VERMONT
ENVIRONMENTAL CONSERVATION

PRACTICE

Drinking Water and Groundwater Protection Division

Title	Process for Managing Microcystin Detections in Raw and Finished Water Samples for Public Surface Water Systems
Serial Number	2007-02
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Water Supply Rule Reference Subchapter	10.2.3

Purpose: To establish a process between the Department of Environmental Conservation (DEC), Department of Health (Health), Vermont Agricultural and Environmental Laboratory (VAEL), and public drinking water suppliers with surface water intakes for managing detections of toxins from cyanobacteria, specifically microcystin, in raw and finished water samples. Microcystin is not regulated by U.S. EPA or Health, but voluntary monitoring is warranted due to documented and potential health risks.

Keyword(s): harmful algal blooms, cyanobacteria, blue-green algae, cyanotoxins, microcystin, source water monitoring, unregulated contaminants, public notice requirements

Toxins Addressed by this Practice

Throughout this Practice, "microcystin" refers to Microcystin-LR (CAS:101043-37-2) and is reported as microcystin-LR equivalents. For more information on the health effects of cyanotoxins, see: http://healthvermont.gov/enviro/bg_algae/bgalgae.aspx.

Background

While Lake Champlain is primarily a recreational lake, it also serves as a drinking water source for 22 public water systems in Vermont. The increase of cyanobacteria blooms in Lake Champlain and health risks associated with ingestion have been of growing concern to public water systems relying on surface water as a source of drinking water. During the summer of 2007, the Drinking Water and Groundwater Protection Division (DWGPD) drafted the initial “PROCESS FOR MANAGING MICROCYSTIN DETECTIONS IN RAW AND FINISHED WATER SAMPLES FOR PUBLIC SURFACE WATER SYSTEMS” protocol. The protocol addressed finished water detections for anatoxin and microcystin levels exceeding 0.5 µg/L for systems that voluntarily chose to sample. The 2009 version of the protocol addressed finished water detections

for anatoxin or microcystin levels equal to or greater than 0.5 µg/L. In 2015, U.S. EPA established health advisories for microcystin (0.3 µg/L for bottle-fed infants and pre-school children and 1.6 µg/L for school-age children and adults) and cylindrospermopsin (0.7 µg/L for bottle-fed infants and small children and 3.0 µg/L for school-age children and adults). In the same year, Health issued health advisories, applicable to all populations, for microcystin (0.16 µg/L), anatoxin-a (0.5 µg/L), and cylindrospermopsin (0.5 µg/L). In 2024, the Vermont Health Advisory (VHA) for microcystin was changed to 0.3 µg/L to reflect the minimum reporting level (MRL) of 0.3 µg/L established by the Vermont Agriculture and Environmental Laboratory (VAEL) using EPA Method 546 validation.

In response to the establishment of state and federal health advisories, the cyanotoxin monitoring program was initiated in 2015 for the 22 Lake Champlain-sourced public water systems. Weekly sampling initially included analysis for both microcystin and cylindrospermopsin; however, cylindrospermopsin was not included in the 2016 season and was permanently removed from the program in 2018 due to funding issues and lack of confirmed detections.

In 2023, the program was expanded to include eight additional public water systems sourced by inland lakes, ponds, and reservoirs. Data collected from this program expansion will be leveraged to assess the vulnerability of inland systems to the effects of algae blooms and cyanotoxins.

The DEC Watershed Management Division, in cooperation with Health and the Lake Champlain Committee, conducts surface water sampling of Lake Champlain and other selected lakes under the umbrella of a lake-wide cyanobacteria monitoring program. Public surface water systems receive lake-wide data published in DEC Watershed Management Division email alerts. The ***Cyanobacteria Bloom Tracker***, an interactive map, is searchable by lake region and town.

I. Procedure for Routine Cyanotoxin Monitoring by Public Drinking Water Systems

Public drinking water systems sourced by Lake Champlain or by inland lakes, ponds, or reservoirs are encouraged to participate in weekly analysis of raw (source) and finished (treated) water samples for microcystin throughout the cyanotoxin monitoring program season. Historically, sampling has been conducted for 12 weeks, from early July to the end of September. In 2023, the sampling season was extended to 18 weeks, concluding in early November, in order capture the effects of late-season blooms.

The DWGPD, in conjunction with the Vermont Agriculture and Environmental Laboratory (VAEL), will provide test kits and relevant training for participating drinking water systems before the sampling season begins. Water systems will properly store the kits until sample collection. Each weekly sampling kit will include two 40 mL amber glass vials (for raw and finished water samples), labels, and a sampling sheet. Finished water sample vials will contain sodium thiosulfate at a concentration of 100 mg/L, following guidance from EPA method 546. Sodium thiosulfate is added to reduce residual chlorine and prevent further degradation of microcystin after the sample is collected.

On a weekly basis from early July to early November, water operators from each participating system will collect raw and finished water samples for microcystin analysis by enzyme-linked immunosorbent assay (ELISA) following EPA method 546. Water systems will keep samples chilled until they are picked up for delivery to VAEL by a DEC-contracted courier.

VAEL will lyse samples via three freeze-thaw cycles and filter samples prior to analysis. VAEL will initially analyze only the raw water sample from each system and will analyze the finished water sample only in the event of a microcystin detection at or above the Vermont Health Advisory level (VHA) in a raw water sample (see Sections II and III for more detail). VAEL will report all test results to the DWGPD when quality assurance and quality control (QA/QC) is complete, with results expected on the Monday following sampling. The Cyanobacteria Coordinator will review the test results upon receipt and email them promptly to participating systems, Health, and other stakeholders. The Cyanobacteria Coordinator will also post results to the ***Cyanotoxin Monitoring Program*** page of the DWGPD website.

II. Procedure for Initial and Confirmed Raw Water Detections

For microcystin level equal to or greater than 0.3 µg/L in raw water only

Initial Raw Water Detections - Notification of Personnel

In the event of a microcystin detection at or above the VHA of 0.3 µg/L in a raw water sample, VAEL will notify the DWGPD Cyanobacteria Coordinator, who will immediately alert the following personnel to the detection:

1) DWGPD Director, Drinking Water Program Manager, and Engineering and Water Resources Program Manager (via email)
2) Environmental Health Scientist responsible for cyanobacteria tracking program and State Toxicologist; alternate: Environmental Health Division (EHD) Director and designated Environmental Health Engineer (via email)
3) PWS Administrative Contact and Designated Operator (via phone and email)

Finished Water Sample Analysis and Immediate Resampling (Confirmation Samples)

If microcystin is detected at or above the VHA in a raw water sample, VAEL will immediately analyze the water system's finished water sample, with results expected on the Monday following sampling. VAEL will not wait for completion of QA/QC to run analysis of the finished water sample. VAEL will not be expected to remain open to analyze an initial finished water sample.

Once both raw and finished water QA/QC are complete, regardless of finished water results, the Cyanobacteria Coordinator will directly notify the PWS Administrative Contact and Designated Operator via phone and email that one confirmation raw water sample and one confirmation finished water sample must be collected immediately. If results are reported on a Friday with no finished water detection, confirmation sampling will instead be required the following Monday.

The Cyanobacteria Coordinator will contact the courier service via phone to initiate confirmation sample pick-up and delivery to VAEL. They will also notify the VAEL Biology Division Supervisor via phone and email that confirmation samples have been requested. Per agreement with VAEL, the lab will analyze both raw and finished confirmation samples on the day that they arrive (Monday-Friday, within reasonable opening hours). VAEL will not be expected to remain open over the weekend for confirmation sample analysis in the absence of a finished water detection. VAEL will report confirmation sample results to DWGPD when QA/QC is complete. No further action will be required of the water system until confirmation samples are analyzed and results are reported.

See "**III. Procedures for Initial and Confirmed Finished Water Detections**" for protocols in the event that the confirmation sample analysis validates the presence of microcystin at or above the VHA level in finished water.

Increase to Ongoing Monitoring

If confirmation sample analysis validates the presence of microcystin at or above the VHA level in raw water only, DWGPD staff will contact the water system within two (2) business days to obtain up-to-date, system-specific water quality parameters including pH, water temperature, and chlorine contact time. Based on these values, DWGPD will use the ***CyanoTOX® Version 3.0*** calculator to predict levels of microcystin in finished water. If finished water is predicted to be:

1) At or above 0.15 µg/L (one half of VHA):
   - Daily monitoring
2) Between 0.03 µg/L (an order of magnitude below the VHA) and 0.15 µg/L:
   - Twice weekly monitoring (Inland systems: Monday/Thursday; Lake Champlain systems: Tuesday/Thursday)
3) Below 0.03 µg/L:
   - Weekly monitoring (routine)

VAEL will have additional testing materials available, and DWGPD will ensure that the system receives necessary testing kits for ongoing monitoring. The Cyanobacteria Coordinator will call and email water system contacts, copying VAEL and Health, to document the requested monitoring.

Per consultation with Health, cyanotoxin detections in raw but not finished water will not warrant an emergency opening of the lab outside of normal business hours; therefore, VAEL will not be expected to conduct ongoing sample analysis on weekends in response to a detection in raw water only. In this case, sampling and analysis will resume the following Monday.

Cessation of Ongoing Monitoring

Ongoing monitoring may be reduced according to the standards outlined in "Increase to Ongoing Monitoring". Assuming no finished water detections, this means that a system will return to routine weekly sampling when the microcystin level in raw water drops below 0.3 µg/L or finished water microcystin level is predicted to be below 0.03 µg/L.

III. Procedure for Initial and Confirmed Finished Water Detections

For microcystin levels equal to or greater than 0.3 µg/L in finished water

Initial Finished Water Detections - Notification of Personnel

In the event of an initial microcystin detection at or above the VHA of 0.3 µg/L in a finished water sample, VAEL will notify the DWGPD Cyanobacteria Coordinator, who will immediately alert the following personnel to the detection:

1) DWGPD Director, Drinking Water Program Manager, and Engineering and Water Resources Program Manager (via phone and email)

2) Environmental Health Scientist responsible for cyanobacteria tracking program, and State Toxicologist; alternate: EHD Director and designated Environmental Health Engineer (via email)
3) PWS Administrative Contact and Designated Operator (via phone and email)

DWGPD staff will schedule a site visit to the water treatment plant within 1-2 business days. Treatment response will follow guidance described in the 6/12/2015 memo "Treatment Protocol for Water Systems Detecting Cyanotoxins" (see Appendix C).

Immediate Resampling (Confirmation Samples)

Per agreement with VAEL, the lab will remain open to analyze confirmation samples over the weekend in the case of a microcystin detection above the health advisory in the finished water. Confirmation samples will be delivered to VAEL by the courier or water system on the same day as collection.

If the courier is unable to transport the sample (e.g., weekend, holiday), the water system will be responsible for transport.

Increase to Daily Monitoring

If confirmation sample analysis shows any detection of microcystin in finished water, the system will monitor for microcystin daily. The DWGPD Cyanobacteria Coordinator will call and email the water system, copying VAEL and Health, to document the requested monitoring.

Cessation of Daily Monitoring

Daily monitoring may be discontinued when microcystin is no longer detected in finished water and further relevant conditions outlined in **II. Procedures for Initial Raw Water and Confirmed Raw Water Detections** are met, unless otherwise advised by DWGPD.

IV. Procedure for Watershed Management Division Support

On an as-needed basis, the Cyanobacteria Coordinator will contact the Watershed Management Cyanobacteria Monitoring Lead to discuss technical assistance to DWGPD's detection response. This assistance may include conducting cell counts on raw water samples, sharing expertise on localized lake conditions (e.g., thermocline depth, internal seiche dynamics), and/or coordinating open water sampling at the system intake.

V. Procedure for Public Notice

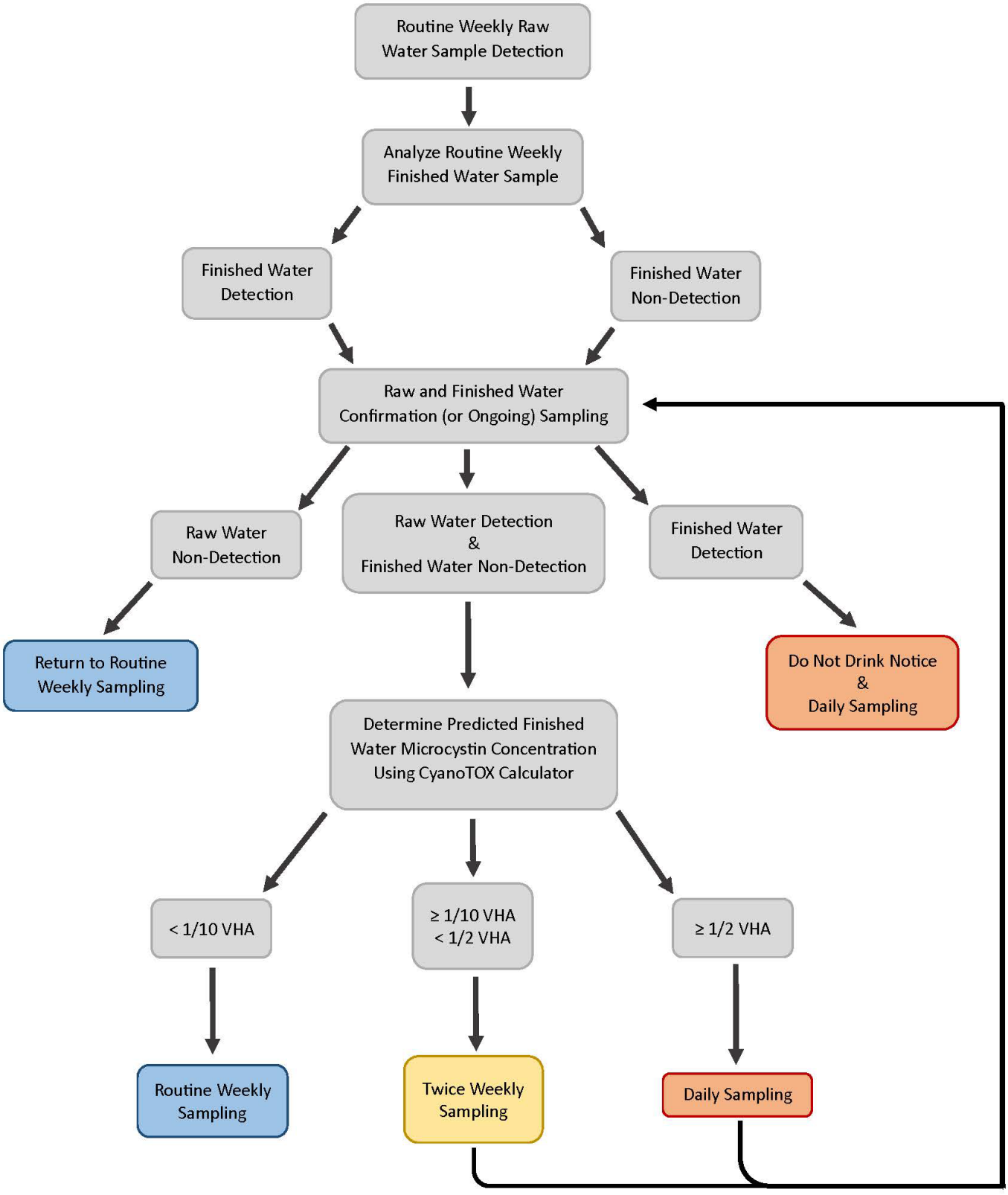
After becoming aware of a confirmed finished water microcystin concentration exceeding the VHA, and per agreement between Health and DEC, the water system shall provide a Do Not Drink (DND) notice (see Appendix D for template) that meets the requirements of Section 10.2.23 of the Vermont Water Supply Rule to every affected consumer. This notice shall be issued as soon as possible and not more than 24 hours after confirmation sample results are received. All correspondence between the DWGPD and public water systems regarding case-specific public notification requirements shall be copied to the Health State Toxicologist and Environmental Health Scientist.

Consumer Confidence Report. For all community water systems, the DWGPD requires that all confirmed finished water microcystin detections be referenced in the annual Consumer Confidence Report.

Operational Response: The water system will notify DWGPD at 802-261-5749 (Cyanobacteria Coordinator) when the emergency response plan (ERP) is activated.

Protection of Public Health and Welfare. Water systems with cyanotoxin concentrations chronically exceeding health advisories may, at the discretion of the Secretary in accordance with Subchapter 21-6 (Health Advisories) and Subchapter 21-1 (Authority and Purpose) of the Water Supply Rule, be required to provide treatment or to modify the drinking water system infrastructure in order to protect public health or welfare.

Appendix A
Cyanotoxin Monitoring Program Detection Procedures



Appendix B
Cyanotoxin Monitoring Directory

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Appendix C
Treatment Protocol for Water Systems Detecting Cyanotoxins

To: The Record
From: Ray Solomon
Subject: Treatment Protocol for Water Systems Detecting Cyanotoxins
Date: 6-12-2015

This memo will describe a water treatment action plan that can be used by any Vermont water system that detects cyanotoxins in either raw or finished water. Currently, the plan will apply to 20 of the surface water systems that draw water from Lake Champlain, as well as eight inland systems with lake, pond, or reservoir sources. The process is following treatment practices as described by EPA's Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water (June 2015).

Voluntary weekly testing for cyanotoxins (microcystins) will commence in July at these systems' surface water treatment plants. These plants employ three different types of filtration. Twenty four utilize rapid sand filtration. Two use slow sand filtration and four use 1-micron absolute cartridge filtration. All systems use chlorination for primary disinfection and all but one use chlorination for secondary disinfection. Champlain Water District uses monochloramination. Because the overall treatments are similar, the plan will discuss modifications that may be necessary for each type of filtration and disinfection. It will not describe, in detail, the specifics and peculiarities of each individual treatment plant and how these factors might influence treatment modifications. These specifics will, of course, come into play if cyanotoxins are detected.

There are some general treatment principles that are well documented and generally agreed upon by drinking water treatment professionals. Taking these into account, the treatment modifications recommended in this plan are based on the following assumptions:

1. All three types of filtration, when working properly, are effective at removing intact algal cells. Only slow sand filtration is effective in removing dissolved toxins.

2. Avoiding algal cell lysis is important since dissolved cyanotoxin removal cannot be achieved by either rapid sand or cartridge filtration.

3. Chlorine will oxidize cylindrospermopsin and microcystin. Increasing CT (chlorine concentration in milligrams per liter multiplied by time in minutes) before the first customer will increase the rate of oxidation of these two toxins. Lower pH and higher temperature will enhance this effect. A CT table, similar to the table used to evaluate giardia cyst inactivation by disinfection, has been developed for microcystin and can serve as a guideline for increasing the chlorine dose.

4. Chlorine is not effective in oxidizing anatoxin-a. Permanganate is effective. A CT table for permanganate inactivation of anatoxin-a has been developed and can be used as a guide for permanganate dose. Dose must be controlled to avoid "pink water."

5. Cell lysing may be accelerated by pre-oxidation (oxidation before filtration). Pre-oxidants currently used in Vermont are either permanganate or chlorine.

6. Cell lysing may increase with longer detention times in filters and sedimentation basins.

7. Recycling backwash supernatant may increase toxin concentration in the raw water. (As of 2023, no surface water treatment plants in Vermont are doing this).

8. Effective treatments for cyanotoxins include ozonation, powdered activated carbon (PAC) and granular activated carbon (GAC). Of the Lake Champlain treatment plants, only Burlington has PAC capability, and it is almost never used. No plant currently uses ozone or GAC. Grand Isle Consolidated has installed GAC filtration for DBP precursor control.

TREATMENT PROTOCOLS

If a cyanotoxin is detected and confirmed, at any level, in a raw water sample, but not in the finished water, pre-oxidation, coagulation, filtration, disinfection, and all other relevant treatment processes will be reviewed to ensure effective treatment. Depending on the concentration of cyanotoxin in the raw water, modifications may be necessary. These modifications are elaborated in the following section, dealing with detection of toxin in the finished water.

If a cyanotoxin is detected and confirmed, at any level, in finished water, the following actions will take place:

1. Pre-oxidation using chlorine should be minimized or entirely halted in order to reduce cyanobacteria cell lysis before filtration. Use of permanganate as a pre-oxidant will be evaluated on a case-by-case basis given its efficiency in oxidizing anatoxin. If continued, permanganate pre-oxidation dose should be carefully considered to minimize risk of cell lysis.

2. For rapid sand filtration plants, coagulant type and dose will be reviewed to ensure optimum turbidity removal through the filters. Parameters used for evaluation will be turbidity, pH and UVA. Procedures may include jar tests, column tests and full plant dose response tests. Filtration rate will be ascertained, and the rate may be lowered, if practical, to minimize breakthrough of coagulated material. Backwash procedure will be reviewed to make sure that no turbidity breakthrough through the filters occurs before backwash, backwash rate is sufficient to fluidize the bed, backwash time is sufficient to clean the bed, time between backwash is minimized to reduce lysing of intact algal cells retained by the filters and filter to waste time, after backwashing is adequate to minimize turbidity spikes.

3. For slow sand filtration plants, filter rate will be ascertained and minimized to the greatest extent possible. This will enhance algal cell removal. Retention time of algal cells in the filter bed is much longer than in rapid sand filters. Cell lysing may be an issue in the filter bed. On the other hand, biological treatment, which commonly occurs in a slow sand filter bed may degrade dissolved toxins. Premature filter scraping (the most common method of cleaning slow sand filters) will disrupt the biological mat and result in the filter being taken offline until a new mature mat develops. We may need to test for the level of both dissolved and intracellular toxin before and after filtration (but before chlorination) in order to determine whether the filter should be cleaned.

4. For 1-micron absolute cartridge filtration systems, filter rate will be measured and reduced to the maximum extent possible. This should enhance algal cell removal. Headloss through the membrane will be measured to insure there are no breaks in the membrane. As in the case of slow sand filters, retention of material on the filter is much longer than is the case for rapid sand filters. The filter cartridges are not backwashed, but simply replaced when headloss becomes too great. Testing for dissolved and intracellular toxins may be necessary to document if this is a problem. If a problem is suspected, filter cartridges should be replaced and a round of testing done to evaluate the effect. In any case, cartridges may be replaced to ensure the structural integrity of the membrane.

5. Post filtration primary disinfection with chlorine will be assessed with enhanced oxidation of toxins in mind. Chlorine residual entering the distribution system is usually a balancing act. There must be sufficient residual to meet CT requirements of the SWTR and to maintain a detectable residual at the far ends of the distribution system. On the other hand, residual should be minimized to lower the formation

of disinfection byproducts, over time, in the distribution system. Assuming that cyanotoxin contamination of the finished water is a temporary issue, chlorine residual will be raised to a level deemed appropriate by DWGPD and the plant operator. A quantitative test may be done to ascertain the level needed to sufficiently lower the toxin level in finished water. This would be a bench test that exposed filtered water to progressively higher CT levels. At specific increments of CT, samples would be analyzed for the presence of the detected cyanotoxin. Test results would be used to set the optimum level of CT.

The evaluation and modification of treatment plant processes that have been listed can be instituted rapidly with little additional cost. If more extensive modifications or a new treatment is necessary, a much more extensive plan would be needed. Ozone, PAC, GAC, intake relocation or other capital-intensive treatments might be required.

Appendix D
Microcystin Do Not Drink (DND) Notice Template

IMPORTANT INFORMATION ABOUT YOUR DRINKING WATER

DO NOT DRINK the Water

[Enter Water System Name], VT00XXXXX is Contaminated with the Cyanotoxin Microcystin

Our water system has levels above the microcystin state drinking water health advisory level. As water system users, you have a right to know what you should do, what this means, and what is being done to correct the situation.

Due to the potential for impact to human health, the Vermont Department of Environmental Conservation and the Vermont Department of Health recommend that you do not drink the water or use it for cooking, brushing teeth, making ice cubes, making baby formula or washing fruits and vegetables. Pets and animals should not drink the water.

What happened?

We routinely monitor for the presence of drinking water contaminants. A sample collected on [Enter Date] shows microcystin at [Enter Level] micrograms per liter (µg/L). The state health advisory level for microcystin is 0.3 µg/L.

[Enter Surface Water Source], which is a source of drinking water for the [Enter Water System] is experiencing a cyanobacteria bloom (also known as blue-green algae bloom) near the intake that serves the water system. The cyanobacteria bloom is producing the toxin microcystin, which poses an immediate risk to human and animal health. This means anyone or any animal that drinks the water can get sick right away.

What should I do?

- You can use bottled water or water from an alternative source with microcystin levels below 0.3 µg/L.
- Do not boil your water. Boiling the water will not remove microcystin and may concentrate it.
- You can use the water for showering, bathing, and washing clothes and dishes. Try to limit the amount of water children swallow while bathing.

What does this mean?

Consuming water containing microcystin at levels above 0.3 µg/L can put you at immediate risk of various negative health effects. Soon after drinking or consuming the water, you or your pets may have an upset stomach, vomiting or diarrhea. Other health effects include liver and kidney damage. If you are having any adverse health effects due to microcystin, contact your health care provider.

What is being done?

Because microcystin can make people sick, the Vermont Department of Environmental Conservation (DEC) has required us to provide this Do Not Drink notice to all users of the water system. This Do Not Drink notice remains in effect until further notice.

We are conducting additional monitoring of your drinking water and we will notify you when the situation has been resolved.

[Additional steps the water system is taking detailed here]_____
_____
_____
_____

For more information from the system, please contact [Enter Contact Person] at [Enter Contact Phone].

For questions regarding the health effects of cyanotoxins, contact the Vermont Department of Health at 1-800-439-8550 or visit www.healthvermont.gov/cyanobacteria.

You may also contact the Drinking Water and Groundwater Protection Division at 802-828-1535 or visit www.dec.vermont.gov/water/drinking-water/water-quality-monitoring/cyanobacteria.

Please share this information with all who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing by hand.

CERTIFICATION FORM (VT00XXXXX) [Enter Water System Name]

Method(s) of Distribution: _____ Date Distributed: _____
(e.g. hand or direct delivery, posting[1], television, radio)

I _____(print name) Certify, as the Responsible Person (or authorized representative) of the water system listed above that this public notice has been provided to customers in accordance with the delivery, content, and format requirements and deadlines in the Vermont Water Supply Rule (Chapter 21, Subchapter 21-10).

Signature: _____Date: _____

Within 10 days of issuance of public notice, send a copy of the notice to:
VT-DEC, Drinking Water and Groundwater Protection Division, 1 National Life Drive – Davis 4
Montpelier, VT 05620-3521

1 - Community Water Systems may use posting as a second method, but must also use radio, television, or hand or direct delivery.