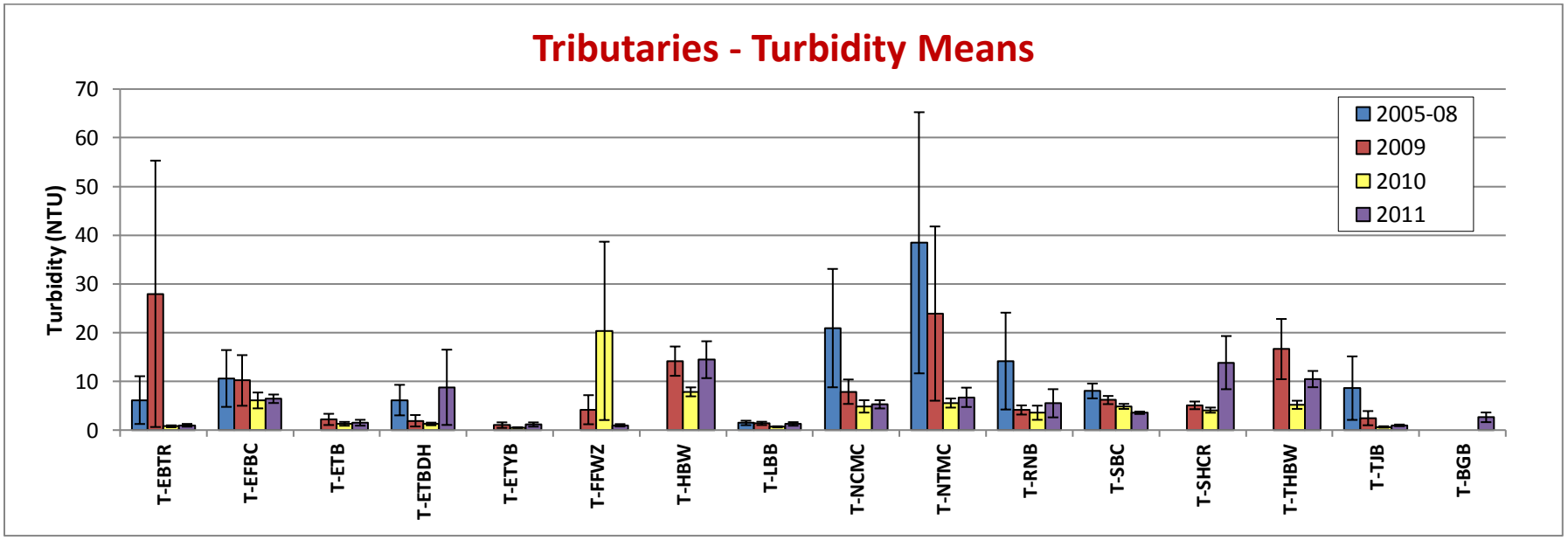

Figure 6b: Missisquoi River Tributary averages for turbidity in NTU (± standard error), from 2005 to 2011.

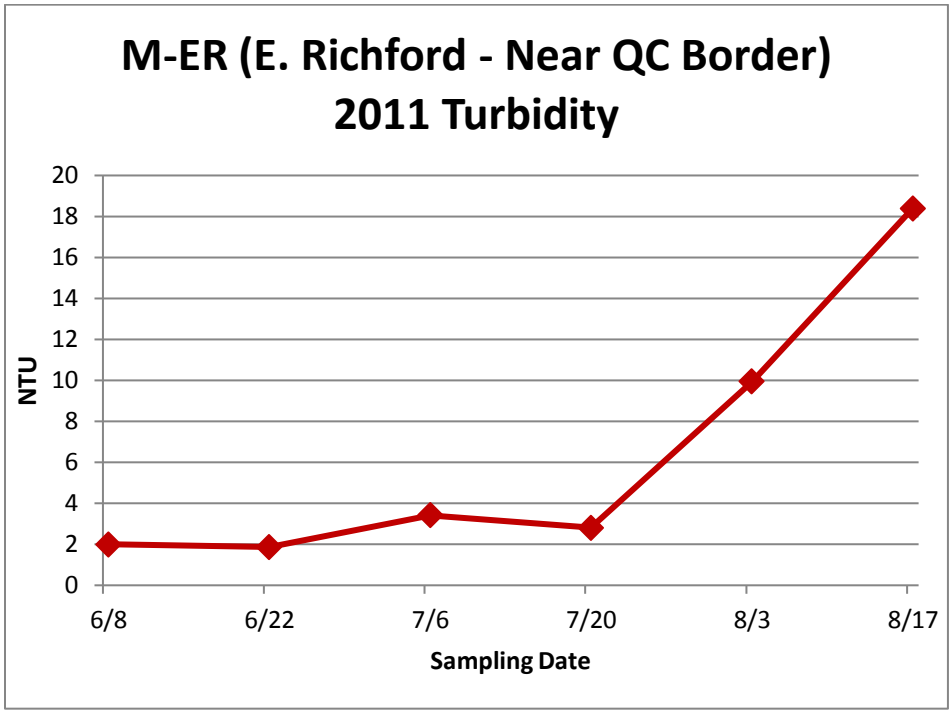

Figure 7. Turbidity values by sampling date for M-ER (E. Richford near Canadian border).

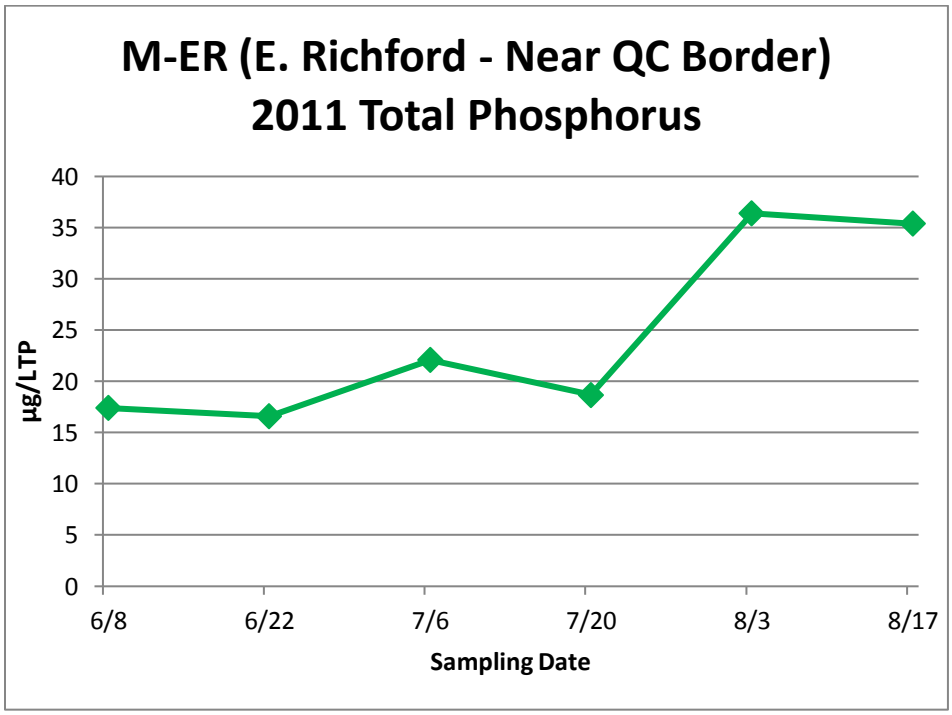

Figure 8. Phosphorus values by sampling date for M-ER (E. Richford near Canadian border).

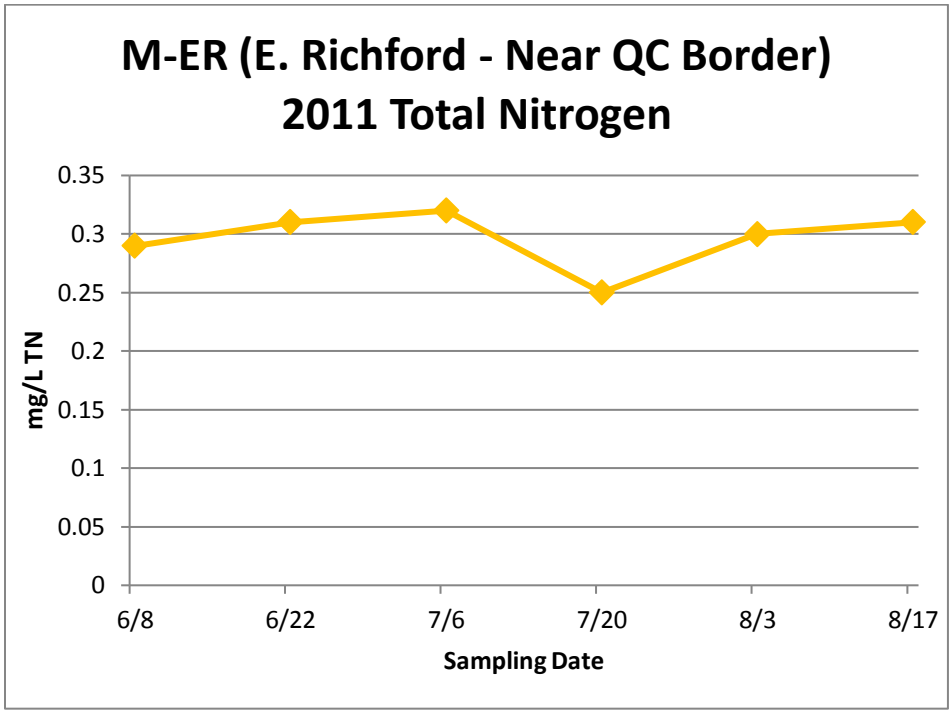

Figure 9. Nitrogen values by sampling date for M-ER (E. Richford near Canadian border).