Cyanobacteria Monitoring on Lake Champlain Summer 2017

Final Report for the Lake Champlain Basin Program

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Executive Summary

An annual monitoring program has been in place on Lake Champlain since 2002. Since 2012, oversight of the program has been the responsibility of the state of Vermont. The program represents a strong partnership between the Vermont Department of Environmental Conservation (VT DEC), the Vermont Department of Health (VDH) and the Lake Champlain Committee (LCC). Funding is provided by the Lake Champlain Basin Program, the State of Vermont, the CDC, and private donors. Data are collected by state staff and an extensive network of trained citizen volunteers.

Cyanobacteria monitoring on Lake Champlain in 2017 continued to integrate qualitative observations, photographic documentation and quantitative analysis of cyanobacteria populations into guidance for lake users. Analysis of water for the presence of microcystin and anatoxin, when warranted, provided additional data to inform public health decisions in response to the presence of cyanobacteria.

Objectives

- monitor cyanobacteria at locations on Lake Champlain and selected Vermont inland lakes through the established partnership between state staff, the Lake Champlain Committee and citizen volunteers;
- provide consistent quantitative data at selected locations around Lake Champlain and selected Vermont lakes;
- test for the presence of cyanotoxins when cyanobacteria density and composition triggers are reached at selected monitoring locations;
- conduct 12 weeks cyanobacteria toxin testing for drinking water facilities drawing from Lake Champlain in Vermont;
- facilitate communication about lake conditions through weekly updates to stakeholders via email and to the public through the Vermont Department of Health webpage; and
- provide outreach and assistance to beach managers, lakeshore property owners and the public so they can learn to recognize and respond appropriately to the presence of cyanobacteria blooms.

More than 1750 site-specific reports were submitted during 2017 from more than 135 locations on Lake Champlain and inland lakes in Vermont. Citizen volunteers trained by the Lake Champlain Committee reported from 132 locations on Lake Champlain and several other Champlain Basin lakes in Vermont. Blooms, defined as category 3 of the visual protocol were reported 129 times during the monitoring period in 2017. Microcystin was detected at several locations on Champlain and Lake Carmi in 2017. No locations exceeded the Vermont recreational guidance values for microcystin. No anatoxin was detected.

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Introduction

Lake Champlain is one of the largest lakes in the United States and an important water resource for the states of Vermont and New York, and the province of Quebec. It is primarily a recreational lake, but also serves as an important drinking water source for all three jurisdictions. Cyanobacteria blooms have been documented in the lake since the 1970s, with some areas experiencing extensive annual blooms. In 1999, several dog deaths were attributed to cyanobacteria toxins, raising health and safety concerns regarding drinking water supplies and recreational activities such as swimming, boating and fishing.

An annual cyanobacteria monitoring program has been in place on Lake Champlain since 2002, developed initially by the University of Vermont (UVM). Since 2012, oversight of the program has been the responsibility of the State of Vermont. Data are collected by state staff and an extensive network of trained citizen volunteers. Qualitative observations, photographic documentation, and quantitative analysis of phytoplankton populations are synthesized into guidance for lake users. Analysis of water - when warranted - for the presence of microcystin, anatoxin and cylindrospermopsin provided additional data to inform public health decisions.

Objectives

- monitor cyanobacteria at locations on Lake Champlain and selected Vermont inland lakes through the established partnership between state staff, the Lake Champlain Committee and citizen volunteers;
- provide consistent quantitative data at selected locations around Lake Champlain and selected Vermont lakes;
- test for the presence of cyanotoxins when cyanobacteria density and composition triggers are reached at selected monitoring locations;
- conduct cyanobacteria toxin testing for drinking water facilities drawing on Lake Champlain in Vermont;
- facilitate communication about lake conditions through weekly updates to stakeholders via email and to the public through the Vermont Department of Health webpage; and
- provide outreach and assistance to beach managers, lakeshore property owners and the public so they can learn to recognize and respond appropriately to the presence of cyanobacteria blooms.

Geographic Coverage

The work described in this report covers cyanobacteria monitoring and response activities in the Champlain Basin supported by the Champlain Long-Term Water Quality and Biological Monitoring Program (CLTM) in coordination with the Vermont Department of Health (VDH), Lake Champlain Committee's (LCC) Volunteer Cyanobacteria Monitoring Program, and the Vermont Department of Environmental Conservation (VT DEC). 2017 funding supporting the CLTM, the LCC, and toxin monitoring for Vermont drinking water facilities was provided by the Lake Champlain Basin Program (LCBP). Additional funding to support this work was provided by the State of Vermont, LCC private

donors, and the CDC funded Vermont Environmental Public Health Tracking program. Lakes in Vermont monitored by LCC-supported volunteers are included in this project. For information on Vermont lakes outside of the Champlain Basin, visit the VT DEC's cyanobacteria webpage. New York maintains their own cyanobacteria reporting protocols for inland lakes including Lake George – see the New York Harmful Algal Blooms notification page.

Methods

The 2017 cyanobacteria monitoring program was coordinated by the VT DEC and implemented in conjunction with the VDH and LCC. Qualitative data from Lake Champlain and other Vermont lakes monitored by LCC volunteers were collected following the protocol developed and maintained by the LCC. Quantitative samples were collected at selected open water stations historically monitored by the CLTM on Lake Champlain. Additional water samples for quantitative assessment were collected at selected shoreline locations on Lake Champlain and Lake Carmi by citizen volunteers and VDH staff. Reports from the monitoring partners and volunteers were uploaded via a controlled web interface directly to the Cyanobacteria Tracking map (CyanoTracker) maintained by the VDH.

Sampling Locations

Reports were received from a total of 135 locations around Lake Champlain and selected Vermont lakes in the Champlain Basin during the summer of 2017 (Figure 1). Table 1 provides a summary of stations by region, evaluation protocol, and type of site. Full documentation of the sampling locations is located in Appendix A.

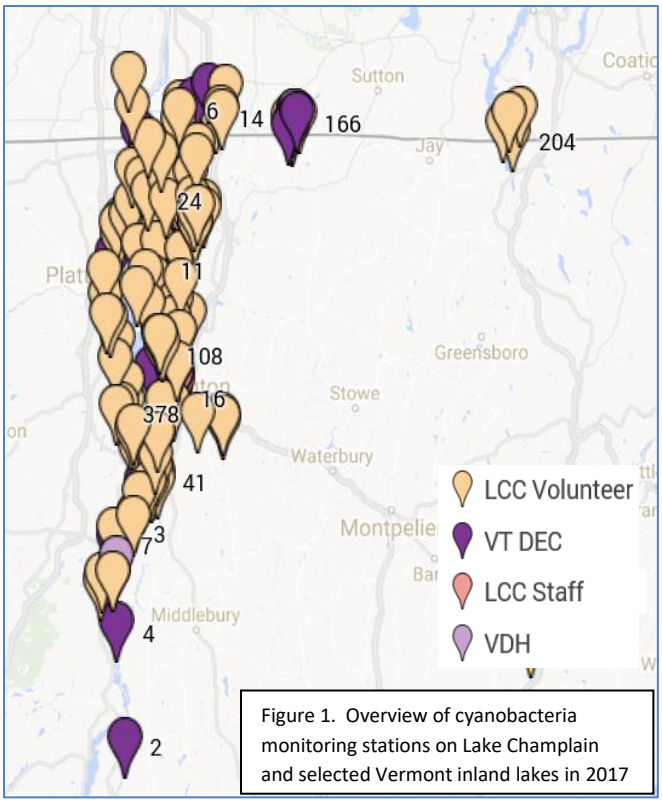


Figure 1. Overview of cyanobacteria monitoring stations on Lake Champlain and selected Vermont inland lakes in 2017

Table 1. Stations routinely monitored on Lake Champlain and the Vermont portion of the Champlain Basin during 2017. Data compiled from the season summary spreadsheet available through the VDH Tracking Map.

Lake	Region	Assessment Type		
		Open Water Protocol	Visual Assessment	Visual/ Quantitative
Carmi		3	4	2
Champlain	Inland Sea	1	21	
	Main Lake Central	4	30	2
	Main Lake North	2	12	1
	Main Lake South	2	14	1
	Malletts Bay	4	1	
	Missisquoi Bay	3	8	1
	South Lake	2		
	St. Albans Bay	1	8	1
Iroquois			2	
Memphremagog			4	
Shelburne Pond			1	
Total Stations	**135**			

Monitoring Protocols

The Visual Monitoring Protocol

Volunteer Recruitment and Training

Volunteers were asked to commit to monitoring at least one location for the duration of the monitoring period (mid-June to early September). While the LCC did recruit to gain as wide a geographic distribution as possible, no volunteer was turned away. In a few areas of the lake, this did lead to a cluster of observation points. All volunteers attended a mandatory training session to learn to recognize cyanobacteria, become familiar with the assessment protocol, and learn how to submit their weekly reports. LCC staff met with or interacted with each volunteer in the weeks following the training to ensure consistency among volunteers and their assessment skills. Not all volunteers were able to use the internet-based reporting system and instead submitted their reports by telephone or email.

Weekly Observation Process - Volunteers

The LCC trained nearly 300 volunteer monitors and interested citizens in 23 formal training sessions during 2017. Additional informal training sessions were provided at roughly a dozen public presentations and tabling events throughout the year. Over the course of the summer, LCC volunteer monitors reported from 132 different locations in 2017 (Figure 1 and Appendix A). Protocols for the observation process, supporting documentation and the submittal process are found in Appendix B. Volunteers were asked to provide a single observation each week, preferably between 10am and 3pm, on the same day of the week Sunday through Saturday. Supplemental reports could also be provided and volunteers were encouraged to report any blooms they witnessed regardless of the reporting day and to report daily through the time

a bloom dissipated. Volunteers evaluated cyanobacteria conditions at their location using the prompts, photographs, and descriptions provided by the LCC, and assigned it one of the three categories:

- Category 1 – very few or no cyanobacteria observed, recreational enjoyment not impaired by cyanobacteria. (Category 1 contained multiple subcategories.)
- Category 2 – cyanobacteria present at less than bloom levels
- Category 3 – cyanobacteria bloom in progress

The description 'bloom' is not a well-defined scientific defined term. For the purposes of the visual monitoring protocol, blooms refer to very dense algal accumulations resulting in highly colored water and/or visible surface scums.

Each volunteer was asked to provide three photographs whenever category 2 or category 3 conditions were observed. All reports were uploaded to the VDH tracking map via a secured interface or submitted to the LCC via their online form. Partners reviewed all bloom reports and photos. LCC conferred with volunteers as needed to verify the presence of cyanobacteria and appropriate status. The LCC approved reports submitted directly by volunteers to the VDH web interface and uploaded any sent directly to LCC as quickly as possible. Staff also followed up with volunteers when no reports were received. Category 2 and 3 reports were given priority, shared with partners at the VDH and VT DEC immediately, and posted immediately after any necessary verification.

In addition to the photos, four sites visited by volunteers were also assessed quantitatively:

North Beach - Burlington VT
Red Rocks Park – South Burlington VT
St. Albans Bay Park – St. Albans VT
The Shipyard - Highgate VT

Each week, these volunteers made a visual assessment and collected water samples from the shore. These unfiltered samples were analyzed for microcystin, anatoxin and cyanobacteria density.

Weekly VDH Surveillance

The VDH conducted routine weekly monitoring at selected sites on Lake Champlain and Lake Carmi:

Alburgh Dunes State Park – Alburgh VT
Tri-Town Rd – West Addison VT
Lake Carmi State Park – Franklin VT
Lake Carmi North Beach – Franklin VT

These locations were areas with high recreational usage or located in the vicinity of drinking water facilities. VDH staff made visual assessments and collected water samples for toxin and cyanobacteria analysis.

The Open Water Protocol

Qualitative and quantitative data on taxonomic distribution, cell density and the presence of toxins were collected by the VT DEC following the Open Water Protocol. VT DEC staff conducted cyanobacteria assessments during their biweekly monitoring for the Champlain Long-term Water Quality and Biological Monitoring Project. At each monitoring site, staff utilized the visual assessment protocol to evaluate

cyanobacteria conditions and collected a 3m plankton tow. Cyanobacteria observed during transit were also assessed using the visual assessment protocol. When category 3 conditions were observed, whole water surface grabs were collected for the analysis of toxins and cyanobacteria density. At locations where blooms were uncommon, whole water surface grabs for toxin and cyanobacteria were also collected during category 2 conditions. Monitoring began the week of June 1st and continued through early October.

Field Methods

Plankton were collected as integrated 63 µm mesh plankton net for determination of cyanobacteria density. Net concentrates were obtained by lowering the plankton net opening to 3m and drawing it steadily back to the surface. When alert level conditions were observed, a single whole water sample was collected by placing a bucket carefully at the surface and tipping to fill, avoiding dilution of the surface scum as much as possible. The sample was mixed thoroughly and decanted into sample bottles for subsequent cyanobacteria enumeration or toxin analysis. All samples were kept on ice in coolers until they reached the lab.

Plankton Enumeration

Plankton samples were analyzed using an inverted compound microscope at 200x in a Sedgewick Rafter (SR) cell. One mL aliquots were settled for 10 – 15 minutes before analysis. Estimates of cell density were obtained for all observed cyanobacteria and selected other taxa using the size categories noted in Table 2. Observed individuals or colonies were assigned to a unit category, or several categories, as needed. The number of units in each category is then multiplied by the cell factor to obtain an estimate of cell density/mL in the sample. During the analysis, all cyanobacteria were identified to the lowest possible taxonomic level while most other algae were identified simply at the division level, e.g. green algae or diatoms. Identical counting protocols were used for whole water and plankton concentrates. Plankton samples were counted by VT DEC staff and data were uploaded to the VDH data interface, typically within 24 -48 hours for open water stations. Bloom and alert level samples were analyzed and posted as soon as possible after samples were received at the laboratory.

Table 2. Size categories and cell factors used to estimate field densities of colonial algae.

Taxon	Unit Category	Estimated cells/unit	Cell factor
Anabaena *Aulocoseira* *Fragilaria*	Fragment Small Medium Large	< 20 20 – 100 100 – 1000 >1000	10 60 500 1000
Microcystis *Coelosphaerium* *Woronichinia*	Small Medium Large	<100 100 – 1000 >1000	50 500 1000
Gloeotrichia	Fragment Small Medium Large	Single trichome Quarter of a colony Half of colony Entire colony	20 2500 5000 10,000
Aphanizomenon	Fragment Small Medium Large	Single trichome Small flake Medium flake Large flake	Measured 200 500 1000

Limnothrix Lyngbya/Scytonema	fragment	Single trichome	Measured

Reports from Other Sources

Cyanobacteria reports were received from numerous other sources. The NY DEC, the NY Department of Health, and the Quebec Ministrie de Développement durable, Environnement, et Lutte Contre les Changements Climatiques (MDDELCC) notified Vermont when blooms were reported their shores. A regional app, BloomWatch, allows the general public toreport blooms to EPA Region 1, which then provides them to VDH. Additionally, reports were received from the general public by email and telephone. These reports were evaluated and confirmed utilizing photos, descriptive information, and available corroborating information before posting to the CyanoTracker map.

Toxin Analysis

Toxin analyses were conducted by the VDH laboratory in Burlington VT. Whole water samples for microcystin were analyzed as received unless biomass was high enough to interfere with analytical procedures. In that event, samples were diluted prior to analysis of microcystin by ELISA.

Whole water samples for anatoxin analysis were concentrated using solid phase extraction cartridges unless large amounts of biomass were present. In that event, aliquots were diluted prior to extraction.

Toxin Monitoring at Vermont Drinking Water Facilities

In 2017, the DWGWPD and the VDH received funding from the LCBP to support 12 weeks of cyanotoxin monitoring at Vermont public drinking water systems drawing from Lake Champlain. Weekly raw and finished water samples were collected by facility staff and transported to the VDH Public Health Laboratory for analysis of microcystin and cylindrospermopsin by ELISA. All sample containers and labels were provided to the facilities. Sample drop-off and pick-up opportunities were also provided.

Sampling began July 10, 2017 and continued through the week of September 29. All but one of the 22 public facilities participated. Several systems do not operate into September; overall 70% of the participating facilities sent samples for the entire 12-week period. Results were shared with operators by the DWGWPD, which also coordinated any confirmation sampling that was needed.

Communication and Outreach

Members of the partner institutions LCC, VT DEC and VDH comprised an internal communication group that shared all bloom reports upon receipt and coordinated response activities as needed. Partners received automated notification of category 2 and 3 reports posted to the tracking database, facilitating communication and enabling volunteer reports to be reviewed and approved quickly. The group also shared literature and other pertinent information. The LCBP, NY DEC, NY DOH, and the MDDELCC were also kept apprised of cyanobacteria conditions.

Weekly email updates summarizing reports, cyanobacteria density, species composition and toxin data were provided to a group of stakeholders responsible for public health. These were primarily state and town health officials, state and town waterfront managers, Champlain water suppliers, and researchers.

Updates were released typically on Friday mornings, but stakeholders also received email notification of extensive blooms as they occurred. The Lake Champlain Committee also provided weekly emails to LCC volunteer monitors and partner agencies and separate emails to a list of interested citizens and agencies and the media.

Notification of the Public

The Vermont Department of Health reported current cyanobacteria status on Lake Champlain on-line at http://healthvermont.gov/tracking/cyanobacteria-tracker. Status was presented as text and on an interactive web map that allowed viewers to find information by location around the lake. Results of the assessments translated to one of three map status categories:

VDH Map Status	Visual
Generally Safe (green)	Category 1
Low Alert (yellow)	Category 2
High Alert (red)	Category 3

Map status was based on the visual assessment protocol for all routinely monitored locations. At the VDH sites and the quantitative sites monitored by LCC volunteers, water samples for toxin and phytoplankton analysis were collected concurrently with the visual assessment. At these locations, the visual assessment was used to generate the map status unless subsequent toxin analysis results indicated that this should change. No changes were necessary in 2017.

The CyanoTracker software occasionally experienced problems beyond VDH's control when displaying coding for locations with more than one report within a two week period in 2017. Occasionally, this resulted in outdated reports being shown. To avoid confusion as VDH worked to resolve the underlying IT issue, single colored points were used in place of the green/yellow/red coding. A permanent solution was developed and the color coding returned to green/yellow/red.

Response to Monitoring Reports

Three jurisdictions were covered by the monitoring program efforts (New York, Vermont and Quebec). While the monitoring program provided a lake-wide system of assessing and reporting cyanobacteria conditions and shared that information via email and the VDH webpage, response to specific events was coordinated and implemented by the appropriate jurisdiction following their respective response protocols.

Outreach

Partners maintained individual websites highlighting monitoring activities, the interactive CyanoTracker map and annual data. Partners also held trainings, made presentations upon request, and responded to inquiries from the public, lake users and the media.

Results

Overall effort

We received 1753 site-specific reports from the geographic area covered by this project. These were provided by project partners, volunteers, and others during 2017 (Table 3). Most of these were from Lake Champlain but regular reports were also provided by VDH staff and LCC-coordinated volunteer efforts from Lake Carmi, Lake Iroquois, Lake Memphremagog and Shelburne Pond in Vermont. Reports based on the visual assessment protocol represented 85% of the total received. The remaining reports were obtained at the shoreline quality control stations or using the open water protocol.

The number of samples analyzed in 2017 is summarized in Table 4. Two hundred thirty-nine water samples were analyzed for phytoplankton density, 594 for microcystin, 112 for anatoxin, and 460 for cylindrospermopsin. Most toxin samples were collected for quality control purposes or as part of the drinking water monitoring effort and were not triggered by assessment reports.

Table 3. Summary of the 2017 cyanobacteria monitoring station reports distributed through the email update and on-line status map. () indicates supplemental reports from locations other than regularly monitored sites or between regular reporting times. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. *Reports provided by the public and others outside of the monitoring program were interpreted using the visual assessment process.

Waterbody	Region	Monitor	Assessment Method		
			Open Water Protocol	Visual Assessment	Visual/ Quantitative
Lake Carmi		LCC		39 (12)	
		VDH			32
		VT DEC		11(3)	2 (1)
		Other		(8)	
Champlain	Inland Sea	LCC		192 (13)	
		VDH		(1)	
		VT DEC	9	(2)	
		Other		7 (5)	
	Main Lake Central	LCC		382 (45)	24
		VDH			(5)
		VT DEC	32	(2)	
		Other		(4)	
	Main Lake North	LCC		157 (5)	
		VDH			10
		VT DEC	15		
		Other		(2)	
	Main Lake South	LCC		180 (30)	
		VDH		(1)	14
		VT DEC	14	(1)	
		Other		(3)	
	Malletts Bay	LCC		59 (4)	

Waterbody	Region	Monitor	Assessment Method		
			Open Water Protocol	Visual Assessment	Visual/ Quantitative
		VT DEC	8		
		Other			
	Missisquoi Bay	LCC		67 (4)	16 (4)
		VDH			(1)
		VT DEC	26	(1)	
		Other		(15)	
Champlain	South Lake	LCC			
		VDH			
		VT DEC	14		
		Other			
	St. Albans Bay	LCC		97 (45)	14 (1)
		VDH		(3)	(3)
		VT DEC	9	(1)	
		Other		(2)	
Lake Iroquois		LCC		26 (8)	
Shelburne Pond		LCC		12 (1)	
Lake Memphremagog		LCC		47 (2)	
Total Reports		**1753**	**127**	**1497**	**129**

Assessment Results – Recreational Monitoring

A summary of the assessment results from regularly monitored stations in 2017 is presented in Figure 2. The highest monitoring category reached in each region of Lake Champlain and Vermont inland lakes for is noted in Table 5. The full list of records is available upon request or can be downloaded from the VDH website (https://apps.health.vermont.gov/vttracking/cyanobacteria/2017summary/index.html).

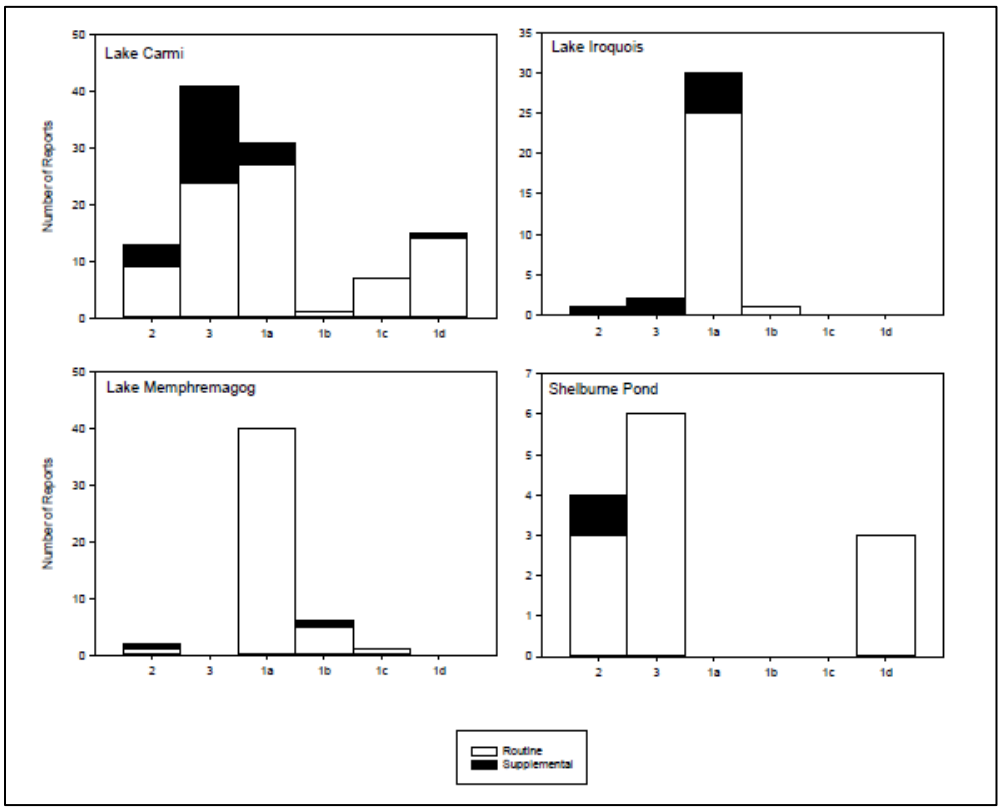
Most reports (85%) received in 2017 indicated that few or no cyanobacteria were present (category 1 of the visual protocol). In all, 259 reports of bloom conditions were received, routine and supplemental during the summer of 2017, 15% of the total reports received. The highest density of potentially toxic cyanobacteria was observed offshore of the Alburgh VT shoreline of Missisquoi Bay on September 12, 2017 (3,454,000 cells/mL).

A total of 132 recreational samples were analyzed for the presence of microcystin and 112 for anatoxin in 2016 (Table 4). The number of samples tested for each waterbody is provided in Table 5. Unlike 2016, microcystin was detected at multiple locations over the summer of 2017. The highest observed concentration observed as part of this project occurred on November 5 at LTM 51 in Missisquoi Bay (5.6 µg/L).

Table 4. Number of water and phytoplankton samples collected and analyzed in 2017. Data compiled from the season summary spreadsheet available through the VDH Tracking Map and the DWGWDP Drinking Water Monitoring Program summary.

Assessment Type	Phytoplankton		Microcystin	Anatoxin	Cylindrospermopsin
	Plankton Net	Whole water	Whole water	Whole water	Whole Water
Open Water Protocol	122	8	8	8	NA
Visual/Quantitative		109	124	104	NA
Drinking Water Monitoring	NA	NA	462	NA	460
Total	**122**	**117**	**594**	**112**	**460**

Figure 2. Summary of assessment reports received in 2017; 2a – inland lakes, 2b – Lake Champlain. Data compiled from the season summary spreadsheet available through the VDH Tracking Map.



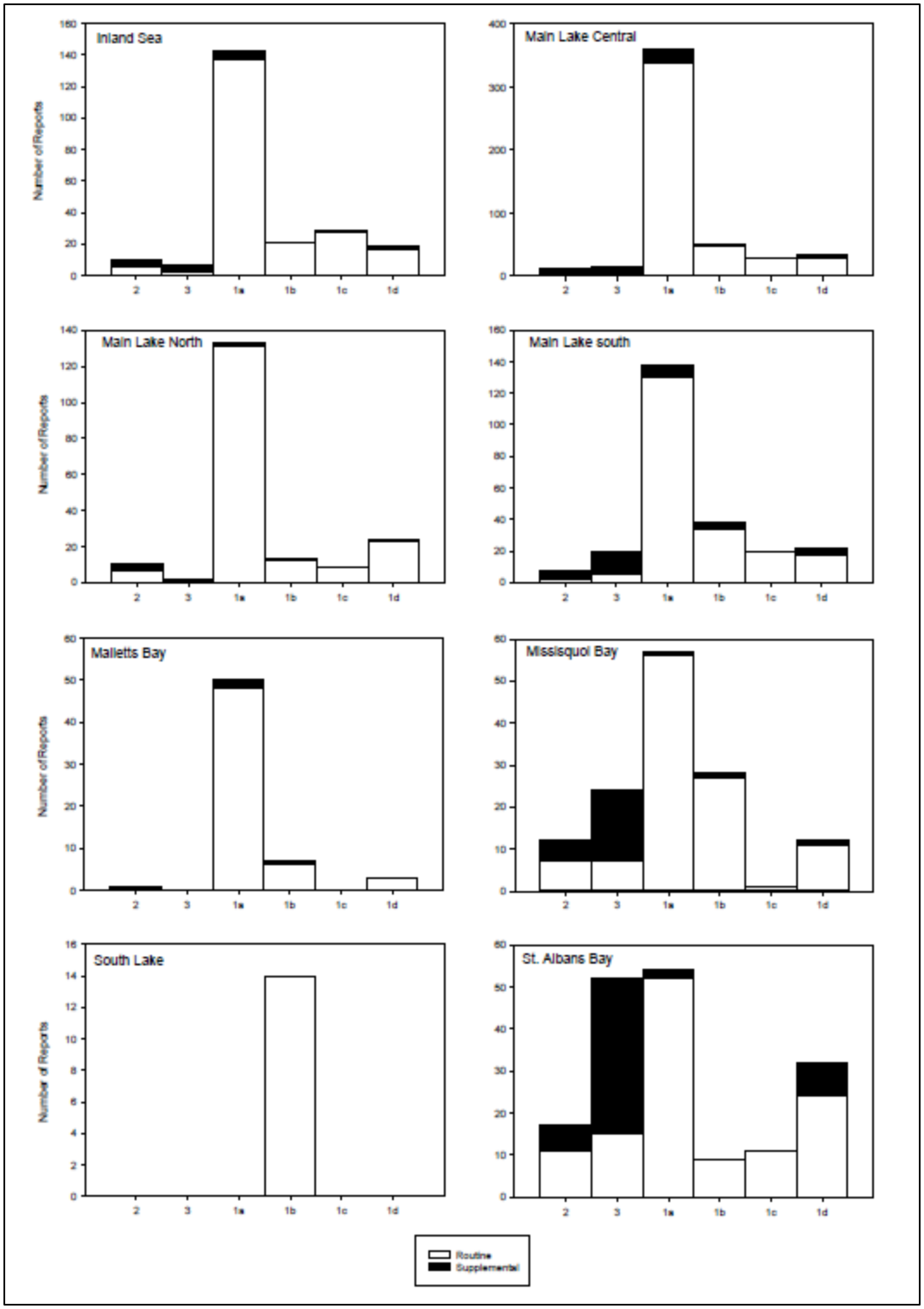

Inland Sea
Main Lake Central
Main Lake North
Main Lake south
Malletts Bay
Missisquoi Bay
South Lake
St. Albans Bay
Number of Reports
2
3
1a
1b
1c
1d
Routine
Supplemental

Table 5. Highest status reached in each waterbody in 2017. Data compiled from the season summary spreadsheet available through the VDH Tracking Map. Methods: V = visual, Q = Quantitative, Q/V = QA/QC station utilizing both quantitative and visual protocols.

Lake	Region	Method	# Reports	Highest Status Observed	Highest Cell Density Observed, cells/mL	Highest Microcystin, µg/L (# Tested)	Highest Anatoxin, µg/L (# Tested)
Lake Carmi		V, V/Q	108	High Alert	3,454,000	4.4 (10)	<0.5 (33)
Champlain	Inland Sea	OW, V	228	High Alert	209	Not Tested	Not Tested
	Main Lake Central	OW, V, V/Q	503	High Alert	8080	1.25 (65)	<0.5 (24)
	Main Lake North	OW, V, V/Q	190	High Alert	4440	<0.16 (10)	<0.5 (10)
	Main Lake South	OW, V, V/Q	244	High Alert	1,547,200	4.25 (16)	<0.5 (12)
	Malletts Bay	OW, V	61	Low Alert	270	Not Tested	Not Tested
	Missisquoi Bay	OW, V, V/Q	134	High Alert	3,249,300	5.6 (18)	<0.5 (17)
	South Lake	OW	14	Generally Safe	1120	Not Tested	Not Tested
	St. Albans Bay	OW, V, V/Q	175	High Alert	298,700	0.35 (22)	<0.5 (17)
Lake Iroquois		V	34	High Alert	Not Tested	Not Tested	Not Tested
Lake Memphremagog		V	49	Low Alert	Not Tested	Not Tested	Not Tested
Shelburne Pond		V	13	High Alert	Not Tested	Not Tested	Not Tested

Twenty-four cyanobacteria taxa were observed in Lake Champlain or inland lakes during the 2017 monitoring period (Table 6). The majority have been identified as potential toxin producers in the scientific literature.

Table 6. Cyanobacteria taxa observed in Lake Champlain cyanobacteria monitoring samples. Year of first report refers only to the cyanobacteria monitoring program. *Prior to 2012, cyanobacteria were noted to genus only.

Name	Toxin producer	Present in 2017	Year of first report
Anabaena circinalis	yes	yes	2003*
Anabaena planctonica	yes	yes	2003*
Anabaena spp	yes	yes	2003*
Anabaena flos-aquae	yes	yes	2015
Aphanizomenon spp. (likely *A. gracile*)	yes	yes	2012
Aphanizomenon flos-aquae	yes	yes	2003*
Aphanocapsa spp.	no	yes	2004
Aphanothece spp.	yes	yes	2012
Arthrospira spp.	no	yes	2012
Chroococcus spp.	no	yes	2003
Coelosphaerium spp.	Yes	yes	2003

Name	Toxin producer	Present in 2017	Year of first report
Cyanodictyon spp.	no	no	2016
Gloeotrichia spp.	yes	yes	2003
Gloeocapsa spp.	yes	no	2004
Komvophoron spp.	yes	no	2016
**Limnothrix* spp.	possible	yes	2012
Merismospedia spp.	no	yes	2003
Microcystis spp.	yes	yes	2003*
Microcystis wesenbergii	yes	yes	2012
Oscillatoria spp.	yes	yes	2005
**Pseudanabaena* spp	yes	yes	2012
**Radiocystis* spp.	possible	yes	2012
Romeria spp.	no	yes	2014
**Scytonema crispum* (synonym *Lyngbya cinncinata*)	yes	yes	2012
Snowella spp	no	yes	2012
Trichodesmium spp	no	no	2015
Woronichinia spp (formerly *Gomphosphaeria* spp.)	yes	yes	2012
colonial taxon (likely *Cyanonephron* spp.)	no	yes	2014

Drinking Water Supply Monitoring

In 2017, the VDH offered, with support from the LCBP, free weekly microcystin testing for public drinking water facilities in Vermont from July 10 through September 26. The DWGWPD organized training sessions for facility operators, where LCC provided guidance on the visual assessment system and VDH provided an overview of Vermont's guidance for cyanotoxins in drinking water. Results of the summer's testing are presented in Tables 7 and 8 and can be found online at http://dec.vermont.gov/water/drinking-water/water-quality-monitoring/blue-green-algae/cyanotoxin-monitoring. There were no microcystin or cylindrospermopsin detections in 2017.

Table 7. Microcystin Results from the Drinking Water Monitoring Project in 2017. Testing was limited to public facilities in Vermont.

Facility	Microcystin - Raw Water		Microcystin – Finished Water	
	Number of Samples	Result	Number of Samples	Result
Alburgh F.D. #1	12	Below detection	12	Below detection
Alburgh Village	8	Below detection	8	Below detection
Apple Island Resort	12	Below detection	12	Below detection
Basin Harbor Club - Ferrisburg	12	Below detection	12	Below detection
Bow and Arrow – North Hero	12	Below detection	12	Below detection
Burlington Public Works	11	Below detection	11	Below detection
Burton Island State Park (Closed for the season Sept 4)	9	Below detection	9	Below detection
Camp Skyland – South Hero (Closed for the season Aug 31)	10	Below detection	10	Below detection
Champlain Water District	12	Below detection	12	Below detection
Grand Isle Consolidated	12	Below detection	12	Below detection
Grand Isle F.D. #4	12	Below detection	12	Below detection
North Hero	12	Below detection	12	Below detection
Paradise Bay – South Hero	12	Below detection	12	Below detection
Ruthcliffe – Isle La Motte (Closed for the season Sept 4)	8	Below detection	8	Below detection
Sandbar State Park – Milton (Closed for the season Sept 4)	9	Below detection	9	Below detection
South Hero F.D. #4	12	Below detection	12	Below detection
St. Albans	12	Below detection	12	Below detection
Swanton	12	Below detection	12	Below detection
Tritown Water District	12	Below detection	12	Below detection
Vergennes/Panton	12	Below detection	12	Below detection
West Wind – Charlotte	10	Below detection	10	Below detection

Table 8. Cylindrospermopsin Results from the Drinking Water Monitoring Project in 2017. Testing was limited to public facilities in Vermont.

Facility	Cylindrospermopsin - Raw Water		Cylindrospermopsin – Finished Water	
	Number of Samples	Result	Number of Samples	Result
Alburgh F.D. #1	12	Below detection	12	Below detection
Alburgh Village	8	Below detection	8	Below detection
Apple Island Resort	12	Below detection	12	Below detection
Basin Harbor Club - Ferrisburg	12	Below detection	12	Below detection
Bow and Arrow – North Hero	12	Below detection	12	Below detection
Burlington Public Works	11	Below detection	11	Below detection
Burton Island State Park (Closed for the season Sept 4)	9	Below detection	9	Below detection
Camp Skyland – South Hero (Closed for the season Aug 31)	10	Below detection	10	Below detection
Champlain Water District	12	Below detection	12	Below detection
Grand Isle Consolidated	12	Below detection	12	Below detection
Grand Isle F.D. #4	12	Below detection	12	Below detection
North Hero	12	Below detection	12	Below detection
Paradise Bay – South Hero	12	Below detection	12	Below detection

Facility	Cylindrospermopsin - Raw Water		Cylindrospermopsin – Finished Water	
	Number of Samples	Result	Number of Samples	Result
Ruthcliffe – Isle La Motte (Closed for the season Sept 4)	8	Below detection	8	Below detection
Sandbar State Park – Milton (Closed for the season Sept 4)	9	Below detection	9	Below detection
South Hero F.D. #4	12	Below detection	12	Below detection
St. Albans	12	Below detection	12	Below detection
Swanton	12	Below detection	12	Below detection
Tritown Water District	12	Below detection	12	Below detection
Vergennes/Panton	12	Below detection	12	Below detection
West Wind – Charlotte	10	Below detection	10	Below detection

Volunteer training

Volunteer trainings were conducted by LCC staff at locations around the Lake Champlain Basin. Twenty-three formal sessions trained nearly 300 potential monitors and interested citizens. Numerous media interviews and appearances alerted the public to the opportunity to become a volunteer monitor. LCC staff provided training for Vermont drinking water facility operators and for watershed organizations on Lakes Carmi, Iroquois and Memphremagog who wished to develop volunteer monitoring networks at those lakes.

Training sessions provided information about cyanobacteria – causes, conditions that favor the development of blooms, appearance, associated health concerns, and management efforts aimed at reducing bloom frequency. Monitors were taught to distinguish cyanobacteria from other phenomena they might see in the lake such as green algae and pollen. Training sessions also introduced volunteers to the on-line LCC cyanobacteria resources and report forms, and the VDH Tracker reporting process.

The volunteer monitor program has an impact beyond the recruitment of volunteers and collection of data. As awareness of the possible health effects associated with cyanobacteria spreads, the interest in learning more about these organisms increases. While not all trained volunteers go on to report, all became familiar with cyanobacteria, potential health risks associated with them, and the water quality conditions that increase the likelihood of blooms.

Outreach and Assistance

Project partners continue to provide outreach and assistance to individuals and municipalities, primarily through phone calls and email. In addition, the LCC sends out a weekly update on conditions to their volunteers and provides separate weekly emails to a list-serve of interested citizens and agencies along with media reports throughout the season. Guidance and assistance to town health officers, beach managers, and residents was provided by partners during bloom events. All partners had webpages with resources and contacts for anyone seeking information about cyanobacteria. Partners also responded to media inquiries.

Regional and National Activities

Project partners are active at the local, regional and national level. Partners continue to work closely with state and provincial staff in New York and Quebec to share monitoring information and bloom reports. VT DEC field staff continue to participate in EPA Region 1 efforts to develop a field screening method for cyanobacteria based on phycocyanin, a photosynthetic pigment found in cyanobacteria but few other algae.

The Program Manager continues to be a member of the Great Lakes HABS Collaboratory, an effort in the Great Lakes Region to leverage relationships among universities, states and federal partners to share cutting edge research and develop collaborative approaches to cyanobacteria monitoring. She also serves as a co-chair of the Inland HABS Program of the North American Lake Society (NALMS).

The combined qualitative and quantitative approach utilized by the Champlain cyanobacteria monitoring project continue to support national efforts to develop remote sensing platforms for use across the country. The CyAN Project (Cyanobacteria Assessment Network) is a collaborative effort of EPA, NASA, NOAA and the USGS to develop a satellite-based early warning indicator system. Project data from the Champlain project will continue to support ground-truthing and algorithm development activities in 2018. In addition, data from the monitoring program is being utilized by research projects at the University of Vermont and the Global Lake Ecological Observatory Network (GLEON).

Communication with the Stakeholders and the Public

Results of the weekly assessments were communicated via email to a variety of stakeholders. The 166 recipients who received the VT DEC emails were largely associated with the states of Vermont and New York (n = 103, including partners). Other recipients included federal officials and LCBP (10), provincial officials in Quebec (6), water facilities or municipal staff (28), non-profits and universities (12, including partners), and unknown recipients (7). As noted earlier, LCC also provided weekly emails to all monitors and partner agencies as well as separate weekly emails to a list-serve and regular emails to the media once blooms began.

Information was shared with the public via the VDH cyanobacteria webpages - see table below. Between June and December 2017, the VDH Cyanobacteria website received over 5,000 visits while the interactive map received more than 4,500 views (Table 9). Activity was greatest in July, August, and September, corresponding to peak months of recreational activity. The monitoring data was also accessible through the VDH's Environmental Public Health tracking portal at http://healthvermont.gov/tracking/index.aspx.

VDH Cyanobacteria Webpages	URL
VDH Cyanobacteria Landing Page	healthvermont.gov/cyanobacteria
VDH Cyanobacteria Lake Conditions Page	healthvermont.gov/health-environment/recreational-water/lake-conditions
EPHT Cyanobacteria Landing Page	healthvermont.gov/tracking/cyanobacteria-tracker
EPHT Cyanobacteria Tracker Map	https://apps.health.vermont.gov/vttracking/cyanobacteria/2017/
VDH Climate Change and Cyanobacteria Page	http://www.healthvermont.gov/health-environment/climate-health/cyanobacteria

Table 9. Usage of the VDH Cyanobacteria webpages mid to late 2017

2017 Month	VDH Cyanobacteria Landing Page - Unique Page Views*	VDH Cyanobacteria Tracker - Unique Page Views**
June	759	379
July	1016	783
August	804	1098
September	1456	1688
October	594	396
November	238	130
December	192	68
Total:	5059	4542

* healthvermont.gov/cyanobacteria
** https://apps.health.vermont.gov/vttracking/cyanobacteria/2017/d/

Discussion

The primary role of the cyanobacteria monitoring program is to provide data on cyanobacteria occurrence and abundance to the VDH and other partners for the protection of public health. The data provided by the program assists drinking water facilities around Lake Champlain evaluate the quality of their raw water and, in Vermont, provides operators with specific information about the presence/absence of selected cyanotoxins. The program serves an education and outreach role, helping volunteers and others recognize situations when recreational activities might not be prudent. Data also provide insight as to the effectiveness of the monitoring approach and contribute to a historical perspective of bloom events in the Basin.

Effectiveness of the visual monitoring protocol

Quantitative data collected in conjunction with visual assessments at selected sites continue to support the visual assessment protocols as an effective tool to assess potential recreational risk. In 2017, LCC volunteers at Red Rocks and North Beaches in the Burlington area, the Shipyard at Highgate Springs, and St. Albans Bay Park collected water samples when they made their assessments. VDH staff did the same for two stations on Lake Champlain (Alburgh Dunes State Park, Tri-town Road in West Addison) and Lake Carmi (North Beach and the beach in Lake Carmi State Park). VT DEC collected 3m net plankton tows in conjunction with their visual assessment.

These data continue to show that the visual assessment protocol is a successful tool for the evaluation of recreational risk from cyanobacteria. The majority of reports noted Category 1 (generally safe conditions), with correspondingly low concentrations of potentially toxic cyanobacteria (Appendix C). No microcystin or anatoxin was detected in any Champlain sample with a visual assessment in Category 1. On Lake Carmi, 3 samples with Category 1 assessments taken from the State Park over the summer had low concentrations of microcystin (0.16 – 0.19 µg/L), well below the Vermont recreational guidance level of 6 µg/L. Potentially toxic cyanobacteria were present in all three samples. All Category 2 and 3 samples with detectable microcystin that were also evaluated for cyanobacteria had cell densities of more than 100,000 cells per mL.

Cyanobacteria conditions in 2017

Weather conditions in 2017 did not follow typical patterns. Regionally, the summer started wet and cool, culminating in lower than normal temperatures in late August. This was followed by higher than normal temperatures across the region, which persisted into early November (Figure 3), accompanied by sunshine and little wind. The combination of early summer rainfall and nutrient loading, followed by warmth and sunshine, stimulated cyanobacteria blooms across the region which lasted well into the fall. Microcystin was detected at several locations on Lake Champlain and Lake Carmi during this period of late season blooms.

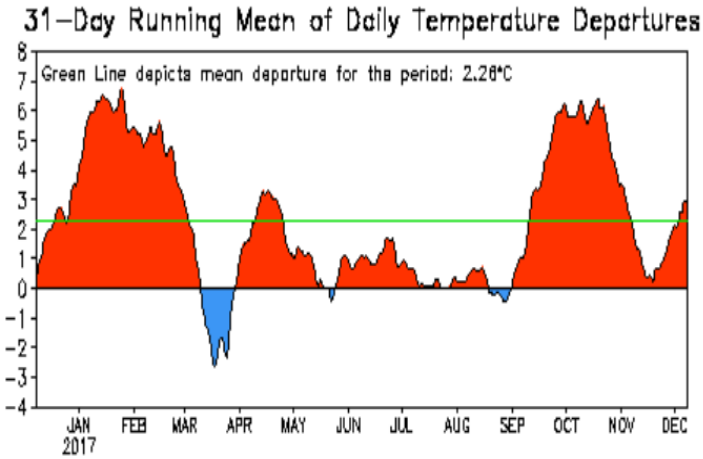


Figure 3. Daily Mean Temperature for Burlington VT (degrees C). From the National Weather Service - http://www.cpc.ncep.noaa.gov/products/global_monitoring/temperature/tn72617_1yr.gif

Vermont inland lakes

The VDH made routine observations following the visual assessment protocol and collected water samples for toxin and phytoplankton analysis from two locations on Lake Carmi. Lake associations at Iroquois, Carmi and Memphremagog conducted routine monitoring sites on their respective lakes utilizing the visual assessment system but did not collect water samples. One LCC volunteer routinely reported from Shelburne Pond using the visual assessment protocol.

Lake Carmi, in particular, was severely impacted by blooms during 2017 (Figure 4). Carmi is eutrophic and experiences low oxygen concentrations in the hypolimnion, which results in internal phosphorus loading. VT DEC conducted routine water quality monitoring on Carmi in 2017 and documented the conditions that occurred. Blooms, primarily at the northern end of the lake, developed in mid-July for a short period and then subsided. In late August, water temperature dropped significantly, triggering early lake turnover and full mixing of phosphorus-rich hypolimnetic waters into the rest of the lake. The higher than normal temperatures along with intense sunshine and calm winds in September re-established stratification with much higher phosphorus concentrations at the surface, prime conditions for late season cyanobacteria blooms. These were severe and persisted into early November. A full description of 2017 water quality conditions for Lake Carmi can be found on the Vermont DEC webpage.

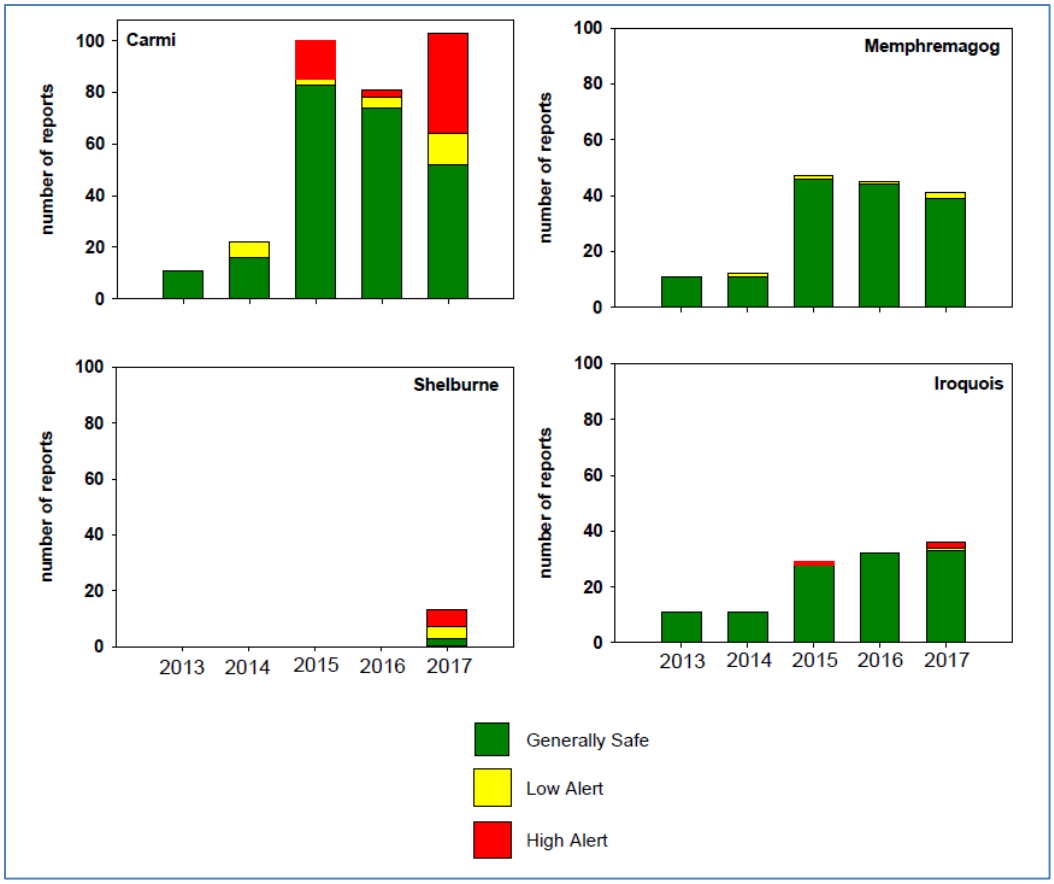


Figure 4. Webpage status reports on selected inland lakes since 2013. Supplemental reports are included. Only one year of routine monitoring data is available for Shelburne Pond.

Shelburne Pond also has a history of frequent cyanobacteria blooms and reports provided by the LCC volunteer monitoring the boat launch area noted blooms there beginning in late June. Lake Memphremagog and Iroquois conditions were good most of the summer, though both were affected by the unusual late season weather. Lake Iroquois experienced short-lived blooms in early August and late September. Low alert conditions were reported from the Newport city dock on Lake Memphremagog in mid-September.

Table 10 summarizes microcystin concentrations observed at selected Vermont inland lakes since monitoring began in 2012. Samples for cyanobacteria testing were collected weekly at two locations on Lake Carmi by the VDH and additional samples were collected during blooms. No toxin testing was conducted on Memphremagog or Iroquois in 2017. Microcystin concentrations exceeding Vermont's recreational guideline of 6µg/L are rarely documented, but microcystin was detected several times on Lake Carmi this year, primarily during the late season blooms. The highest concentration was on September 26 at the North Beach - 4.4 µg/L.

Table 10. Microcystin concentrations in selected Vermont lakes, 2013 - 2017. Lakes Carmi, Iroquois and Memphremagog were monitored weekly. <0.16 is the reporting limit

Lake		2013	2014	2015	2016	2017
Lake Carmi	median	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 - 0.21	<0.16 - 0.39	<0.16 – 0.40	<0.16	<0.16 – 4.4
	#samples	10	19	17	25	35
	#stations	1	4	2	3	3
Lake Elmore	median	<0.16	<0.16	<0.16	Not Monitored	Not Monitored
	range	<0.16	<0.16 - 0.18	<0.16 – 0.19		
	#samples	11	11	11		
	#stations	1	1	1		
Lake Iroquois	median	<0.16	<0.16	<0.16	Not tested	Not tested
	range	<0.16	<0.16	<0.16		
	#samples	11	11	11		
	#stations	1	1	2		
Lake Memphremagog	median	<0.16	<0.16	<0.16	Not Tested	Not Tested
	range	<0.16	<0.16	<0.16 – 0.17		
	#samples	11	11	11		
	#stations	1	1	1		

Cyanobacteria Conditions on Lake Champlain:

Eighty-eight percent of the reports from 2017 indicated generally safe conditions. Alert-level conditions were reported 186 times, 119 as supplemental reports (Figure 5, Table 11), approximately 12% of the reports submitted (Figure 6). Alert level conditions were reported most frequently in Missisquoi Bay and St. Albans Bay in 2017 (Figure 7). The number of alert level reports was higher than in 2016 but similar to the number reported in 2015.

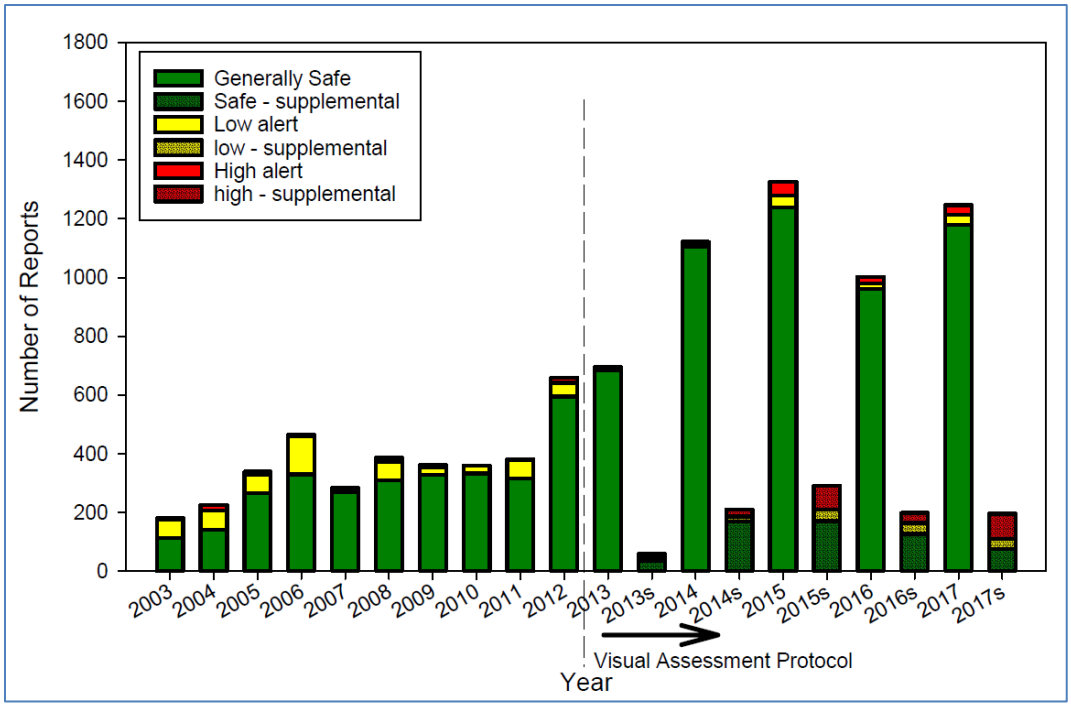


Figure 5. Number of yearly cyanobacteria status reports for Lake Champlain by category. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included separately, indicated by an 's' following the year on the x axis.

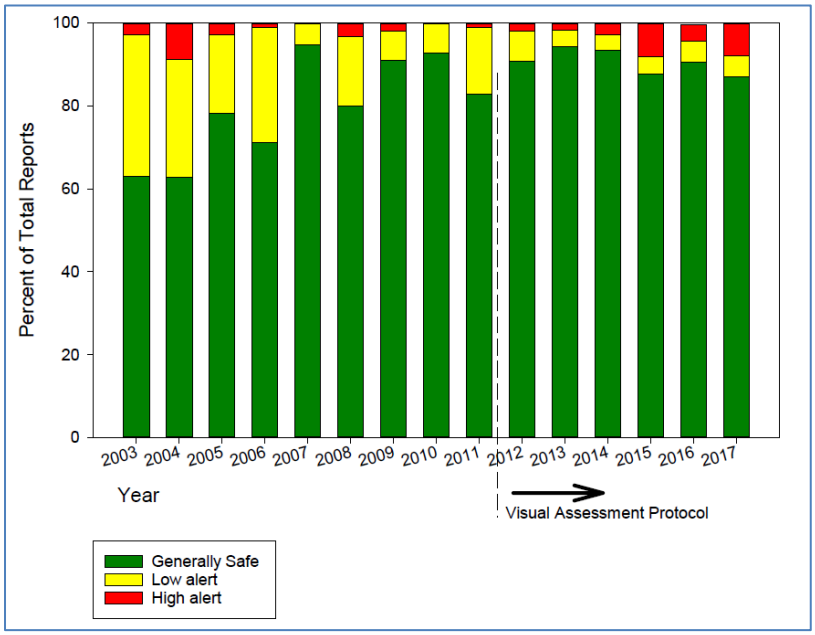


Figure 5. Cyanobacteria status reports Lake Champlain by category, percent of total reports received. Records prior to 2012 were determined using historical cell count and toxin data. Beginning in 2012, summaries include records obtained using the visual assessment protocol. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included but not reported separately.

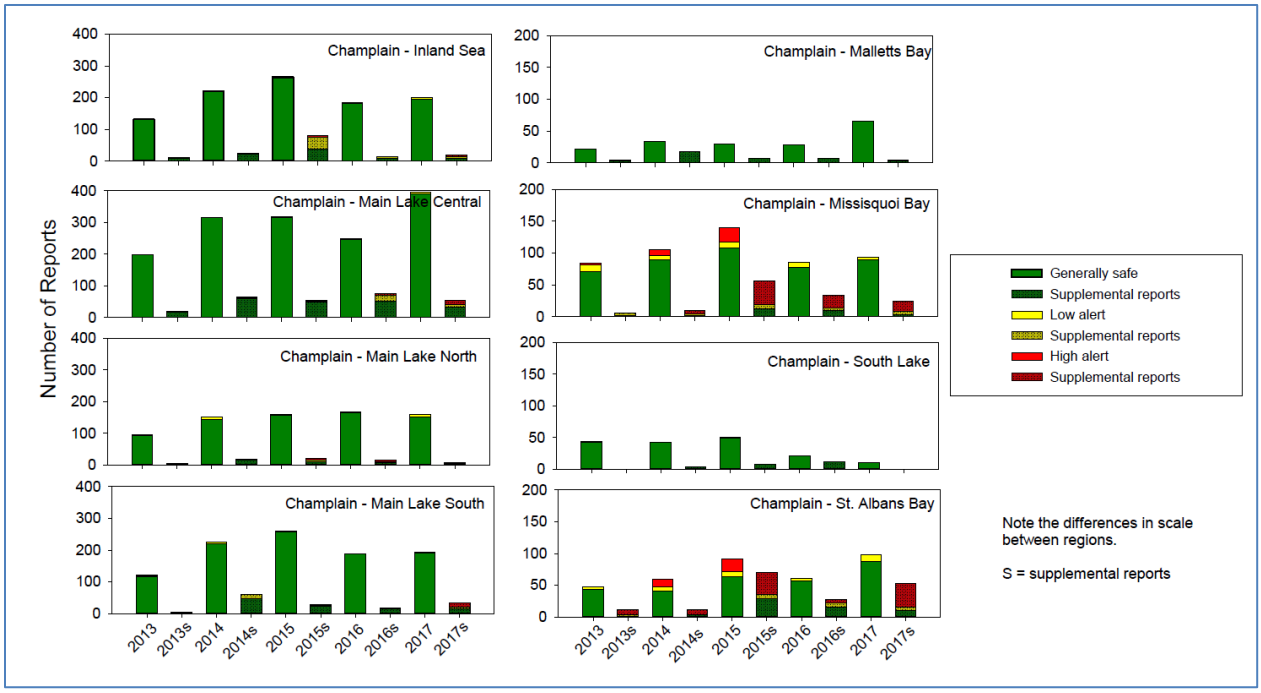


Figure 7. Number of yearly cyanobacteria reports for Lake Champlain by region, 2013 – 2016. The status generated by the visual assessment protocol is used at locations where both types of assessment were employed. Supplemental reports are included separately, indicated by an 'sr' preceeding the year on the x axis.

As noted previously, the unseasonable warm and calm weather, which persisted into late fall, resulted in late season cyanobacteria blooms across the region. The Vermont shoreline of the main lake was affected from Burlington Bay southward and numerous reports of alert level conditions were received in late September. The warm weather brought beachgoers out to the waterfront at a period when park and beach staffing levels are typically low. In Burlington, city Parks and Recreation staff were stretched but continued to make frequent updates about conditions and maintain signage along the shoreline. LCC staff increased their presence on the Burlington waterfront, talking with swimmers and others about the possible health consequences of contact with cyanobacteria blooms. Town Health Officers posted signage at locations outside of Burlington.

Cyanotoxin sample efforts continue to target bloom situations whenever possible. Because microcystin concentrations are expected to be highest in these situations, this targeted sampling increases the opportunity to capture high microcystin events. Microcystin concentrations exceeding Vermont's recreational guideline of 6µg/L are rarely documented and have occurred only in Missisquoi Bay (Table 11). In 2017, microcystin was detected at multiple locations on Lake Champlain and Lake Carmi. The Vermont recreational guidance value was not reached, but concentrations did exceed 4 µg/L on 3 occasions in Lake Champlain (Shipyard – Missisquoi Bay, August 8 – 5.1 µg/L; Charlotte Town Beach, September 25 – 4.25 µg/L; LTM 51 – October 5 – 5.6 µg/L).

Table 11. Microcystin concentrations in major lake segments, 2011 – 2017. Data are from routine monitoring locations and bloom events. Data do not distinguish between net plankton, which were tested through 2012, and whole water samples. ND = not detected. Shaded boxes = not applicable. Full historical data can be found in Appendix D.

Lake Segment		Max 2003 - 2011	2012	2013	2014	2015	2016	2017
Inland Sea	median	1.10		<0.16	<0.16	<0.16		
	range	0.01 – 22.5		<0.16 - 0.43	<0.16 - 0.28	<0.16 – 0.02		
	#samples		0	45	56	26	0	0
	#stations			4	4	4		
Main Lake Central	median	7.42	0.13	<0.16	<0.16	<0.16	<0.16	<0.16
	range	0.01 -23.3	0.13-0.64	<0.16 -0.17	<0.16 -0.19	All <0.16	All <0.16	<0.16 – 1.25
	#samples		3	23	31	27	26	31
	#stations		1	2	2	2	2	4
Main Lake North	median						<0.16	<0.16
	range	0.01 – 1.56					All <0.16	All <0.16
	#samples		0	0	0	0	12	10
	#stations						1	1
Main Lake South	median	0.04		<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 – 3.47		<0.16 - 0.16	<0.16-0.51	All <0.16	All <0.16	<0.16 – 4.25
	#samples		0	22	33	28	12	16
	#stations			2	3	2	1	3
St. Albans Bay	median	0.30	0.03	0.032	<0.16	<0.16	<0.16	<0.16
	range	<0.16 – 22.48	0.03-0.04	0.002-0.062	<0.16 - 0.2	<0.16 – 0.77	All <0.16	<0.16 – 0.35
	#samples		5	2	4	12	15	21
	#stations		1	2	2	2	3	3
Malletts Bay	median	0.04						
	range	0.04 – 0.08						
	#samples		0	0	0	0	0	
	#stations							
South Lake	median	0.96						
	range	0.53 – 1.86						
	#samples		0	0	0	0	0	
	#stations							
Missisquoi Bay	median	2.56	0.99	<0.16	<0.16	<0.16	<0.16	<0.16
	range	<0.16 - 6490	0.26-54.76	<0.16 - 1.3	<0.16 -2.29	<0.16 – 0.43	All <0.16	<0.16 – 5.6
	#samples		36	30	40	38	19	18
	#stations		3	6	7	5	6	3

Summary

As in years past, the majority of monitoring reports noted generally safe conditions on Lake Champlain and selected Vermont inland lakes. Persistent and extensive late season blooms did occur in 2017 during a period of unusually warm weather in the region that continued into late October. The main lake area

of Champlain, St. Albans Bay and Lake Carmi were particularly impacted. The warm weather drew residents to the beaches and shoreline at a time when parks and beaches typically are closed or operating with reduced staffing, stretching resources at many levels. Outreach and signage at affected areas were very important in raising awareness of the potential health consequences of exposure to cyanobacteria. Climate change is expected to lengthen the cyanobacteria growing season and this year's late season blooms highlighted gaps in resources that should be considered in the future.

The monitoring project continues to grow. LCC Volunteers continue to be the backbone of the monitoring program, providing areal coverage and report frequencies which are difficult to obtain with a traditional monitoring program. While several federal agencies are cooperating to develop satellite monitoring for the Northeast, volunteers will continue to be essential to this monitoring program because of their ability to report more frequently and without interruption by cloud cover. The monitoring partnership continues to leverage existing resources in the Champlain Basin to support the cyanobacteria program. In 2018, we will be working in conjunction with the New York DEC and New York Department of Health to raise awareness of the CyanoTracker and volunteer opportunities along the New York shores of Lake Champlain.

Acknowledgements

Project funding was provided by the Lake Champlain Basin Program, the State of Vermont, CDC grants to the VDH, and LCBP and private funding to the Lake Champlain Committee. This project is very much a collaborative effort and we'd like to thank all those who have contributed to its successful implementation - Pete Stangel and Ali Davis (VT DEC Watershed Management); Lisa Cicchetti and Bennett Truman (VDH); Kirk Kimball and Marie Sawyer (VDH Laboratory); Pete Young and Jan Leja (VDH developers of the Tracker map); Dom Brennan and Alexa Hachigian (LCC), and especially the LCC citizen volunteer monitors who continue to be the backbone of this monitoring effort.

Literature Cited

Rogalus, M. and M. Watzin. 2008. Evaluation of Sampling and Screening Techniques for Tiered Monitoring of Toxic Cyanobacteria in Lakes. Harmful Algae 7(4):504-514.

Appendix A – 2017 Sampling locations

Waterbody	Region	Station	Site	Latitude	Longitude
Lake Carmi		Carmi DEC01- Central Open Water	409	44.9726	-72.8745
		Carmi DEC02- Southern open water	410	44.9592	-72.8869
		Carmi DEC03- Northeastern open water	411	44.98328	-72.8599
		Carmi State Park Boat Launch		44.95979	-72.8759
		Lake Carmi - Patton Shore Road		44.95692	-72.8773
		Lake Carmi State Park	201	44.96081	-72.8767
		Lake Carmi State Park South	165	44.95692	-72.8773
		Lake Carmi, Black Woods	164	44.9753	-72.8855
		Lake Carmi, Dewing Road	166	44.98214	-72.8535
		Lake Carmi, Hammond Shore		44.97859	-72.8575
		Lake Carmi, North Beach	167	44.99054	-72.8703
Lake Champlain	Inland Sea	Alburgh Passage South		44.84965	-73.2842
		Burton Island	37	44.77686	-73.1963
		Cedar Ledge	131	44.84695	-73.2622
		City Bay - Rt 2	78	44.81589	-73.2891
		Cohen Park St. Albans	174	44.86476	-73.1823
		Everest Rd.	185	44.64983	-73.2131
		Grand Isle State Park	11	44.68602	-73.2891
		Keeler Bay Boat Launch	135	44.66791	-73.3199
		Keeler Bay East	134	44.65414	-73.292
		Knight Island	146	44.81072	-73.2581
		Knight Point State Park	80	44.76867	-73.2945
		Lapan Bay	385	44.81537	-73.1778
		LTM 34	34	44.70817	-73.2268
		Maquam Beach	139	44.92081	-73.1614
		Maquam Shore (Swanton, VT)	386	44.90156	-73.1671
		Marycrest Beach	116	44.72336	-73.2815
		North Hero State Park	23	44.92175	-73.2408
		Pelots Bay	24	44.82537	-73.2991
		Sand Bar State Park	57	44.62876	-73.2399
		South Alburgh - Squires Bay	182	44.90301	-73.2717
		South Hero Fish & Wildlife Access	110	44.63641	-73.2652
		The Gut	49	44.75137	-73.2903
		Van Everest Boat Launch Milton	175	44.70596	-73.2103
		Woods Island	145	44.80487	-73.2045
	Main Lake Central	Allen Point	189	44.5992	-73.3114
		Ausable Point	376	44.57213	-73.4266
		Beech Bay	190	44.6325	-73.3429

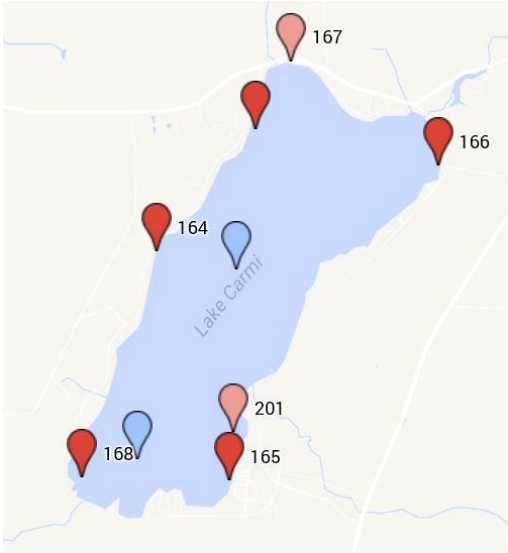
Waterbody	Region	Station	Site	Latitude	Longitude
Lake Champlain	Main Lake Central	Big Brook Cove, Southern Willsboro Bay	378	44.39268	-73.4053
		Buena Vista Park, Willsboro NY	61	44.40395	-73.3735
		Burlington Boathouse Beach		44.47626	-73.2227
		Burlington Dog Park		44.48556	-73.2276
		Burlington Inner Dock	381	44.482	-73.2246
		Burlington, VT - Texaco Beach	72	44.48764	-73.2321
		Camp Kiniya	142	44.60644	-73.2291
		Charlotte Town Beach	76	44.33473	-73.2829
		Cliff Haven Camp	404	44.66734	-73.4422
		Coast Guard Boat Launch		44.48206	-73.2255
		Colchester Point Boat Launch	412	44.53622	-73.2746
		Community Sailing Center	107	44.48206	-73.2255
		Corlear Bay, Port Douglas Boat Launch	160	44.48612	-73.4117
		Dead Creek Inlet	413	44.57782	-73.4375
		Delta Park	405	44.5367	-73.2775
		Essex Road	382	44.34376	-73.3577
		Hills Point	384	44.33916	-73.2818
		LaPlatte River mouth, Shelburne Bay	55	44.40034	-73.2335
		Leddy Park	54	44.50083	-73.2534
		LTM 16	16	44.425	-73.232
		LTM 19	19	44.471	-73.299
		LTM 21	21	44.47483	-73.2317
		LTM 33	33	44.70117	-73.4182
		Meach Cove Farm area	48	44.36306	-73.2676
		Noblewood Park	390	44.355	-73.3567
		North Beach	22	44.49106	-73.2404
		North Shore Beach	391	44.52076	-73.2696
		Oakledge Park Blanchard Beach	42	44.45744	-73.2255
		Oakledge Park rocky shoreline	44	44.45671	-73.228
		Oakledge Park South Cove	43	44.45496	-73.23
		Oakledge Park Southern Cove	43	44.45496	-73.23
		Peru Boat Launch	159	44.61884	-73.4404
		Port Kent Beach	152	44.52865	-73.4035
		Red Rock Point, Colchester		44.58045	-73.2271
		Red Rocks Beach	27	44.442	-73.2241
		Shelburne Beach	48	44.36306	-73.2676
		Shelburne Farms	123	44.40445	-73.2683
		Starr Farm Beach	108	44.51376	-73.2714
		Sunset/Crescent Beach	132	44.60888	-73.3158
		Teddy Bear Point Cove, Willsboro NY	63	44.44272	-73.3743
		Twilight Bay		44.355	-73.2704
		White's Beach in Crescent Bay	114	44.62114	-73.3234

Waterbody	Region	Station	Site	Latitude	Longitude
Lake Champlain	Main Lake Central	White's Beach in Crescent Bay	114	44.62114	-73.3234
		Willsboro Boat Launch	68	44.39945	-73.3916
	Main Lake North	Alburgh Dunes State Park	35	44.86462	-73.302
		Alburgh Passage		44.84965	-73.2842
		Holcomb Boat Launch	129	44.85468	-73.3316
		Horicans Fish and Wildlife Access	127	44.91408	-73.3145
		LTM 36	36	44.75617	-73.355
		LTM 46	46	44.94833	-73.34
		Mud Point	389	44.93165	-73.3121
		Oliver Bay	45	44.73745	-73.4023
		Pelots Point West	130	44.82608	-73.3101
		Pt. Au Roche Boat Launch	109	44.8044	-73.363
		Pt. Au Roche S.P. Deep Bay	84	44.77751	-73.3789
		Pt. Au Roche State Park Beach	26	44.77414	-73.3938
		RPt DEC Old Beach	395	44.99911	-73.3578
		Stoney Point, Isle la Motte	128	44.87148	-73.3594
		Treadwell Bay, Beekmantown NY	64	44.76008	-73.4075
		Vantines Boat Launch	115	44.71981	-73.3419
	Champlain - Main Lake South	Arnold Bay	3	44.14974	-73.3695
		Arnold Bay Rd	206	44.14857	-73.3686
		Beggs Park Beach, Essex NY	60	44.30846	-73.3473
		Bulwagga Bay/Port Henry	138	44.03688	-73.4548
		Burgey Farm Road	380	44.05594	-73.4172
		Button Bay Boat Launch	74	44.17616	-73.3523
		Button Bay South	183	44.16863	-73.3556
		Button Bay State Park	180	44.18093	-73.3616
		Camp Dudley, Westport NY	75	44.14322	-73.4157
		Charlotte Town Beach	76	44.33473	-73.2829
		Converse Bay	184	44.2938	-73.2897
		DAR State Park	39	44.05453	-73.4183
		Ferrisburgh Stone Beach	137	44.2379	-73.3083
		Ferrisburgh Town Beach	117	44.23594	-73.301
		Hawkins Bay	105	44.24376	-73.2834
		Kingsland Bay State Park	15	44.2403	-73.2987
		Long Pt, - North and South Rd, Ferrisburgh	41	44.25662	-73.2831
		LTM 07	7	44.126	-73.4128
		LTM 09	9	44.24217	-73.3292
		Port Henry Boat Launch	153	44.05278	-73.4506
		Port Henry Town Beach		44.05278	-73.4506
		Summer Point	148	44.21825	-73.338
		Town Farm Bay	119	44.26916	-73.2887
		Tri-Town Road, West Addison	210	44.08538	-73.4079

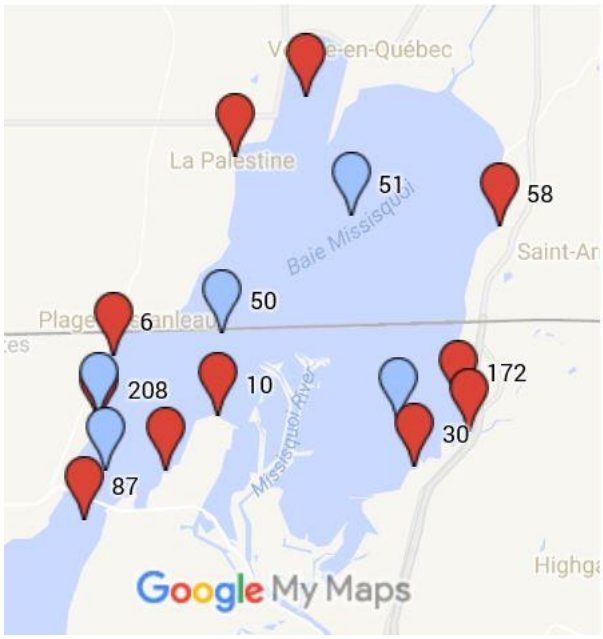
Waterbody	Region	Station	Site	Latitude	Longitude
Lake Champlain	Malletts Bay	Bayside Beach	377	44.54566	-73.2159
		Converse Bay	184	44.2938	-73.2897
		Cove at Niquette Bay State Park		44.58129	-73.1889
		LTM 25	25	44.582	-73.2812
		Marble Island	154	44.57281	-73.2366
		Mouth of Mallets Bay		44.57641	-73.2291
		Niquette Bay State Park	67	44.58129	-73.1889
		Rosetti Park	111	44.55501	-73.2528
	Missisquoi Bay	Alburgh Springs	208	44.99135	-73.216
		Chapman Bay	6	45.00785	-73.2112
		Country Club Road	172	44.9962	-73.093
		Donaldson Point	10	44.9932	-73.1753
		Highgate Springs	14	44.99177	-73.1134
		Highgate Springs, VT	14	44.99177	-73.1134
		Larry Greene Fish and Wildlife Access	87	44.96797	-73.2211
		LTM 50	50	45.01333	-73.1738
		LTM 51	51	45.04167	-73.1297
		Philipsburg, QC	58	45.03906	-73.0787
		Pike River Mouth, QC		45.07164	-73.0965
		Rock River - Highgate	178	44.9893	-73.0889
		Shipyard, Highgate Springs	30	44.98076	-73.1079
		Venise en Quebec	399	45.0705	-73.1451
	South Lake	LTM 02	2	43.714	-73.383
		LTM 04	4	43.951	-73.407
	St. Albans Bay	Black Bridge	191	44.8103	-73.1518
		Ferrand Rd. St. Albans	113	44.79171	-73.1425
		Georgia Beach	383	44.762	-73.1674
		Hackett's Way	402	44.78439	-73.174
		Hathaway Point Road	403	44.79637	-73.1631
		Kill Kare State Park	56	44.7777	-73.1808
		LTM 40	40	44.78533	-73.1622
		Melville Landing	176	44.762	-73.1674
		St. Albans Bay Boat dock		44.78533	-73.1622
		St. Albans Bay Park	31	44.80866	-73.1444
		St. Albans Boat Launch	32	44.79372	-73.1714
		St. Albans Town Dock		44.80703	-73.1402
Lake Iroquois		Lake Iroquois	203	44.37807	-73.0867
		Lake Iroquois Southwest	169	44.36327	-73.0856
		Lake Iroquois - Pine shore drive	335	44.37112	-73.0853
Lake Memphremagog		Derby Bay	211	44.99435	-72.1886
		Holbrook Bay	212	44.96418	-72.2399
		Newport City Dock	342	44.93686	-72.2122

Waterbody	Region	Station	Site	Latitude	Longitude
Lake Memphremagog		Prouty Beach	204	44.94501	-72.21
Lake Morey		Lake Morey	345	43.92139	-72.1532
		Lake Morey	345	43.92139	-72.1532
Shelburne Pond		Shelburne Pond Boat Launch	396	44.3772	-73.1621

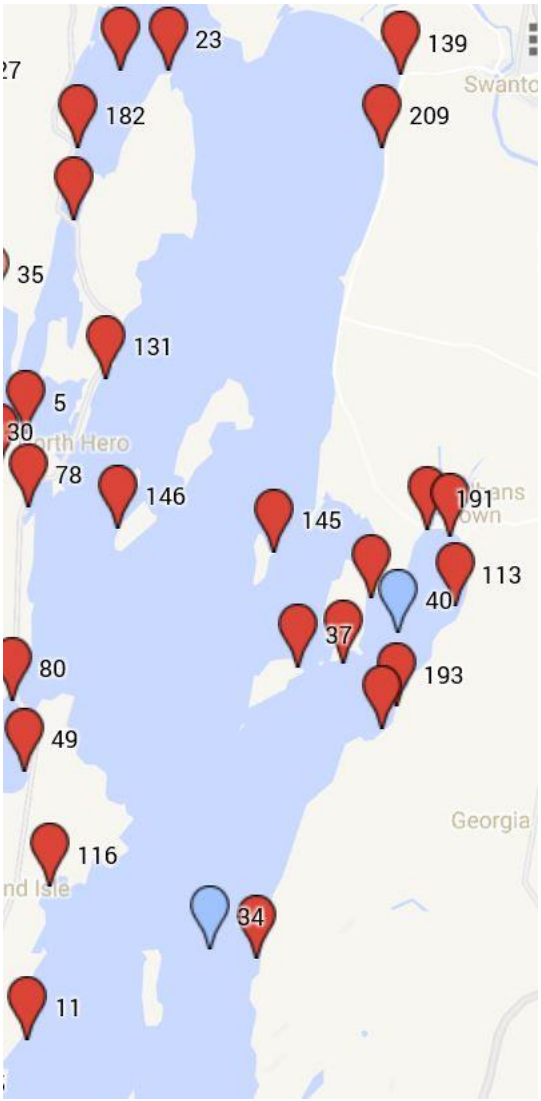
Maps of monitoring stations – 2017



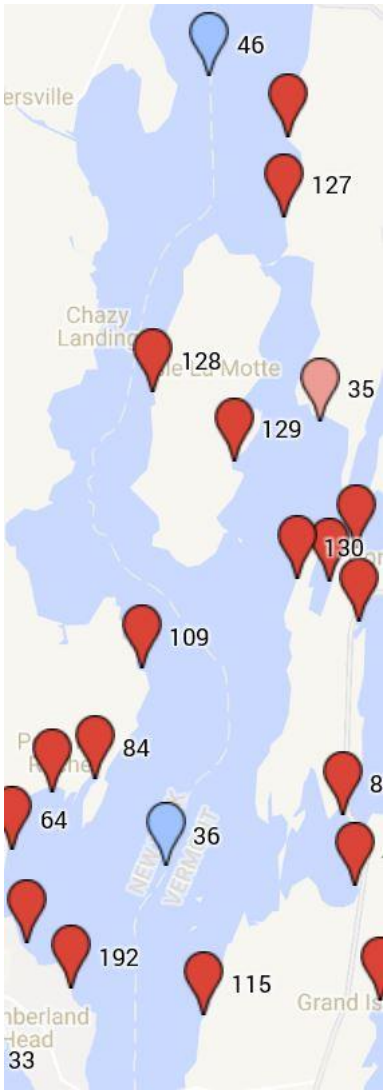
Lake Carmi



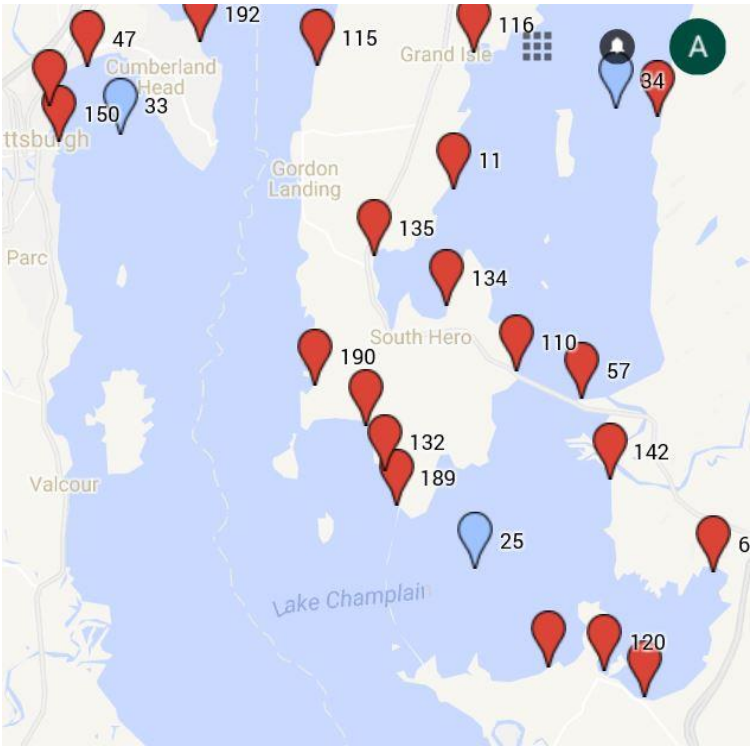
Champlain – Missisquoi Bay



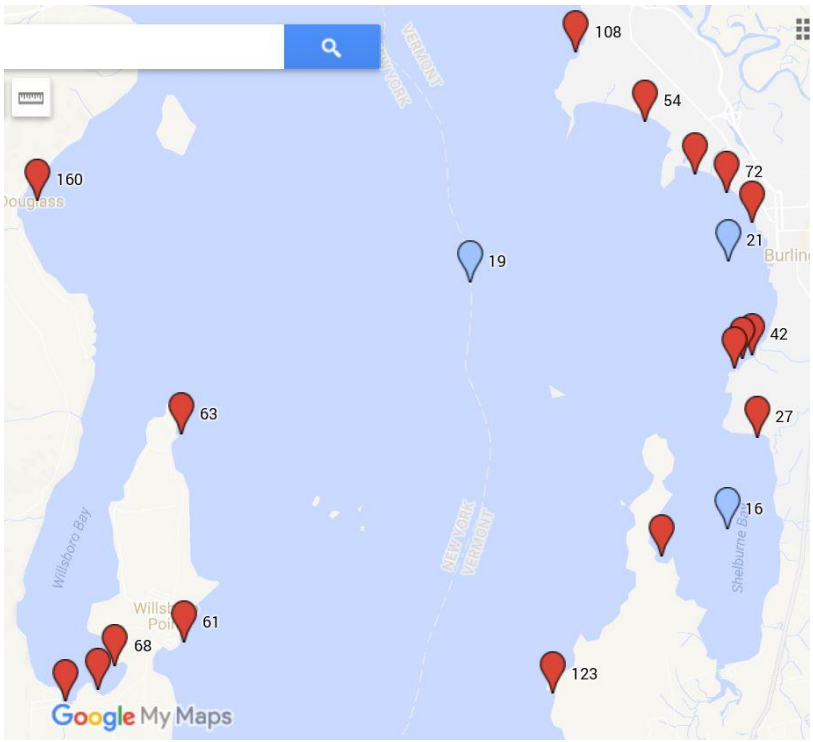
Champlain – Inland Sea (northern portion)



Champlain – Main Lake North (northern portion)

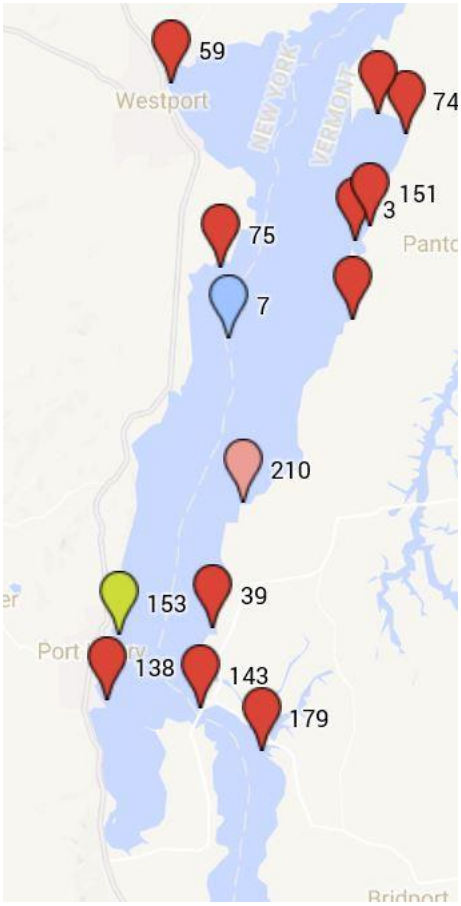


Champlain – Main Lake North (southern portion), Main Lake Central (northern portion), Inland Sea (southern portion), Malletts Bay



Champlain – Main Lake Central (Burlington area)

Champlain – Main Lake Central (southern portion), Main Lake South (northern portion), Lake Iroquois



Champlain – Main Lake South (southern portion)

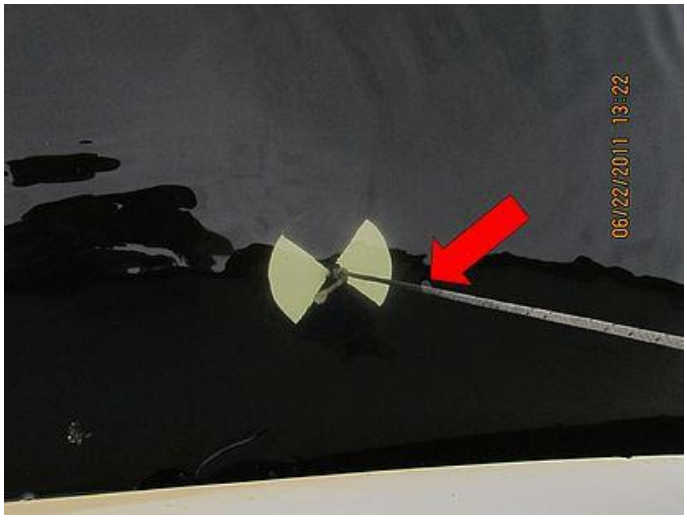
Champlain – South Lake

Appendix B. Visual assessment protocols from the Lake Champlain Committee website

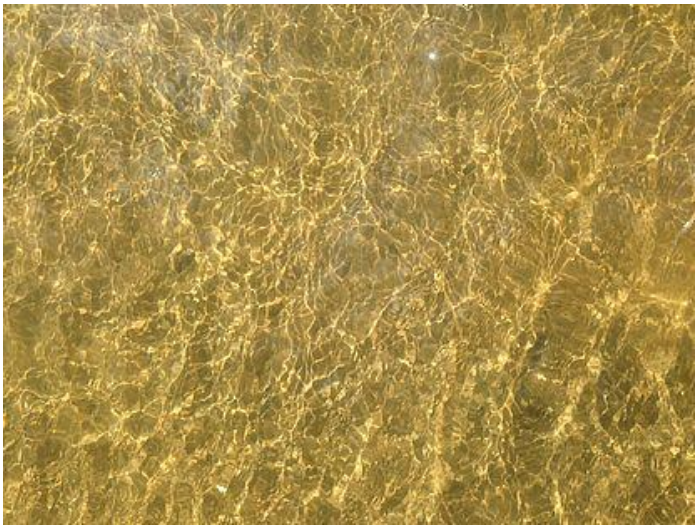
B.1. LCC Guidance for Determining Algae Bloom Intensity

Category 1a: No cyanobacteria present - clear water

Any organisms floating in water column are clear (e.g. insect 'skins') rather than green. Leafy or grass-like plants (including duckweed) may be present. Foam may be present.



Objects sitting lower in the water column are clearly visible (red arrow indicates water surface)



Overall appearance of water is clear

Category 1b - No cyanobacteria present - brown and turbid conditions

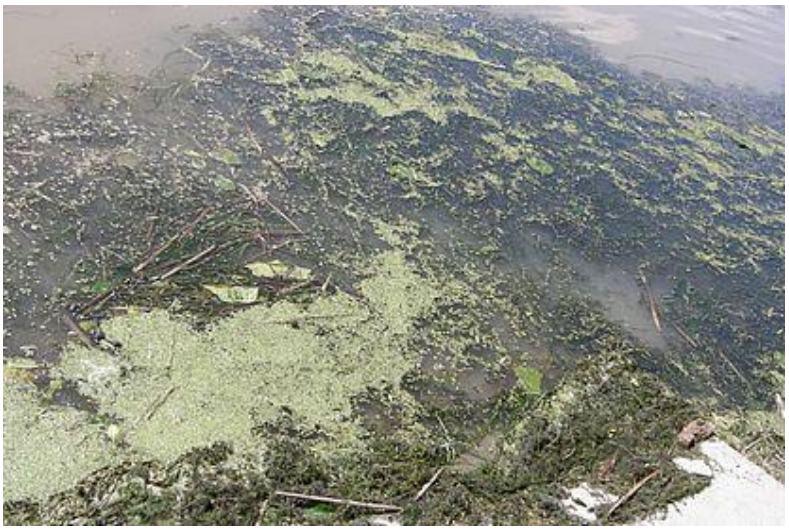
Brown turbid low visibility through water column

Brown and cloudy does not indicate presence of cyanobacteria

Category 1c - No cyanobacteria present - other plant material

Other material that doesn't count as cyanobacteria might include:

- Long strands that tangle around paddles or boat hooks
- Small bright mustard yellow (pollen) or grass green (duckweed) particles
- Algae attached to rocks or the lake bottom.



Green dots are duckweed; stringy algae are not cyanobacteria

From a distance duckweed may look like green algae or cyanobacteria

Stringy algae attached to the bottom are not cyanobacteria

Duckweed up close

Category 1d - Little cyanobacteria present - Generally safe conditions

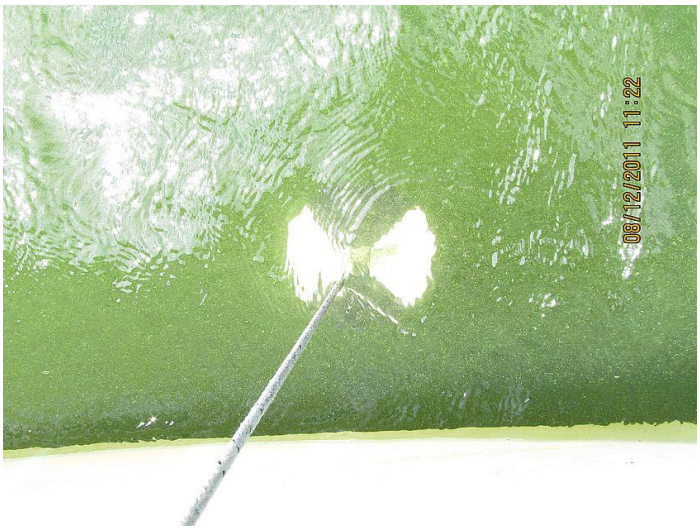
Green floating balls may be visible, but only on close inspection and in densities so low that they do not impair recreational enjoyment of the water. There are no surface or near shore accumulations of cyanobacteria.

Water appears perfectly clear

But close inspection shows some cyanobacteria present

Category 2: Cyanobacteria present, but at less than 'bloom' levels - Low alert conditions

Numerous green balls (pinhead size or larger) floating in water column, but not accumulated at water surface. Possible small (smaller than a softball) patches of algae accumulation. Open water color **not** green. Possible narrow band of cyanobacteria accumulation at shoreline.



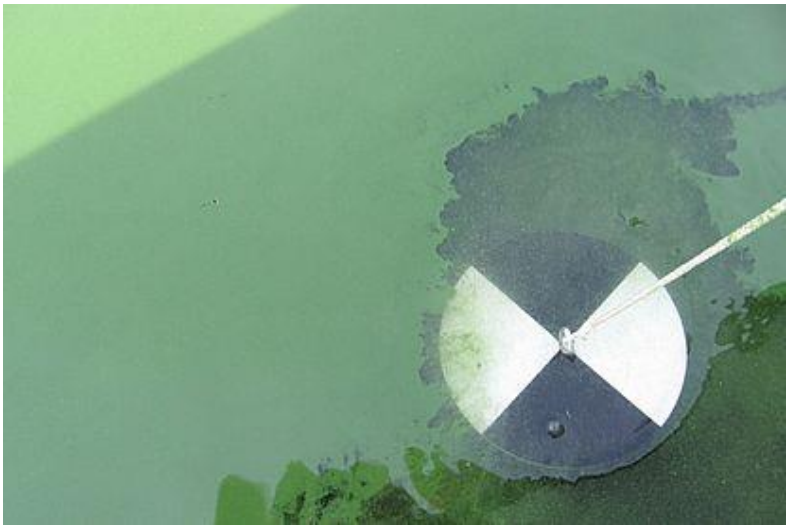
Some cyanobacteria in water but not a uniform layer

Open water not green

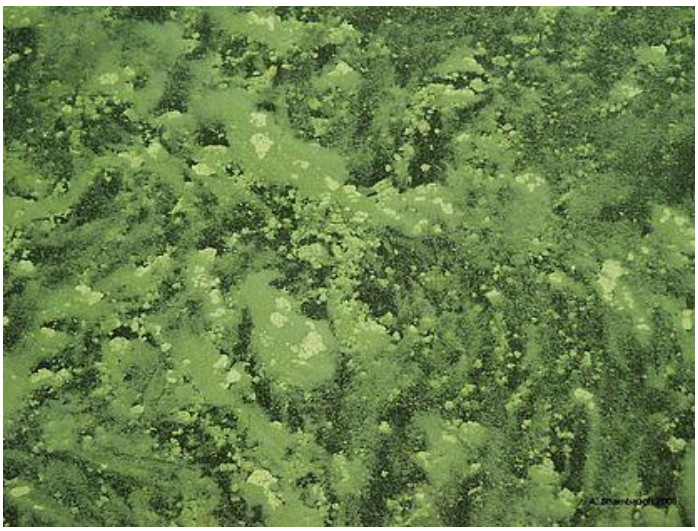
Band of cyanobacteria at shoreline

<u>Category 3: Cyanobacteria bloom in progress - High alert conditions</u>

Extensive surface scum on water – color may range from green to electric blue (not yellow/pollen). Usually accompanied by a thick accumulation at shoreline. Open water appears green.



Continuous layer of cyanobacteria at the surface - not stringy



Thick surface scum present

Open water surface green to turquoise

B.2. LCC Guidelines for Photographic Documentation

Instructions for Photographing Algae Blooms

Please take digital photographs of the water when category 2 or 3 bloom conditions are observed.

We need three photographs:

1. A close-up of the water surface,
2. A broad view of water in the vicinity, and
3. A close-up of a water sample in a clear container and placed against a background that provides contrast such as a sheet of paper or a wall. Darker colors provide more contrast.

1.Use your camera's date stamp, or hold up a card in the photo with time, date, and location.

2. Photograph both a close-up and a broad view.

3. For close-ups, take a sample of water in a clear container and photograph against a contrasting background. Over about 1/2 hour algae will rise toward the surface; detritus will sink.

When collecting a water sample to photograph take care to avoid exposure to blue-green algae. Wear gloves, don't wade or immerse yourself in the water and wash any exposed portions of your body immediately after collecting the sample. It is okay not to collect a physical sample for photography if you are uncomfortable doing so.

All photographs should include the time, date, and location. This information can be added by using the date stamp in your camera or by holding a piece of paper with the relevant information in the picture. Name the photograph file using the year, month, day-photographer's name-location-photo type.

Example file name: 2014-07-15_MWinslow_DonaldsonPt_Closeup

Appendix C – QA/QC Sample Data for 2017

Report Date	Waterbody	Station	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (ug/L)	Anatoxin (ug/L)
6/27/2017	Carmi	Lake Carmi State Park	1a - Little or no BGA - clear water	130700	<0.16	<0.5
7/5/2017			1d - Little BGA - recreation not impaired	27400	**0.19**	<0.5
7/11/2017			1c - Little or no BGA - other material present	1680	<0.16	<0.5
7/18/2017			1a - Little or no BGA - clear water	6000	**0.18**	<0.5
7/25/2017			1d - Little BGA - recreation not impaired	2050	<0.16	<0.5
8/1/2017			1d - Little BGA - recreation not impaired	4630	<0.16	<0.5
8/8/2017			1d - Little BGA - recreation not impaired	27500	<0.16	<0.5
8/15/2017			1d - Little BGA - recreation not impaired	13300	<0.16	<0.5
8/22/2017			1a - Little or no BGA - clear water	29100	<0.16	<0.5
8/29/2017			3 - BGA bloom in progress	129700	<0.16	<0.5
9/6/2017			3 - BGA bloom in progress	171400	<0.16	<0.5
9/12/2017			3 - BGA bloom in progress	333600	<0.16	<0.5
9/19/2017			1d - Little BGA - recreation not impaired	8730	<0.16	<0.5
9/26/2017			3 - BGA bloom in progress	850400	**0.53**	<0.5
10/3/2017			1d - Little BGA - recreation not impaired	131800	<0.16	<0.5
10/9/2017			1c - Little or no BGA - other material present	0	<0.16	<0.5
6/27/2017		Lake Carmi, North Beach	1c - Little or no BGA - other material present	133600	<0.16	<0.5
7/5/2017			3 - BGA bloom in progress	2627500	**0.19**	<0.5
7/11/2017			1c - Little or no BGA - other material present	293100	<0.16	<0.5
7/18/2017			3 - BGA bloom in progress	102800	<0.16	<0.5
7/25/2017			1a - Little or no BGA - clear water	30700	<0.16	<0.5
8/1/2017			1d - Little BGA - recreation not impaired	16700	<0.16	<0.5
8/8/2017			1d - Little BGA - recreation not impaired	46500	<0.16	<0.5
8/15/2017			1d - Little BGA - recreation not impaired	10900	<0.16	<0.5
8/22/2017			1c - Little or no BGA - other material present	0	<0.16	<0.5
8/29/2017			3 - BGA bloom in progress	288500	**0.43**	<0.5
9/6/2017			3 - BGA bloom in progress	777600	**0.52**	<0.5
9/12/2017			3 - BGA bloom in progress	3454000	**0.34**	<0.5
9/19/2017			3 - BGA bloom in progress	274000	**3.1**	<0.5
9/26/2017			3 - BGA bloom in progress	498000	**4.4**	<0.5
10/3/2017			3 - BGA bloom in progress	224000	**0.34**	<0.5
10/9/2017			1d - Little BGA - recreation not impaired	108700	<0.16	<0.5
6/27/2017	Lake Champlain	Alburgh Dunes State Park	1c - Little or no BGA - other material present	0	<0.16	<0.5
7/5/2017			1c - Little or no BGA - other material present	0	<0.16	<0.5
7/11/2017			1b - Little or no BGA - brown or turbid water	1930	<0.16	<0.5
7/18/2017			1c - Little or no BGA - other material present	79	<0.16	<0.5
7/25/2017			1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5

Report Date	Waterbody	Station	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (ug/L)	Anatoxin (ug/L)
8/1/2017	Champlain	Alburgh Dunes State Park	1d - Little BGA - recreation not impaired	0	<0.16	<0.5
8/8/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
8/15/2017			1d - Little BGA - recreation not impaired	0	<0.16	<0.5
8/22/2017			1d - Little BGA - recreation not impaired	4440	<0.16	<0.5
8/29/2017			1d - Little BGA - recreation not impaired	53	<0.16	<0.5
6/1/2017		High-gate Springs, VT	1b - Little or no BGA - brown or turbid water	0	not tested	
7/5/2017			1d - Little BGA - recreation not impaired	0		
7/20/2017			1d - Little BGA - recreation not impaired	0		
8/3/2017			1b - Little or no BGA - brown or turbid water	1170		
8/21/2017			1d - Little BGA - recreation not impaired	124		
9/8/2017			1d - Little BGA - recreation not impaired	18		
9/21/2017			2 - BGA present - less than bloom levels	225		
6/13/2017		LTM 02	1b - Little or no BGA - brown or turbid water	0	not tested	
7/6/2017			1b - Little or no BGA - brown or turbid water	6		
7/26/2017			1b - Little or no BGA - brown or turbid water	3		
8/4/2017			1b - Little or no BGA - brown or turbid water	0		
8/22/2017			1b - Little or no BGA - brown or turbid water	18		
9/11/2017			1b - Little or no BGA - brown or turbid water	2		
9/25/2017			1b - Little or no BGA - brown or turbid water	7		
6/13/2017		LTM 04	1b - Little or no BGA - brown or turbid water	0	not tested	
7/6/2017			1b - Little or no BGA - brown or turbid water	29		
7/26/2017			1b - Little or no BGA - brown or turbid water	280		
8/4/2017			1b - Little or no BGA - brown or turbid water	1120		
8/22/2017			1b - Little or no BGA - brown or turbid water	85		
9/11/2017			1b - Little or no BGA - brown or turbid water	29		
9/25/2017			1b - Little or no BGA - brown or turbid water	74		
6/8/2017		LTM 07	1c - Little or no BGA - other material present	0	not tested	
6/26/2017			1a - Little or no BGA - clear water	0		
7/14/2017			1b - Little or no BGA - brown or turbid water	15		
8/2/2017			1d - Little BGA - recreation not impaired	91		
8/16/2017			1d - Little BGA - recreation not impaired	3230		
9/7/2017			1d - Little BGA - recreation not impaired	272		
9/20/2017			1a - Little or no BGA - clear water	457		
6/8/2017		LTM 09	1a - Little or no BGA - clear water	0	not tested	
6/26/2017			1b - Little or no BGA - brown or turbid water	0		
7/14/2017			1b - Little or no BGA - brown or turbid water	35		
8/2/2017			2 - BGA present - less than bloom levels	31		
8/16/2017			1d - Little BGA - recreation not impaired	686		
9/7/2017			1d - Little BGA - recreation not impaired	88		
9/20/2017			1d - Little BGA - recreation not impaired	231		

Report Date	Waterbody	Station	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (ug/L)	Anatoxin (ug/L)
6/5/2017	Champlain	LTM 16	1a - Little or no BGA - clear water	1	not tested	
6/21/2017			1a - Little or no BGA - clear water	2		
7/11/2017			1a - Little or no BGA - clear water	9		
7/28/2017			1d - Little BGA - recreation not impaired	166		
8/7/2017			1d - Little BGA - recreation not impaired	75		
8/24/2017			1a - Little or no BGA - clear water	39		
9/12/2017			1d - Little BGA - recreation not impaired	149		
9/22/2017			1d - Little BGA - recreation not impaired	208		
6/5/2017		LTM 19	1a - Little or no BGA - clear water	0	not tested	
6/21/2017			1a - Little or no BGA - clear water	3		
7/11/2017			1a - Little or no BGA - clear water	0		
7/28/2017			1d - Little BGA - recreation not impaired	151		
8/7/2017			1d - Little BGA - recreation not impaired	41		
8/24/2017			1a - Little or no BGA - clear water	43		
9/12/2017			1d - Little BGA - recreation not impaired	198		
9/22/2017			1d - Little BGA - recreation not impaired	235		
6/5/2017		LTM 21	1a - Little or no BGA - clear water	1	not tested	
6/21/2017			1a - Little or no BGA - clear water	0		
7/11/2017			1a - Little or no BGA - clear water	25		
7/28/2017			1d - Little BGA - recreation not impaired	66		
8/7/2017			1d - Little BGA - recreation not impaired	333		
8/24/2017			1a - Little or no BGA - clear water	124		
9/12/2017			1d - Little BGA - recreation not impaired	358		
9/22/2017			1d - Little BGA - recreation not impaired	77		
6/9/2017		LTM 25	1a - Little or no BGA - clear water	33	not tested	
6/27/2017			1a - Little or no BGA - clear water	96		
7/17/2017			1a - Little or no BGA - clear water	73		
8/1/2017			1d - Little BGA - recreation not impaired	15		
8/17/2017			1a - Little or no BGA - clear water	112		
8/30/2017			1d - Little BGA - recreation not impaired	169		
9/14/2017			1a - Little or no BGA - clear water	270		
9/27/2017			1d - Little BGA - recreation not impaired	185		
6/12/2017		LTM 33	1a - Little or no BGA - clear water	0	not tested	
6/29/2017			1a - Little or no BGA - clear water	0		
7/19/2017			1d - Little BGA - recreation not impaired	36		
8/1/2017			1d - Little BGA - recreation not impaired	120		
8/10/2017			1d - Little BGA - recreation not impaired	42		
8/25/2017			1d - Little BGA - recreation not impaired	3		
9/14/2017			1d - Little BGA - recreation not impaired	0		
9/26/2017			1d - Little BGA - recreation not impaired	483		

Report Date	Waterbody	Station	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (ug/L)	Anatoxin (ug/L)
6/2/2017	Champlain	LTM 34	1a - Little or no BGA - clear water	0	not tested	
6/15/2017			1a - Little or no BGA - clear water	0		
6/27/2017			1a - Little or no BGA - clear water	19		
7/18/2017			1a - Little or no BGA - clear water	0		
7/31/2017			1d - Little BGA - recreation not impaired	3		
8/9/2017			1d - Little BGA - recreation not impaired	0		
8/31/2017			1d - Little BGA - recreation not impaired	78		
9/18/2017			1d - Little BGA - recreation not impaired	209		
9/29/2017			1d - Little BGA - recreation not impaired	167		
6/12/2017		LTM 36	1a - Little or no BGA - clear water	2	not tested	
6/29/2017			1a - Little or no BGA - clear water	17		
7/19/2017			1d - Little BGA - recreation not impaired	45		
8/1/2017			1d - Little BGA - recreation not impaired	87		
8/10/2017			1d - Little BGA - recreation not impaired	85		
8/25/2017			1d - Little BGA - recreation not impaired	59		
9/14/2017			1d - Little BGA - recreation not impaired	36		
9/26/2017			1d - Little BGA - recreation not impaired	757		
6/2/2017		LTM 40	1b - Little or no BGA - brown or turbid water	0	not tested	
6/15/2017			1a - Little or no BGA - clear water	0		
6/27/2017			1a - Little or no BGA - clear water	1		
7/18/2017			1d - Little BGA - recreation not impaired	101		
7/31/2017			1d - Little BGA - recreation not impaired	3200		
8/9/2017			2 - BGA present - less than bloom levels	1620		
8/31/2017			2 - BGA present - less than bloom levels	53400	<0.16	<0.5
9/18/2017			2 - BGA present - less than bloom levels	1670	<0.16	<0.5
9/29/2017			2 - BGA present - less than bloom levels	3710	<0.16	<0.5
6/14/2017		LTM 46	1a - Little or no BGA - clear water	0	not tested	
7/5/2017			1a - Little or no BGA - clear water	2		
7/20/2017			1a - Little or no BGA - clear water	36		
8/3/2017			1d - Little BGA - recreation not impaired	42		
8/21/2017			1d - Little BGA - recreation not impaired	13		
9/8/2017			1d - Little BGA - recreation not impaired	8		
9/26/2017			1d - Little BGA - recreation not impaired	173		
6/1/2017		LTM 50	1b - Little or no BGA - brown or turbid water	0	not tested	
6/14/2017			1a - Little or no BGA - clear water	16		
7/5/2017			1d - Little BGA - recreation not impaired	0		
7/20/2017			2 - BGA present - less than bloom levels	0		
8/3/2017			1b - Little or no BGA - brown or turbid water	0		
8/21/2017			1d - Little BGA - recreation not impaired	406		
9/8/2017			1d - Little BGA - recreation not impaired	174		

Report Date	Waterbody	Station	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (ug/L)	Anatoxin (ug/L)
9/21/2017	Champlain	LTM 50	2 - BGA present - less than bloom levels	547	not tested	
10/5/2017			2 - BGA present - less than bloom levels	628		
6/1/2017		LTM 51	1b - Little or no BGA - brown or turbid water	0	not tested	
6/14/2017			1d - Little BGA - recreation not impaired	26		
7/5/2017			1d - Little BGA - recreation not impaired	1710		
7/20/2017			1d - Little BGA - recreation not impaired	0		
8/3/2017			1b - Little or no BGA - brown or turbid water	0		
8/21/2017			2 - BGA present - less than bloom levels	1420	<0.16	<0.5
9/8/2017			2 - BGA present - less than bloom levels	0	<0.16	<0.5
9/21/2017			2 - BGA present - less than bloom levels	27900	<0.16	<0.5
10/5/2017			3 - BGA bloom in progress	3249300	**5.6**	<0.5
7/31/2017		North Beach	1a - Little or no BGA - clear water	0	<0.16	<0.5
6/26/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/3/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/10/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/17/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/25/2017			1a - Little or no BGA - clear water	133	<0.16	<0.5
8/7/2017			1a - Little or no BGA - clear water	800	<0.16	<0.5
8/14/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
8/21/2017			1c - Little or no BGA - other material present	0	<0.16	<0.5
8/28/2017			1a - Little or no BGA - clear water	427	<0.16	<0.5
9/5/2017			1a - Little or no BGA - clear water	1140	<0.16	<0.5
9/11/2017			1a - Little or no BGA - clear water	1730	<0.16	<0.5
6/26/2017		Red Rocks Beach	1a - Little or no BGA - clear water	0	<0.16	<0.5
7/3/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/10/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/17/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/23/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/31/2017			1a - Little or no BGA - clear water	1990	<0.16	<0.5
8/7/2017			1a - Little or no BGA - clear water	747	<0.16	<0.5
8/14/2017			1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5
8/21/2017			1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5
8/28/2017			1a - Little or no BGA - clear water	293	<0.16	<0.5
9/4/2017			1b - Little or no BGA - brown or turbid water	689	<0.16	<0.5
9/11/2017			1a - Little or no BGA - clear water	8080	<0.16	<0.5
6/26/2017		Ship-yard, High-gate Springs	1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5
7/4/2017			1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5
7/10/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/17/2017			1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5
7/24/2017			1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5

Report Date	Waterbody	Station	Bloom Intensity	Cyano-bacteria Density (cells/mL)	Micro-cystin (ug/L)	Anatoxin (ug/L)
7/31/2017	Champlain	Ship-yard, High-gate Springs	1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5
8/7/2017			1a - Little or no BGA - clear water	7200	<0.16	<0.5
8/14/2017			1a - Little or no BGA - clear water	8133	<0.16	<0.5
8/21/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
8/28/2017			3 - BGA bloom in progress	756800	**5.1**	<0.5
9/4/2017			1a - Little or no BGA - clear water	2530	<0.16	<0.5
9/11/2017			1a - Little or no BGA - clear water	960	<0.16	<0.5
10/3/2017			2 - BGA present - less than bloom levels	882300	**0.16**	not tested
6/27/2017		St. Albans Bay Park	1a - Little or no BGA - clear water	0	<0.16	<0.5
7/5/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/11/2017			1c - Little or no BGA - other material present	0	<0.16	<0.5
7/18/2017			1a - Little or no BGA - clear water	106700	<0.16	<0.5
7/25/2017			1a - Little or no BGA - clear water	6670	<0.16	<0.5
8/1/2017			1a - Little or no BGA - clear water	1760	<0.16	<0.5
8/8/2017			1d - Little BGA - recreation not impaired	7650	<0.16	<0.5
8/11/2017			3 - BGA bloom in progress	33200	<0.16	<0.5
8/14/2017			1b - Little or no BGA - brown or turbid water	2060	<0.16	<0.5
8/22/2017			1d - Little BGA - recreation not impaired	67300	<0.16	<0.5
8/29/2017			3 - BGA bloom in progress	216400	<0.16	<0.5
8/15/2017			3 - BGA bloom in progress	2060	<0.16	not tested
9/6/2017			3 - BGA bloom in progress	not tested	<0.16	not tested
9/19/2017			3 - BGA bloom in progress	45700	<0.16	not tested
9/26/2017			2 - BGA present - less than bloom levels	50800	<0.16	<0.5
10/3/2017			1d - Little BGA - recreation not impaired	36000	<0.16	<0.5
6/26/2017		Tri-Town Road, West Addison	1c - Little or no BGA - other material present	0	<0.16	<0.5
7/3/2017			1b - Little or no BGA - brown or turbid water	0	<0.16	<0.5
7/10/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/17/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/24/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5
7/31/2017			1d - Little BGA - recreation not impaired	10500	<0.16	<0.5
8/7/2017			1d - Little BGA - recreation not impaired	3280	<0.16	<0.5
8/14/2017			1d - Little BGA - recreation not impaired	560	<0.16	<0.5
8/21/2017			1a - Little or no BGA - clear water	93300	<0.16	<0.5
8/28/2017			1c - Little or no BGA - other material present	5410	<0.16	<0.5
9/5/2017			1c - Little or no BGA - other material present	462	<0.16	<0.5
9/11/2017			1a - Little or no BGA - clear water	0	<0.16	<0.5

Appendix D – Historical Microcystin Data for Lake Champlain

Lake Segment		2003	2004	2005	2006	2007	2008	2009	2010	2011
Inland Sea	median	0.05	0.41	0.08	0.27	0.05	1.10	0.07	0.03	0.08
	range	0.05 - 0.18	0.08-17.56	0.01-0.19	0.04-42.14	0.04 - 0.07	0.03-22.50	0.06-0.08	0.03 - 0.13	0.01-0.82
	#samples	6	8	8	16	4	11	2	3	9
	#stations	1	3	3	7	3	4	2	2	4
Main Lake Central	median	0.05	NA	7.42	NA	2.82	0.25	0.03	0.10	0.02
	range	0.01-0.12	NA	6.04-8.80	NA	0.02 - 5.61	0.03-0.47	0.03-23.36	0.02 - 0.14	0.01-0.03
	#samples	19	0	2	0	2	2	6	8	4
	#stations	4	NA	1	NA	2	2	3	5	4
Main Lake North	median	NA	NA	NA	NA	NA	NA	NA	NA	NA
	range	NA	NA	NA	NA	NA	1.56	0.03	NA	0.01
	#samples	0	0	0	0	0	1	1	0	1
	#stations	NA	NA	NA	NA	NA	1	1	NA	1
Main Lake South	median	NA	NA	0.04	NA	NA	NA	NA	NA	0.01
	range	0.07	NA	ND - 0.07	3.47	NA	NA	NA	NA	0.01
	#samples	1	0	2	1	0	0	0	0	2
	#stations	1	NA	1	1	NA	NA	NA	NA	2
St. Albans Bay	median	0.05	0.05	0.30	0.06	0.05	0.04	0.02	0.05	0.04
	range	0.01-0.41	ND - 22.48	0.06-0.82	0.01-0.43	0.02 - 0.54	0.02-0.12	0.01-0.17	0.01 - 0.80	0.02-0.14
	#samples	32	29	18	36	20	10	4	10	12
	#stations	1	2	1	2	4	3	2	3	2
Malletts Bay	median	NA	NA	NA	0.04	NA	NA	NA	NA	NA
	range	NA	NA	NA	0.04-0.08	NA	NA	NA	NA	0.04
	#samples	0	0	0	7	0	0	0	0	1
	#stations	NA	NA	NA	2	NA	NA	NA	NA	1
South Lake	median	0.96	NA	NA	NA	NA	NA	NA	NA	NA
	range	0.53-1.38	NA	0.01	NA	NA	NA	NA	NA	0.02
	#samples	2	0	1	0	0	0	0	0	1
	#stations	2	NA	1	NA	NA	NA	NA	NA	1
Missisquoi Bay	median	0.09	0.84	0.66	0.52	NA	2.56	0.54	0.03	0.65
	range	ND - 23.91	0.01-6490.06	ND - 22.11	0.01-21.29	NA	0.06-94.58	0.03-54.16	0.01 - 0.12	0.02-180.2
	#samples	341	228	146	152	0	81	29	10	59
	#stations	14	11	10	12	NA	10	8	7	8