City of Salem: Watershed Program HABs Monitoring and Response


Mt. Jefferson


Blow Out Arm

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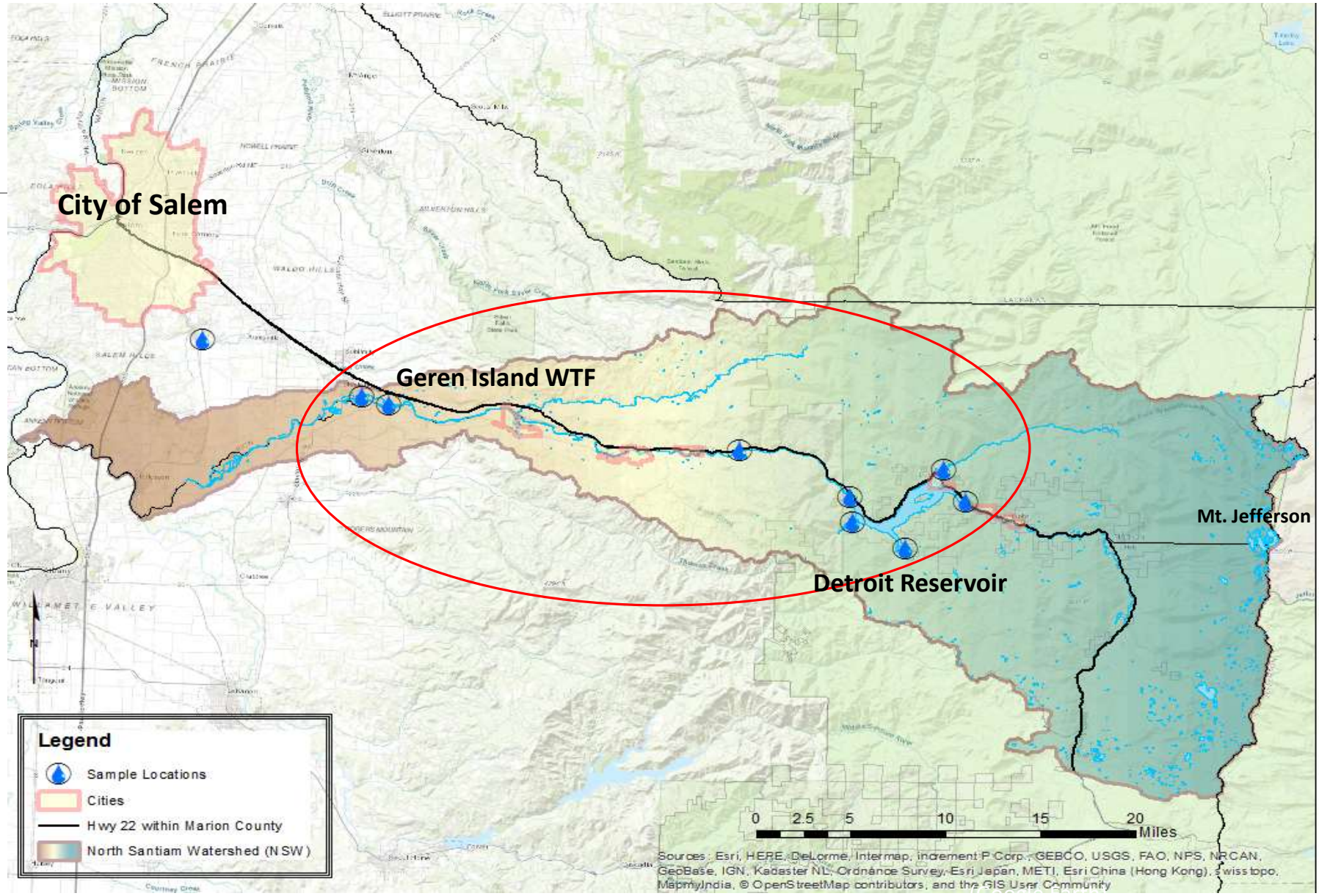
Salem's Drinking Water Source and System

The North Santiam River Watershed

- Large, mostly-forested watershed (500,000 + acres)
- 92 mile tributary of the Santiam River; high quality source water
- No City land ownership
- Two-thirds publicly owned
- Dams/reservoirs
- Major transportation corridor



Brief History of Salem's Drinking Water

1935 – Salem City Council buys the Oregon Washington Water Company for $1,000,000; acquired 1856 water rights to 154 million gallons/day near Stayton

1936 – Fairmount Reservoir was built; First transmission line was constructed

1937 – Source shift from Willamette River to the North Santiam River

1952 – Construction of Franzen Reservoir begins

1953 – Detroit Dam (400ft) and Big Cliff construction is finished

1956 – Slow Sand Filtration selected as treatment

1958 – First 5-acre slow sand filter was built

1958 – Second transmission line was constructed

1970 – Second 5-acre slow sand filter was built

1987 – Official name change to Geren Island

Sand screen facility looking upstream on Geren Island, 1956.
(Oregon State Archives, Ben Maxwell Collection, 1075)

Salem's Water System

1- River

2- Pre-treatment

3-Filtration

4- Disinfection & Fluoridation

5- Corrosion Control

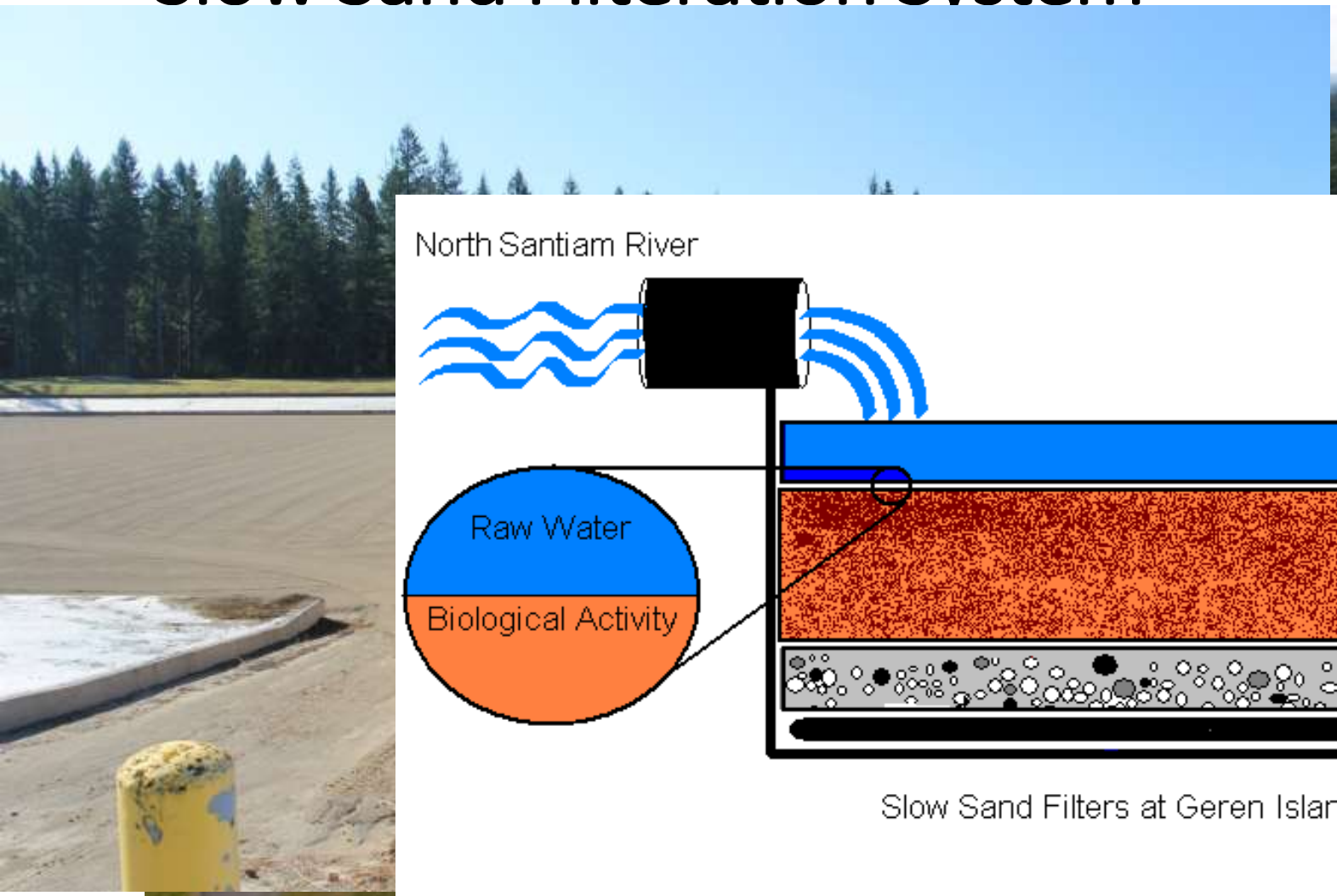
6- Delivery

Middle Intake – City of Salem's Diversion

Drinking Water Treatment: Slow Sand Filtration

- Highly effective on removal of particulates, microbial contaminants, algae and toxins
  - Schmutzdecke biological layer - “good” bacteria, fungi, protozoa, and aquatic insects
  - Filters rotated roughly every month and half
- No detected issues post-treatment
  - Can sample filter effluents
- Once filtered, effluent is piped to treatment facility
  - Chlorine
  - Fluoridation
  - Soda Ash

Slow Sand Filteration System



Distribution

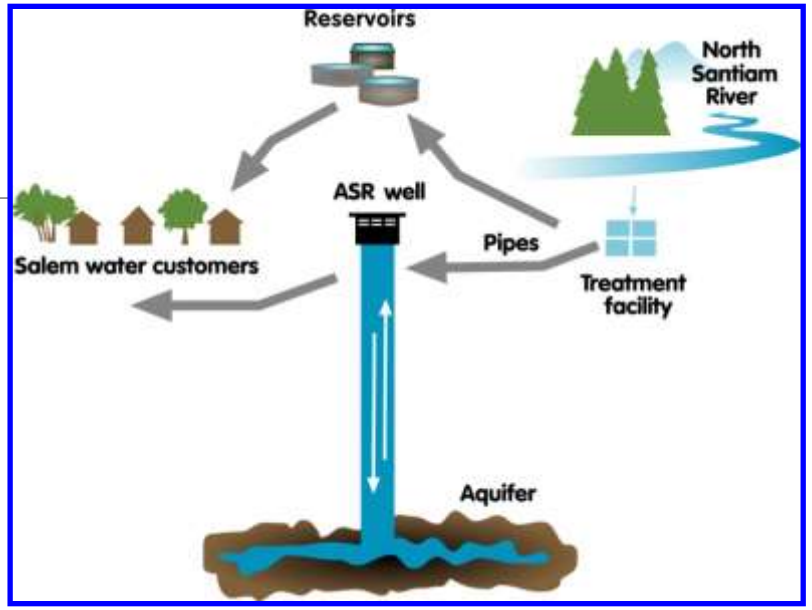
- Two main lines from Geren Island to Turner Control: ~ 7 miles
- Water mains from Turner Control throughout the system: > 700 miles
- Service lines throughout the system: > 300 miles
- 5,000 fire hydrants
- 46,000 metered services
- 19,000 valves
- Population: 192,800

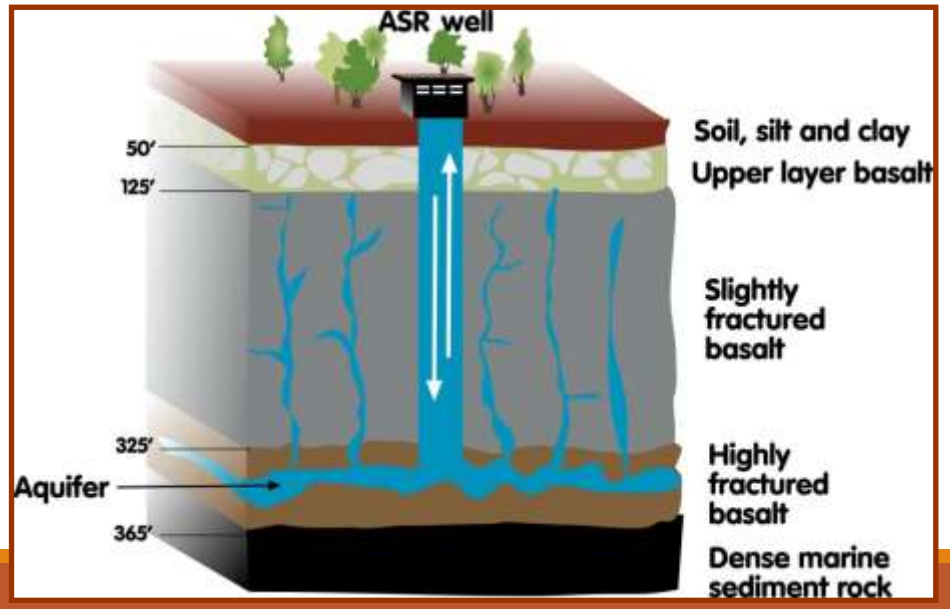
Salem stores 139 million gallons in Reservoirs

Franzen Reservoir

This reservoir holds 92 million gallons of water.

Aquifer Storage and Recovery





Salem can store an additional 350 million gallons underground in South Salem.

Last Stop –To the Tap

How the Watershed Program came to be:

Perfect Storm event during 2009 Mid-Summer:

- Hottest Week of the Year
  - Summer peaks at around 50mgd
- Clogging of Filters on Geren Island
  - Fragilaria (sticky matrix) and Anabaena
- One cell of Franzen Reservoir was operational
  - 42 million available out of 92Mil
- Operational Maintenance at Big Cliff Dam
  - Passing water through for maintenance, malfunction occurred and result were plans to reduce in-stream flow near 500cfs
- Result was to go into Stage 2 - Voluntary Curtailment

Watershed Program

Goal

- To protect the City of Salem's drinking water by providing advance notice of threats from algae activity, or other potential harmful activities.
- Baseline Data Collection– prepare for regulation, forecasting and better management

History

- 2010 – in house testing for Microcystin (Abraxis kits) – detected once
- 2011 – started sending samples to certified lab, for Anatoxin-a and Microcystin
- 2012 – Saxitoxin was added; no detects
- 2013 – Cylindro was added – low-level detections under OHA guidelines; until May bloom on lake – sporadic toxin sampling
- 2014 –May Bloom occurs again – program increases toxin sampling
- 2015 – Drought Year – Bloom occurred earlier on May 12th
- 2016 – Occurred Memorial Day weekend – small toxin hit, but lake wide
- 2017 – Wet and Mild Year - Lake-wide bloom on Memorial Day, largest hit of Cylindro toxin; Wildfire in watershed
  - Observed range of Dolichospermum bloom between mid-May to early June – Data Supported

Data Collection History:

- Water Chemistry: 2013 - Present
- Algae ID/Enumeration: 2011 – Present
- Nutrients: 2009 - Present
- Toxins: 2013 – Present

Watershed Monitoring Program – Data Overview

What types of data do we collect?

Water Quality

- Nutrients
- pH
- Temperature
- Conductivity
- Turbidity
- Dissolved Oxygen
- Dissolved Organic Matter
- Algae enumeration and speciation
- Chlorophyll-a
- Phycocyanin (BGA)
- Silica
- Cyanotoxins
- Water clarity (Secchi depth)
- Visible blooms or scum

Dam Operations

- Discharge-- spill vs. power generation
  Reservoir Elevation

Climate and Streamflow Conditions

- Annual Precipitation and Snowpack
  Snow-Water Equivalent
- Realtime Flow & Discharge Forecast
- Wind direction & speed
- Solar radiation
- Air temperature

Other

- Vehicle Accidents
- Hazardous Materials Spills
- Construction Activities
- Timber Sales
- Wildfires

Program Components:

Summer Season (May – Oct)

Sites

- Geren Island WTP – 7 sites
- Detroit Reservoir – 2-5 sites
- N. Santiam River – 1 site, weekly during the summer

Weekly Sampling at Detroit Reservoir

- Intensive sampling at all sites
  - Water Quality Parameters
  - Algae ID and #
  - Nutrients (including NH4)
  - Toxins, if conditions warrant
  - Field Observations (wind, temp, etc)

Winter Season (Nov - April)

Sites

- Geren Island WTP – 7 sites
- Detroit Reservoir – Observation around the Lake
- N. Santiam River – 1 site

Sampling is lessened; Geren Island is weekly, Detroit Reservoir is once a month

- Water Quality Parameters
- Algae ID and #
- Nutrients (including NH4)
- Toxins, if conditions warrant
- Field Observations (wind, temp, etc)

Detroit Reservoir Sites

Water Treatment Facility Sites

Toxin Routine: System-Wide Sites

Oregon BMPS: Cyanotoxin Guidelines

Under OHA's Response Flow Chart for Public Water:

- ID/Enumeration results > 2,000 cells/mL for microcystins, or > 15,000 cells/mL for other HAB genera

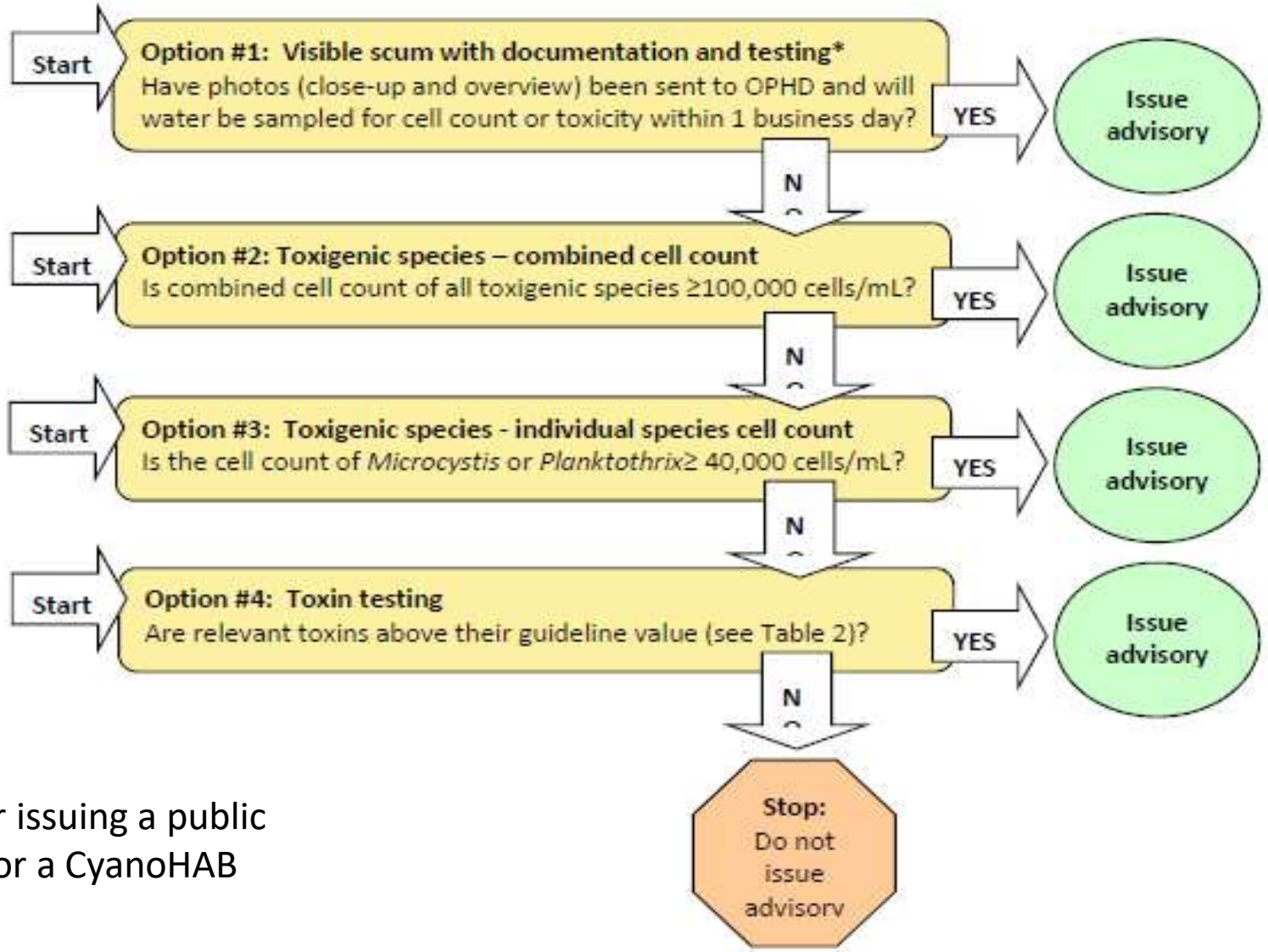
Table 1. Cyanotoxins on the Contaminant Candidate List (CCL)

Cyanotoxin	Number of Known Variants or Analogues	Primary Organ Affected	Health Effects[1]	Most Common Cyanobacteria Producing Toxin[2]
Microcystin-LR	80~90	Liver	Abdominal pain Vomiting and diarrhea Liver inflammation and hemorrhage	*Microcystis* *Anabaena* *Planktothrix* *Anabaenopsis* *Aphanizomenon*
Cylindrospermopsin	3	Liver	Acute pneumonia Acute dermatitis Kidney damage Potential tumor growth promotion	*Cylindrospermopsis* *Aphanizomenon* *Anabaena* *Lyngbya* *Rhaphidiopsis* *Umezakia*
Anatoxin-a group[3]	2-6	Nervous System	Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis leading to death	*Anabaena* *Planktothrix* *Aphanizomenon* *Cylindrospermopsis* *Oscillatoria*

[1]Source: *Harmful Algal Research and Response National Environmental Science Strategy (HARRNESS)*
[2]Not all species of the listed genera produce toxin; in addition, listed genera are not equally as important in producing cyanotoxins.
[3]The anatoxin-a group does not include the organophosphate toxin anatoxin-a(S) as it is a separate group. In the US, the most common member is thought to be anatoxin-a, and thus this toxin is listed specifically.

(www.epa.gov)

Toxin Sampling



- OPHD process for issuing a public health advisory for a CyanoHAB

Cyanotoxin Threshold

Thresholds (ppb)	Anatoxin	Cylindro	Saxitoxin	Microcystin
Recreation	20	20	10	10
Drinking	3	3	1.6	1.6
Child / Dog	0.7 / 0.4	0.7 / 0.4	0.3 / 0.2	0.3 / 0.02

2017: 213 ppb @ Heater
2016: 8 ppb @ Heater Creek
2015: 38.9ppb @ Heater Creek
2014: 191 ppb @ Blowout Creek

Observed Cyanobacteria Species:

Dolichospermum lemmermannii

Dolichospermum lemmermannii

Aphanizomenon

Cuspidothrix cf issatschenkoi
(Aphanizomenon group)

Woronichinia & Microcystis

All photos by BSA Environmental Services, INC 2017

Drinking Water Treatment: When Toxins Occur

Shut down intake

Turn on Roughing Filter

Ability to mix with subsurface groundwater
- Time limitations

Highly effective on removal of algae and toxins
- Schmutzdecke biological layer
- Algae enumeration and toxin results support this

Post-filtering -Treat with chlorine; oxidation with contact time

No detected issues post-treatment
- Sample CFE immediately after treatment process
- Travel to Turner – sample treated water at distribution entry point (6miles from GI)

Monitor Dam Operations
- Reservoir water level
- Is spillway operating?

CyanoHABs: Past Blooms

Trends observed on Detroit:

- Large Anabaena sp. (Anabaena lemmermannii or Anabaena flos-aquae) bloom that occurs regularly end of May/early June
  - Big hit of toxins, then degrades after 1-2weeks
  - Small amount linger throughout summer
- Second large bloom end of August/Sept. With data collected, usually Anabaena flos-aquae, but has been Aphanizomenon sp. and Aphanocapsa sp. cyanobacteria
  - Small concentration of toxins

- Indications of bloom events during sampling:
  - Color of water
  - Observable particulates and/or scum
  - Water Quality parameter indicators:
    - Dissolved Oxygen (above 105%)
    - PC (BGA >0.5 RFU and Chloro-A > 1.00 RFU)
    - pH change – typically more basic (~ 9)

- Preparation and communication with Operators and Managers
- Good relationship with Forest Service and Army Corp

Challenges

Limited Time and Resources

- Takes time to develop Schmutzdecke
- Labor intensive
- Limitations to mixing groundwater

What we know and what we don't know

- Dam Operations
- Drought
- Flooding
- Geomorphology – water access
- Second Source
- Pilot Studies

External Resources

- Switched Cyanotoxin labs

Water Quality call for a HABs Bloom in a City Park

Other events

- Turbidity events - < 10 NTU for filters
- High Precipitation Season
- Wildfires
- Fuel Spills (above vs below dam)
- Benthic?

Woronichinia & Microcystis Bloom

Questions?

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CITY OF Salem AT YOUR SERVICE

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