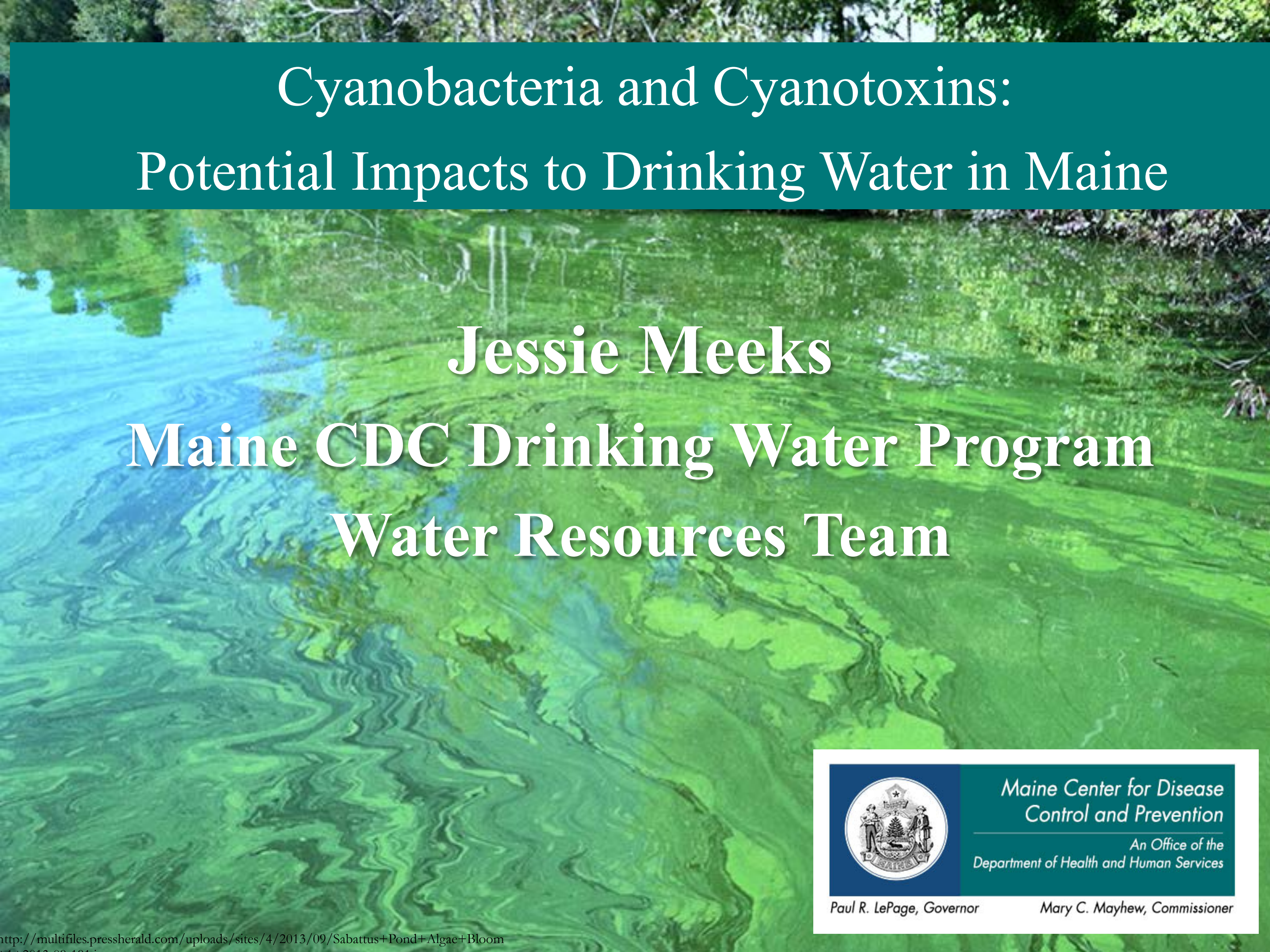
Cyanobacteria and Cyanotoxins: Potential Impacts to Drinking Water in Maine



Jessie Meeks

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Water Resources Team

ttp://multifiles.pressherald.com/uploads/sites/4/2013/09/Sabattus+Pond+Algae+Bloom

Maine Center for Disease Control and Prevention

An Office of the Department of Health and Human Services

Paul R. LePage, Governor

Mary C. Mayhew, Commissioner

Impacts of Cyanotoxins on Drinking Water Systems

CLEAN WATER ACTION
CLEAN WATER FUND

Increasingly, water systems are monitoring for and addressing cyanotoxins and the algal growth that can cause their formation. Some cyanotoxins are on EPA's list of drinking water contaminants of concern. In 2016, EPA published "Health Advisories" for two cyanotoxins.

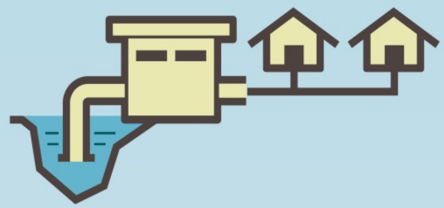
WATER SOURCE → DRINKING WATER SYSTEM → DRINKING WATER

WATER SOURCE

Source water indicators for cyanobacteria:

- Is it affected by drought?
- Are the odors and colors off?
- Does the water stratify thermally?
- Is there an algae growth?
- Is the water stagnant?

DRINKING WATER SYSTEM



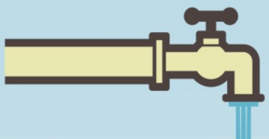
How to prepare and monitor for blooms:

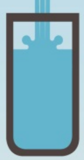
- Initiate more frequent and specific monitoring
- Draw water from multiple depths and locations
- Adjust treatment to specifically remove and destroy cyanobacteria and cyanotoxins

Effects of cyanotoxins on water treatment:

- Treatment for cyanobacteria can increase production of harmful byproducts if cyanotoxins are present in the bacteria
- Treatment selection is context-specific and can be difficult to determine

DRINKING WATER





If left untreated, cyanotoxins can lead to:

- Off tastes and odors in the water; not necessarily a health threat if present
- Public health threats
- Increase in water rates due to additional treatment costs

http://www.cleanwateraction.org/features/harmful-algal-blooms-and-drinking-water

Health Impacts of Cyanotoxins

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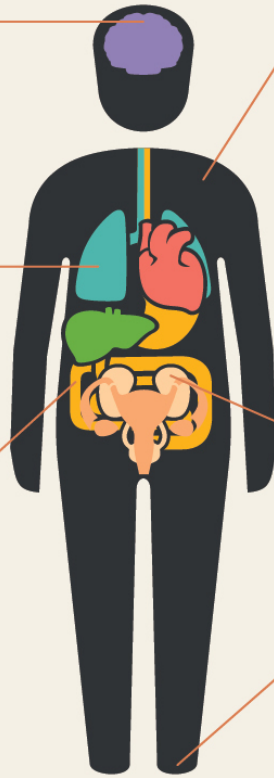
Note: *Not all cyanotoxins lead to all of these health impacts. These listed impacts are caused by microcystins or cylindrospermopsin, the two cyanotoxins that EPA has issued Health Advisories for.*

IN HUMANS



Brain
Source: Ingestion
Symptoms:
- Headache
- Incoherent speech
- Drowsiness
- Loss of coordination

Respiratory System
Source: Inhalation
Symptoms:
- Dry cough
- Pneumonia
- Sore throat
- Shortness of breath
- Loss of coordination

Digestive System
Source: Ingestion, drinking contaminated water, or eating contaminated fish
Symptoms:
- Abdominal pain
- Nausea
- Vomiting
- Diarrhea
- Stomach cramps

Body
Source: Contact, e.g. swimming
Symptoms:
- Irritation in eyes, nose, and throat
- Blistering around the mouth
- Skin rash, including tingling, burning and numbness
- Fever
- Muscle aches (from ingestion)
- Weakness (from ingestion)

Organs
Source: Ingestion
Symptoms:
- Kidney damage
- Abnormal kidney function
- Liver inflammation

Nervous System
Source: Ingestion
Symptoms:
- Tingling
- Burning
- Numbness

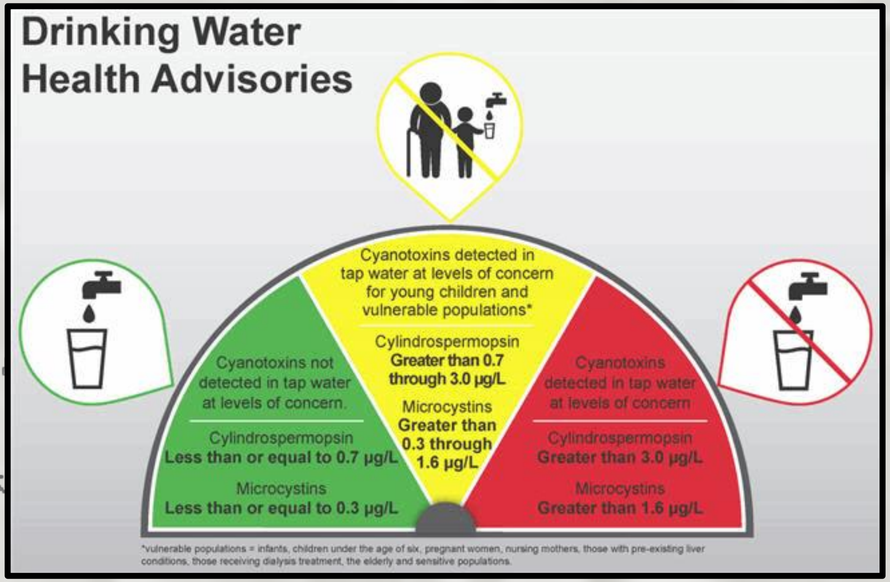
IN PETS

Symptoms:
Vomiting
Fatigue
Shortness of breath
Difficulty breathing
Coughing
Convulsions
Liver failure
Respiratory paralysis leading to death

http://www.cleanwateraction.org/features/harmful-algal-blooms-and-drinking-water

Regulatory Framework

- No Drinking Water Standards (Federal or State).
- EPA has issued 10-Day Drinking Water Health Advisories (HAs) for **microcystins** and **cylindrospermopsin**:
  - For children < 6 years old, recommended HA levels at or below **0.3 µg/L** for microcystins and 0.7 µg/L for cylindrospermopsin in drinking water
  - For school-age children through adults, the recommended HA levels for drinking water are at or below **1.6 µg/L** for microcystins and 3.0 µg/L for cylindrospermopsin.
- WHO Guideline is **1 µg/L** for microcystin-LR.
- Proposed UCMR 4 (12/11/2015) includes ten new Cyanotoxin Chemical Contaminants and recommended testing methods.



https://www.wateronline.com/doc/epa-speaks-for-utilities-on-cyanotoxins-0001

Proposed Fourth Unregulated Contaminant Monitoring Rule Assessment Monitoring for Cyanotoxins

Contaminant	CAS Registry Number[1]	Minimum Reporting Level	Sampling Points[2]	Analytical Methods
total microcystin	N/A	0.3 µg/L	EPTDS and SR	ELISA Exit
microcystin-LA	96180-79-9	0.008 µg/L	EPTDS	EPA 544
microcystin-LF	154037-70-4	0.006 µg/L	EPTDS	EPA 544
microcystin-LR	101043-37-2	0.02 µg/L	EPTDS	EPA 544
microcystin-LY	123304-10-9	0.009 µg/L	EPTDS	EPA 544
microcystin-RR	111755-37-4	0.006 µg/L	EPTDS	EPA 544
microcystin-YR	101064-48-6	0.02 µg/L	EPTDS	EPA 544
Nodularin	118399-22-7	0.005 µg/L	EPTDS	EPA 544
anatoxin-a	64285-06-9	0.03 µg/L	EPTDS	EPA 545
cylindrospermopsin	143545-90-8	0.09 µg/L	EPTDS	EPA 545

EPA Method 544 is LC/MS/MS (liquid chromatography/tandem mass spec)
For anatoxin-a and cylindrospermopsin, use Method 545 LC/ESI-MS/MS . ESI is "electrospray ionization".

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Senator George J. Mitchell
Center for Sustainability Solutions

Objectives: to determine what risks cyanobacteria pose public water suppliers using surface water sources have in Maine.

1. Analyze Data for Multi-Year Water Quality Trends.
2. Document Site Specific Bloom History.
3. Field Data Collection.
4. Generate a Site Specific Risk Profile.
5. Establish HAB Monitoring Protocol.

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Objective 2: Document Site Specific Bloom History

- Have blooms occurred recently?
- What type of bloom?
- What the conditions when the blooms occurred?
- What actions were needed to handle the bloom?

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Objective 2: Document Site Specific Bloom History

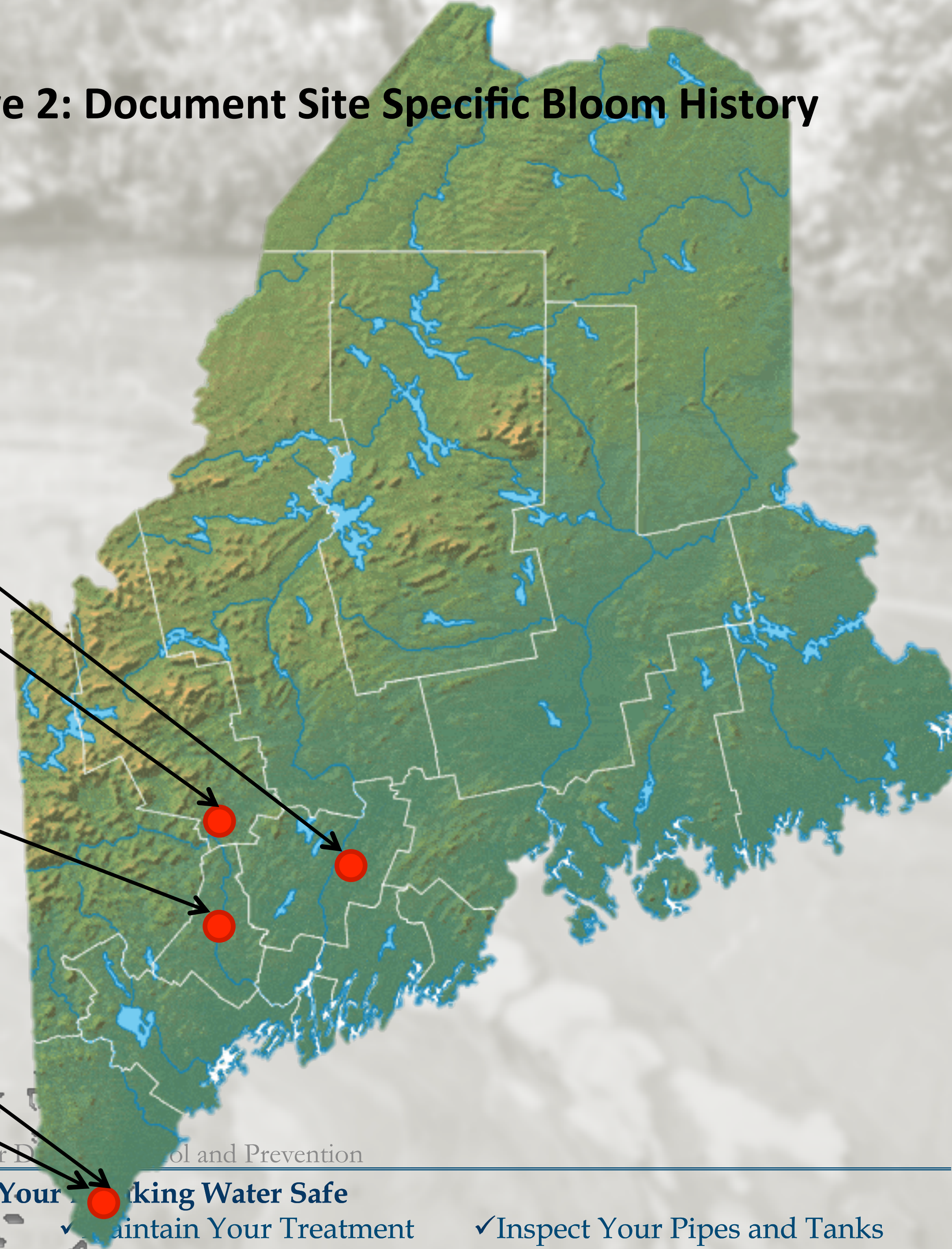
China Lake
- Kennebec Water District

Moose Hill Pond
- Livermore Falls Water District

Lake Auburn
- Auburn Water District

Chase Pond
- York Water District

Bell Marsh Reservoir
- Kittery Water District



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Objective 2: Document Site Specific Bloom History

Source: Moose Hill Pond – Livermore Falls Water District

Type: Cyanobacteria – Anabeana

Conditions: Plenty of rain, bloom occurred in source during the fall and continued under ice in the absence of snow (clear ice)

When: September - December, 2010

Actions: Cleaning slow sand filter daily, switched to use of alternative source, daily sampling, hired consulting firm to determine alternate treatment processes in the case of repeat incident, investigate alternative sources and found good source but could not access due to town politics.

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Objective 3: Treatment Process Analysis

- 23 water districts have the ability to mitigate algae and/or toxins.

System Name/ID	Jackman Utility District ME:0090880	System Cyanobacteria Removal Capability Assessment
Pre-Treatment	Micro flocc Upflow clarifier – plastic bead media	Effective Removal of Intracellular Toxin – Backwash will need to be frequent enough to prevent toxin releases
Filtration	Rapid Sand Filter Garnet Anthracite & sand Backwash every 6 hour – no recycle	Effective Removal of Intracellular Toxin - the combination of flocculation and rapid sand filtration increases the efficacy of this system – backwash is frequent enough to prevent toxin releases
Disinfection I	NaClO 4 mg/L	Effective Extracelular Toxin Oxidant – Hypochlorite levels will likely require an increase during a bloom event to successfully degrade toxins
Disinfection II	---	---
Additions to Finished Water	Soda Ash pH 8	
System Capable: Yes		

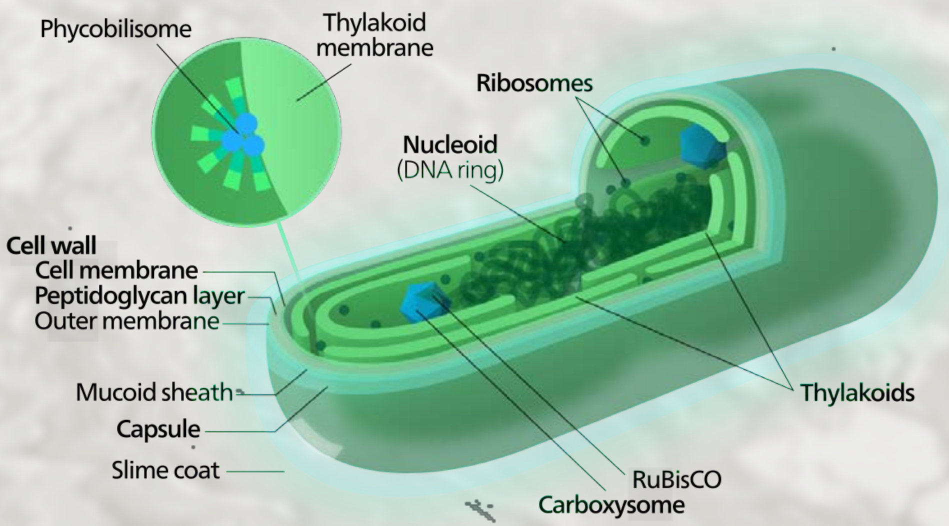
How are Cyanotoxins Removed from Drinking Water?

Intracellular Toxin

- toxins produced within the cyanobacterial cells remain inside the cells as long as they are healthy

Extracellular Toxin

- the water soluble toxin outside of healthy cells



http://www.turdak.com/siyanobaktericyanobacteria-tedavisinde-akilci-antibiyotik-kullanimi/

How are Cyanotoxins Removed from Drinking Water?

Intracellular Toxin

- The goal of intracellular toxin removal is to remove the majority of the toxin from the water by removing whole cells containing the toxin without lysing or otherwise rupturing cells. There are several methods available to remove the whole cells with varying degrees of efficacy.

Sedimentation

- Via alum or lime

Dissolved Air Flotation

- Via flocculation

Slow Sand Filtration

- highly effective

Rapid Filtration – Granular Activated Carbon/Sand

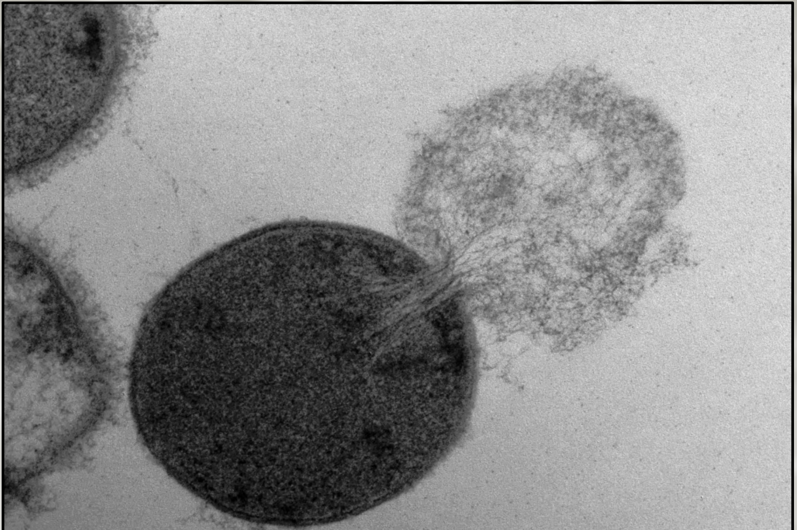
- less effective than slow sand filtration

http://www.turdak.com/siyanobaktericyanobacteria-tedavisinde-akilci-antibiyotik-kullanimi/

How are Cyanotoxins Removed from Drinking Water?

Extracellular Toxin

- Extracellular toxin removal must be degraded.



http://www.news.gatech.edu/2013/01/09/study-quantifies-size-holes-antibacterials-create-cell-walls-kill-bacteria

Chlorine

- sodium hypochlorite (degrade)

***Potassium Permanganate* (degrade)**

Chloramine

- *not great*

UV Radiation

- *not practical due to demands*

Powdered Activated Carbon (PAC)

- very effective at removing cyanotoxins

Granular Activated Carbon (GAC)

- most effective against microcystins as opposed to anatoxins or cylindrospermopsins

Ozone

- capable of degrading all types of cyanotoxins

Preliminary results have indicated that Cyanotoxins are present at low concentrations in many of Maine's lakes and ponds that serve as public drinking water supplies.

What Next?

Monitor 6 systems throughout the summer and fall of 2017

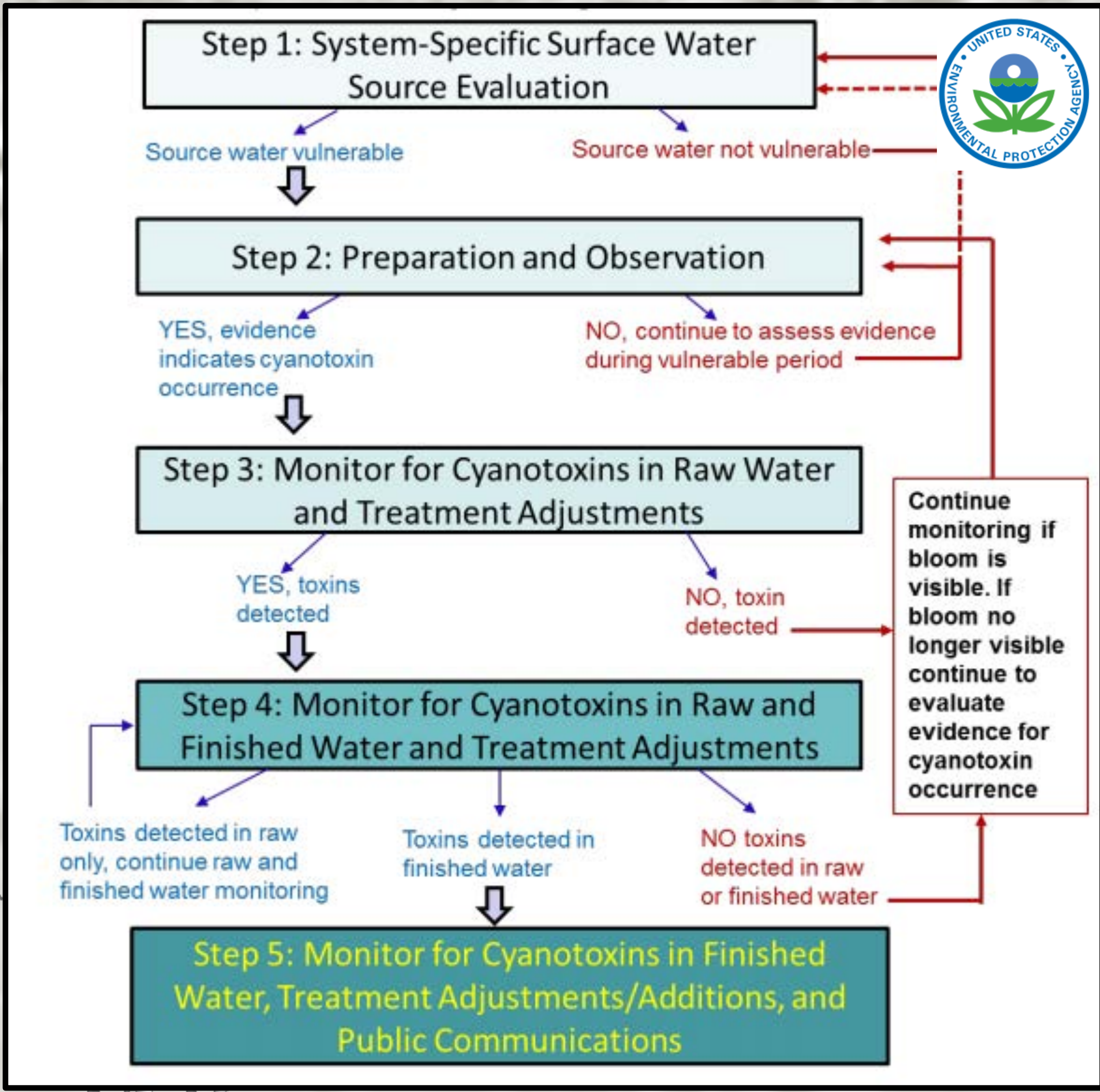
- Monthly to weekly grab samples of raw and treated water.
- Solid Phase Adsorption Toxin Tracking (SPATT)

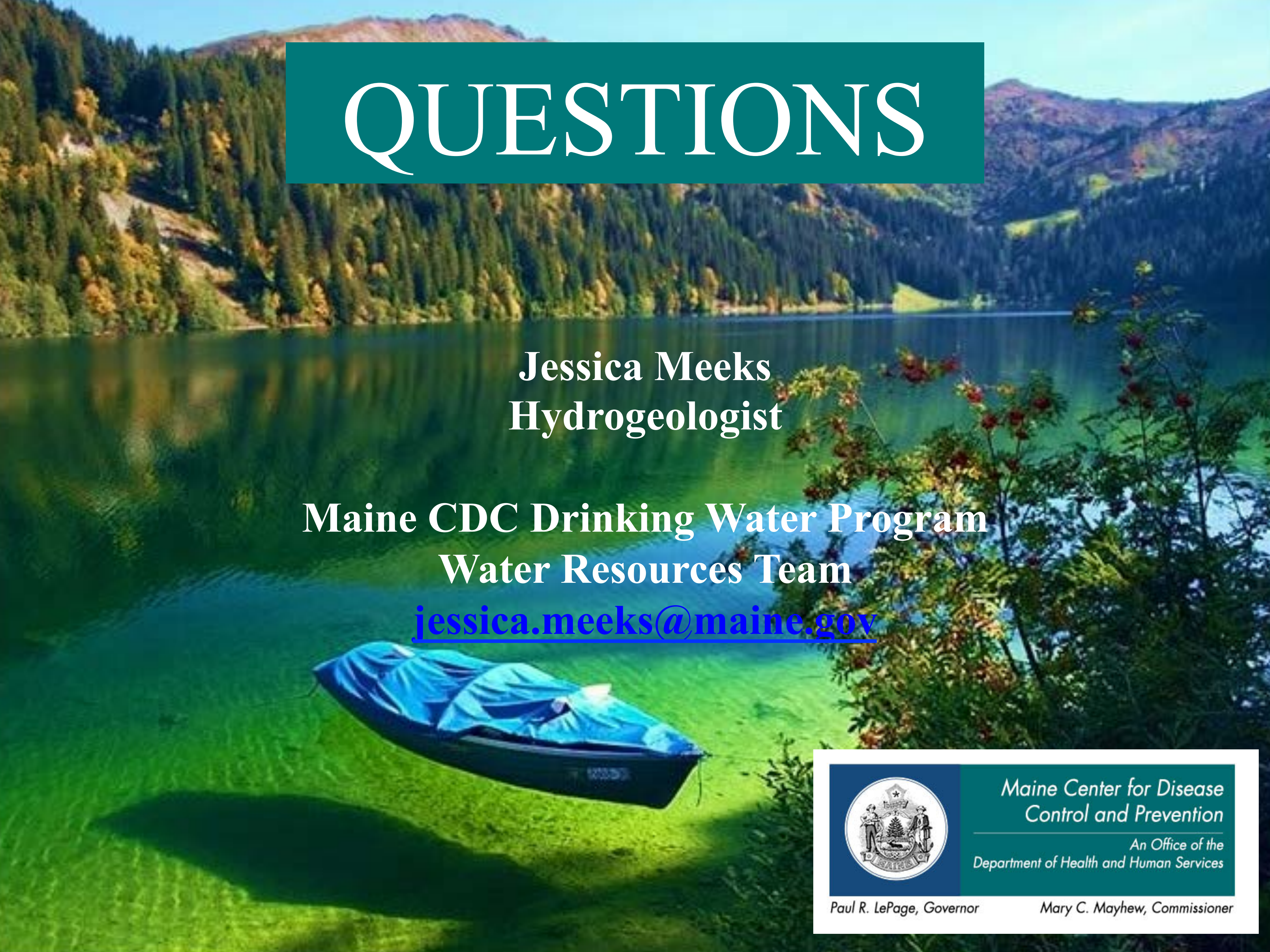
What Next?

Longer term:

- Adopted Maximum Contaminant Levels (MCLs) for certain cyanotoxins (e.g., microcystin-LR, anatoxin-a, cylindrospermopsin, saxitoxin)

- Formalize approach to determining whether cyanotxins are in drinking water.





QUESTIONS

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