Cyanotoxin results at different stages of water treatment in Clear Lake, CA

A snapshot only

EPA Expert Workshop on Cyanobacteria and Cyanotoxins, July 2012

California Department of Public Health – Drinking Water Program
Amy J. Little, in collaboration with William Draper

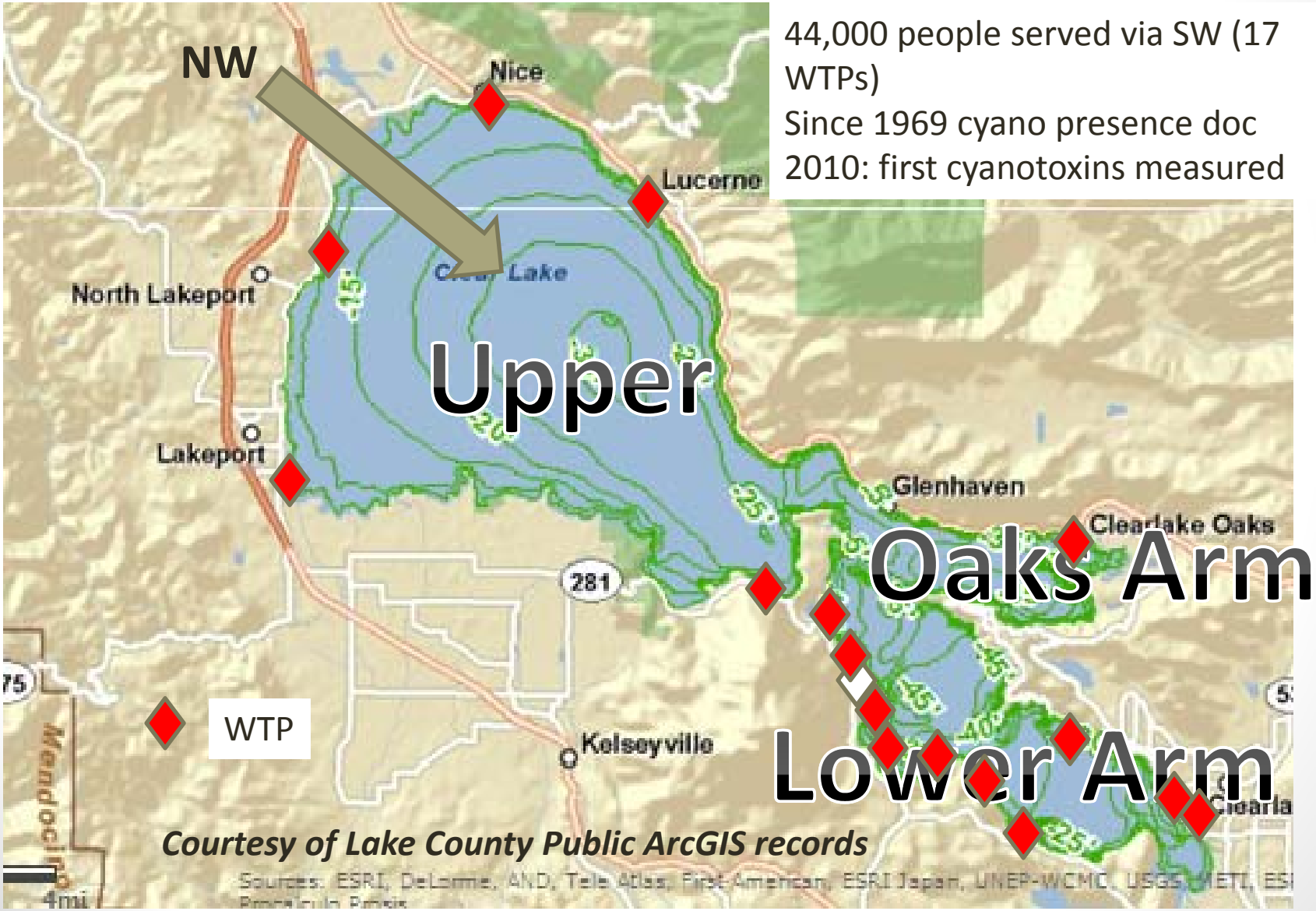
Overview

- Terms
- Clear Lake, CA facing extraordinary water treatment challenges
- Water Treatment around the lake: then and now
- Identifying 10 representative water treatment plants
- Results: Table and with WTP process flow diagrams
- Conclusion
- What is next?
- Field day + Methods

Terms

- Conventional Treatment: coagulation, flocculation, sedimentation, filtration
- Direct Filtration: coagulation, flocculation, filtration
- Contact clarification: like roughing filter except there is adequate time for flocculation formation
- Inline filtration (not approved): coagulation, filtration
- Diatomaceous Earth: process that removes particulates with a pre-coat of graded diatomaceous earth filter media is continuously deposited on a support membrane (septum)
- Alternative Technology: membrane filtration
- WTP – water treatment plant
- AOP – advanced oxidation process
- Risk:Treatment Score – a ranking system developed to identify representative treatment plants.

WTPs around Clear Lake, CA



44,000 people served via SW (17 WTPs)
Since 1969 cyano presence doc
2010: first cyanotoxins measured

Cyanobacteria Water Treatment challenges

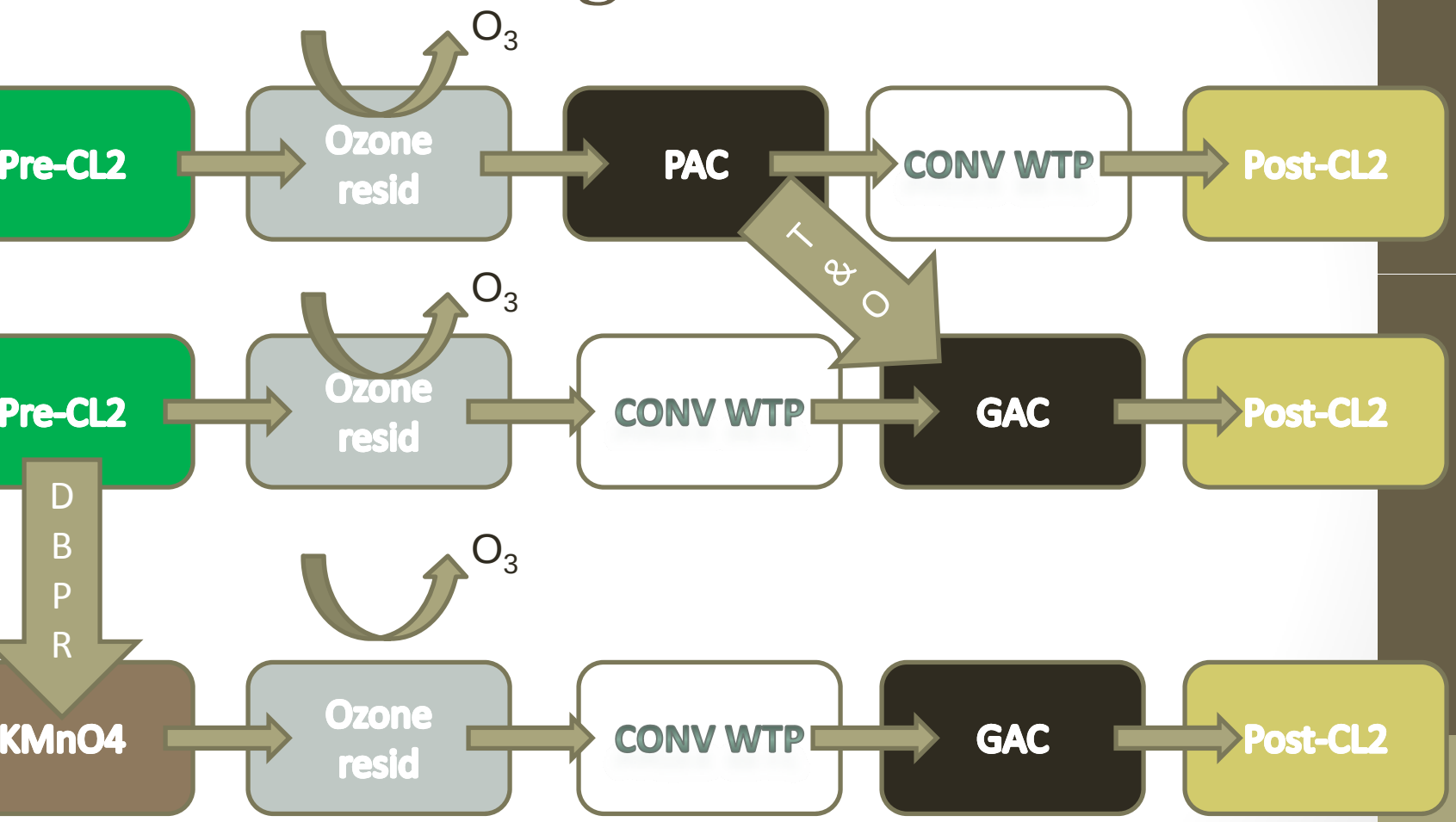
Source Water Quality

- Diel pH fluctuations can be extreme (acid additions to counter)
- Elevated total organic carbon (at times >10 ug/L)

Suite of Treatment Issues:

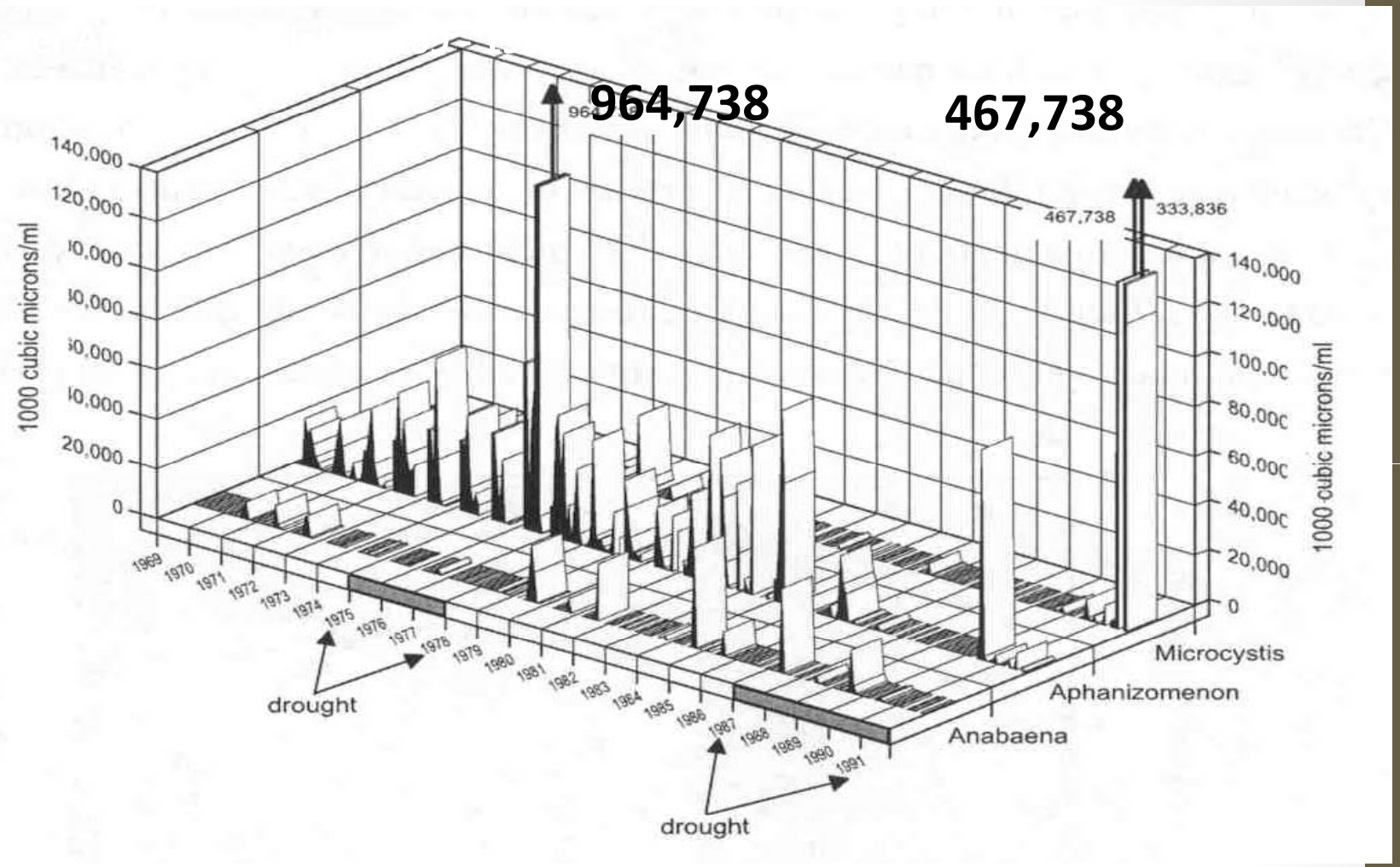
- Short filter runs/Clogged filters
- Increased pre-oxidation demand
- Increased coagulant demands
- Increased filter backwashing/clarifier sludge removal
- Increase in disinfection applications to maintain required residuals
- Increase DBP formation
- Taste & Odor complaints
- Unknown impacts from cyanotoxins

lear Lake Treatment "Model"
reatment Strategies Evolve



look at cyanobacteria from the reatment perspective…

- Cyanobacteria properties:
  - **NEGATIVELY CHARGED PARTICLE (Edzwald, 1993)**
  - **Removing an intact cell is preferred** (Steffensen, International Symposium on Cyanobacteria Harmful Blooms, Chapter 37, Sept 2005) over water soluble compounds
  - Organic content varies within this group
  - Tolerant, small, low specific gravity, low cell density
  - Blooms: warm, high nutrients, stable water column
  - Pigments: Chl a + **accessory pigments**
  - Motile: glide & regulate buoyancy
  - Toxicity expected in 60% of all samples (WHO, 2003)
  - UC Davis doc 3 types of cyanobacteria; end of drought years



ource: Managing for Healthy Ecosystems, Chapter 121: Evaluating and Managing a Multiply-Stressed Ecosystem At ear Lake, California: A Holistic Ecosystem Approach, Suchanek, T.H., et. al. (2002)

crocystis & Aphanizomenon – 5 um, taste & odor problems

Aphanizonmenon max ~ 14 million cells/mL

Message to operators: Keeping cells intact vs. lysing

- Cells Intact
  - Coagulation
  - Sedimentation
  - Filtration
- Lysed Cells
  - Oxidation
  - GAC

What is your treatment approach? And, does it change in a season?

Risk:Treatment Score

Risk (Score 10 to 40)

- North West exposure
- Toxin levels at different reaches of lake
- [Chlorophyll a]
- DOC

- Treatment*
  - Pre-oxidation: KMnO4/Ozone (3), AOP (4), NaOCl(0)
  - Filtration: Conv (1), upflow package (1), membrane (0), CC (0.5), direct (0.5), DE (0)
  - Polishing Ozone (3)
  - Polishing GAC (1)
  - UV disinfection (0)
  - Post disinfection (0)

* Based on assumption that bloom was in senescent phase; toxins released

electing Representative Sites

Considerations

- Risk:Treatment Score
- Logistics: 10 of 17 WTPs, decision limited to ~1 day
- Availability/Willingness – all utilities welcomed us; some expressed relief; have some information available to customers

Caveats

- Time frame – extremely short (~ 2 days to plan/prep)
- Limited Knowledge on Risk:Treatment Score

February x, 2012

TO: INSERT WATER SYSTEM

In a response to Lake County communicating public concerns about recreating and drinking water from Clear Lake, CA during noxious cyanobacteria blooms, the California Department of Public Health (Department) collected water samples at representative drinking water plants from around the lake. The water samples were collected at different stages of treatment on September 8, 2011 and analyzed for six cyanotoxins, specifically microcystin-LF, microcystin-LR, microcystin-RR, microcystin-YR, microcystin-LW and microcystin-LA.

The purpose of the sample collection was to measure the concentration of the four microcystins entering water treatment plants and to assess how effectively the four microcystins were removed at different stages of treatment. The Department appreciates the coordination and cooperation of INSERT NAME OF WATER SYSTEM on such short notice.

During sample collection the Department understands that the following treatment processes were in place at [INSERT NAME OF WATER SYSTEM]:

INSERT TREATMENT UNIT PROCESSES

If any of the treatment information is incomplete or inaccurate, please contact the Department with the correct information. The water samples were using a liquid chromatography-mass spectrometry laboratory technique. The results of the analyses for INSERT WATER SYSTEM are as follows:

INSERT TABLE OF RESULTS

The success of the removal of these four microcystins during this sampling is attributed to INSERT WATER SYSTESM optimizing treatment to remove the compounds in both soluble and insoluble form. If you have any questions about these results, please contact Amy Little at (707) 576-2147.

DRAFT

VTPs around Clear Lake, CA

TP	Connections	Population	Treatment	Risk:Treat Score
escent Bay provement	24	18	DE	687.0
ckingham k Water trict	451	580	Conventional	44.4
hmond k	41	25	Direct Filtration	25.8
arwater VC	94	250	Contact Clarification	25.8
estwind HP	45	200	Contact Clarification	15.3
lden State ter Co.	2,286	7,544	Conventional	13.7

VTPs around Clear Lake, CA

TP	Connections	Population	Treatment	Risk:Treat Score
. Konocti WC	1,567	3,150	Conventional	13.4
e MWC	1,059	2,500	1: Conventional 2: Alternative	12.2
iera West WC	235	550	Inline filtration	11.9
cerne	1,280	2,870	Membrane+AOP	8.9
ghlands WC*	2,303	5,300	Conventional	8.6
nocti VD	1,758	4,027	Conventional	8.6

** Dialysis patients are served*

VTPs around Clear Lake, CA

TP	Connections	Population	Treatment	Risk:Treat Score
ke County da Bay	612	1,342	Conventional	8.4
arlake ks CWD	1,700	2,458	Conventional	5.0
y of keport*	2,188	5,200	Conventional	3.0
rth keport	1,214	2,868	Conventional	3.0
nocti rbor Resort	INACTIVE	INACTIVE	Conventional	N/A

** Dialysis patients are served*

Results for microcystins*, ug/L

TP	Raw	Process	Finish	Type
escent Bay provement	0.89		ND	DE
ckingham Park ater District	0.33		ND	Conv
chmond Park	0.44^	0.48 (post-GAC)	ND (post NaOCl)	Direct
earwater MWC	0.29^	ND^ pre-GAC	ND	Contact
estwind CDPH	0.43	0.53+ (post Ozone)	ND^	Contact
estwind - UCSC	1.15+6.82	0.38	0.17	Contact

ND = non-detected
Total microcystin concentration reported
UCSC confirmed results (^ indicates a deviation)
* MC-LR + MC-RR (if detected)

Results for microcystins*, ug/L

TP	Raw	Process	Finish	Type
e MWC	ND	ND^	ND	Conv/Mem
cerne	0.16	ND	ND	Mem+AOP
ghlands	**2.96⁺+0.11**	0.26 (pre-GAC)	ND	Conv
ke Co – Soda y	0.11	ND	ND	Conv
arlake Oaks	**3.45⁺**	0.40 (pre-GAC)	ND	Conv

ND = non-detected

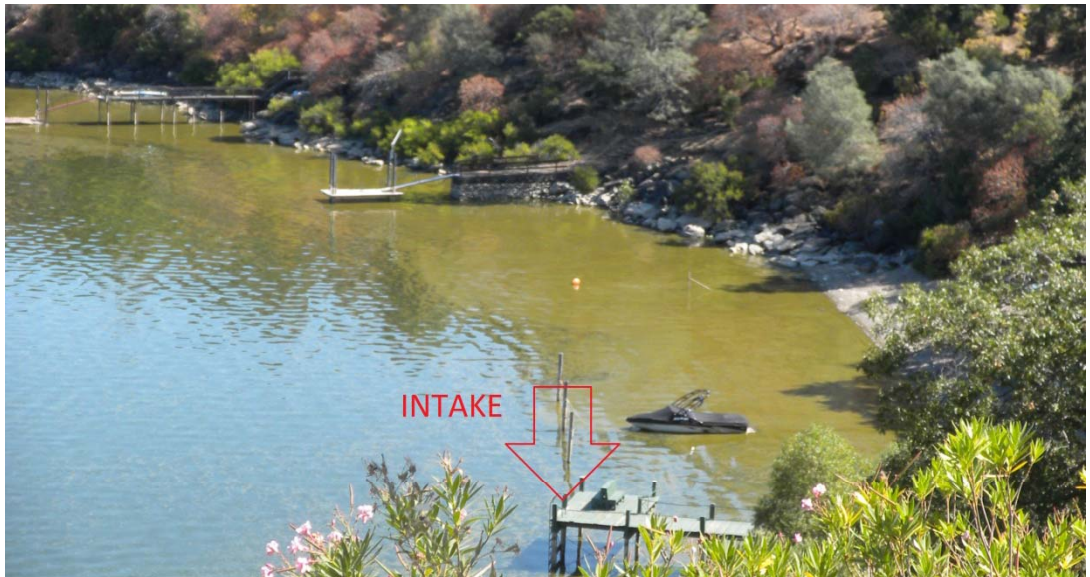
Total microcystin concentration reported

* MC-LR + MC-RR (if detected)

+ average of two analyses

ample Locations

Crescent Bay Improvement Company

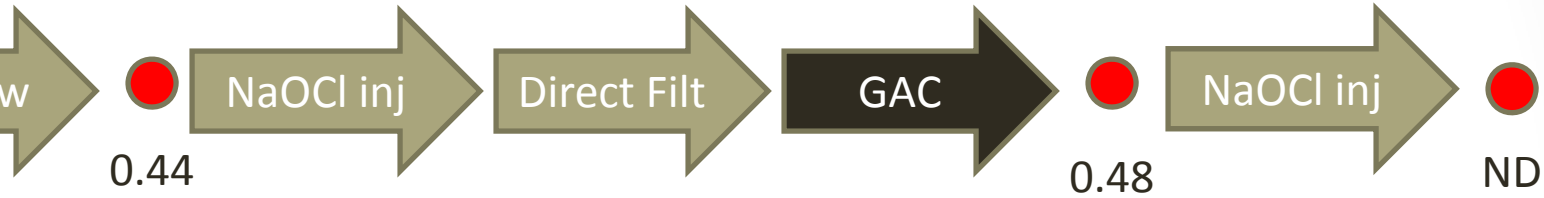


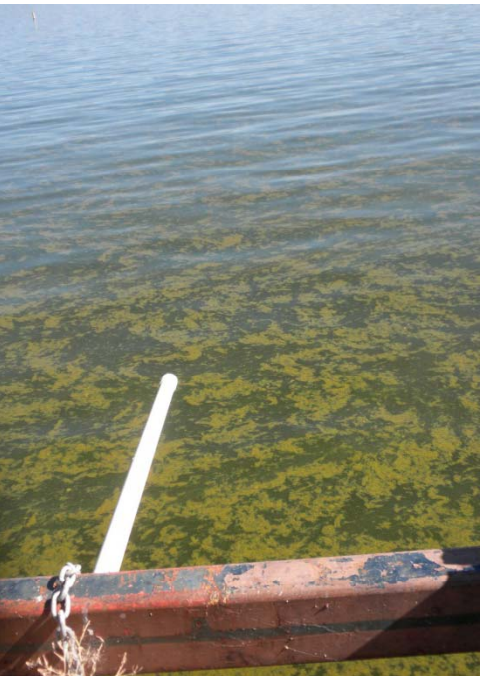
ample Locations

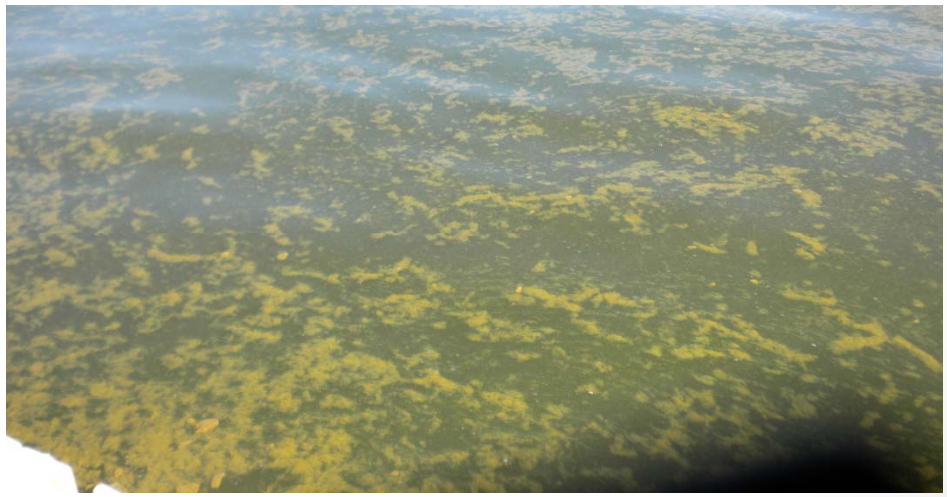
Buckingham Park Water District

ample Locations

Richmond Park Resort

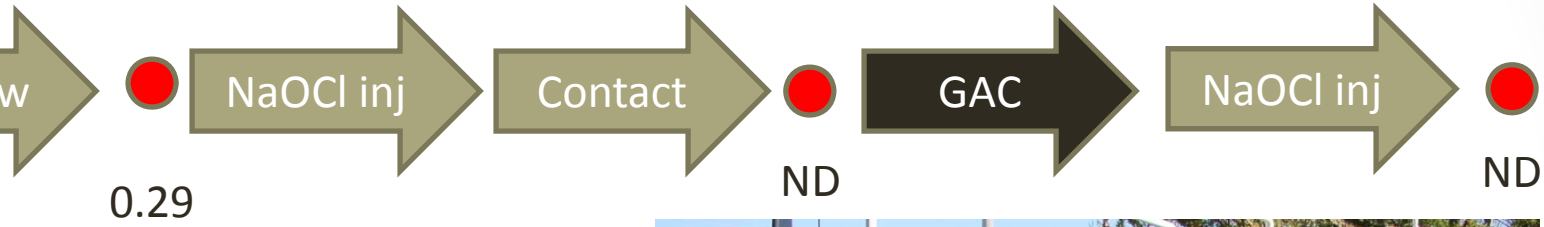






ample Locations

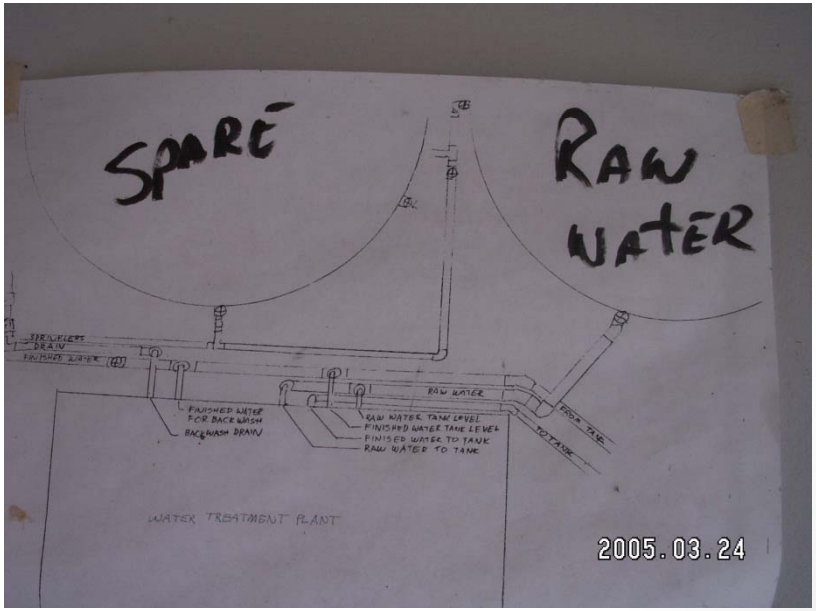
Clearwater Mutual Water Company



ample Locations

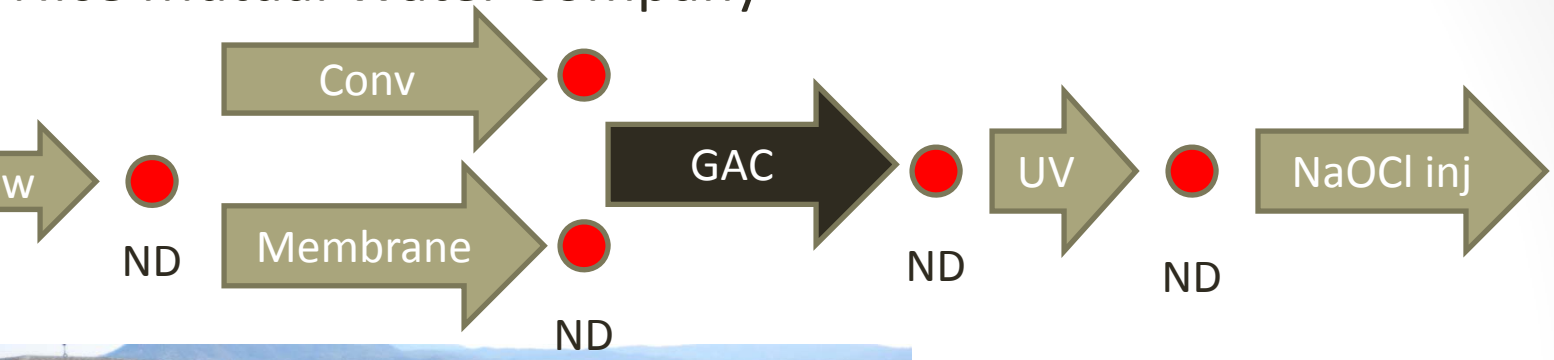
Westwind Mobile Home Park

w → 0.43 → Ozone → 0.53⁺ → Contact → NaOCl inj → ND^



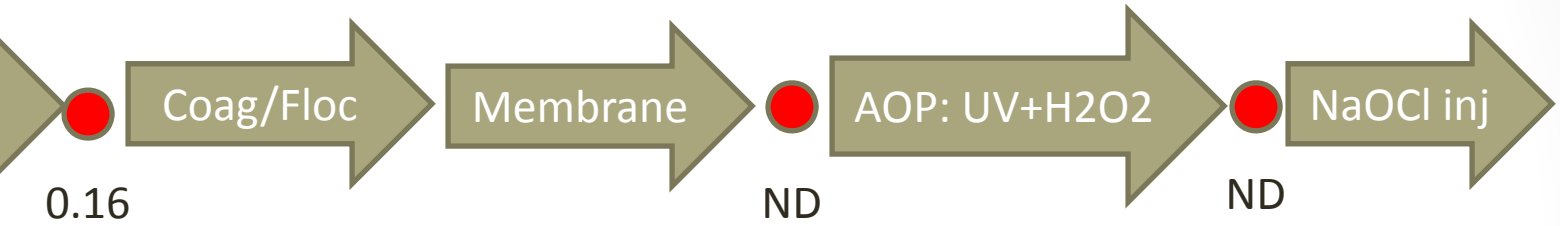
ample Locations

Nice Mutual Water Company



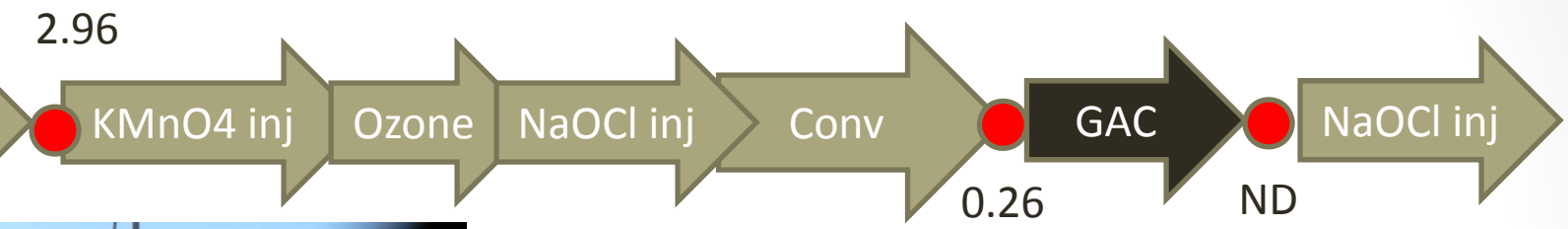
ample Locations

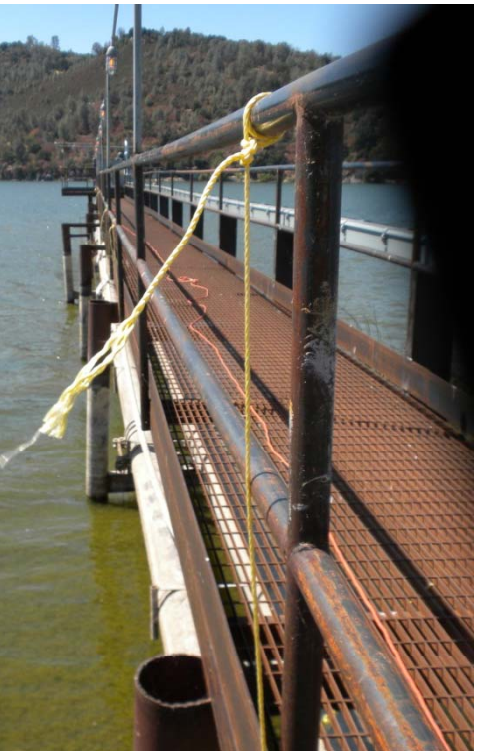
Lucerne Water Company – California Water Service

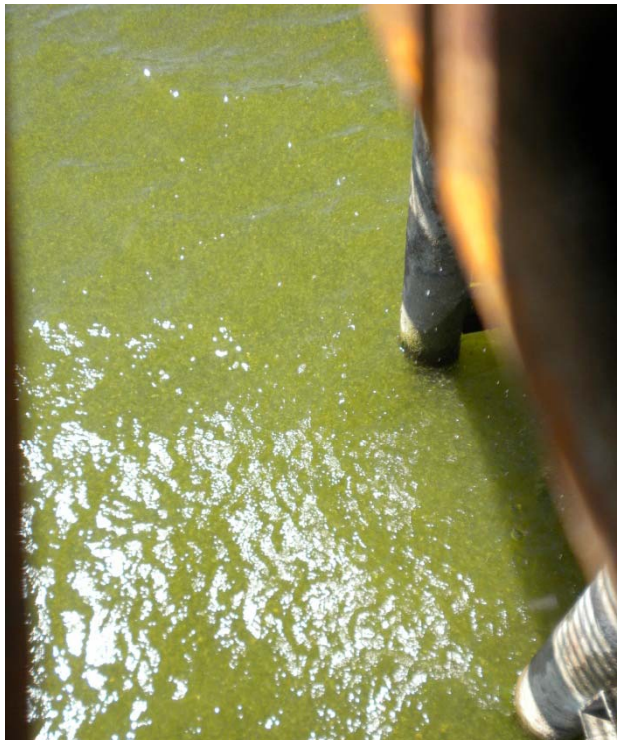


ample Locations

Highlands Mutual Water Company

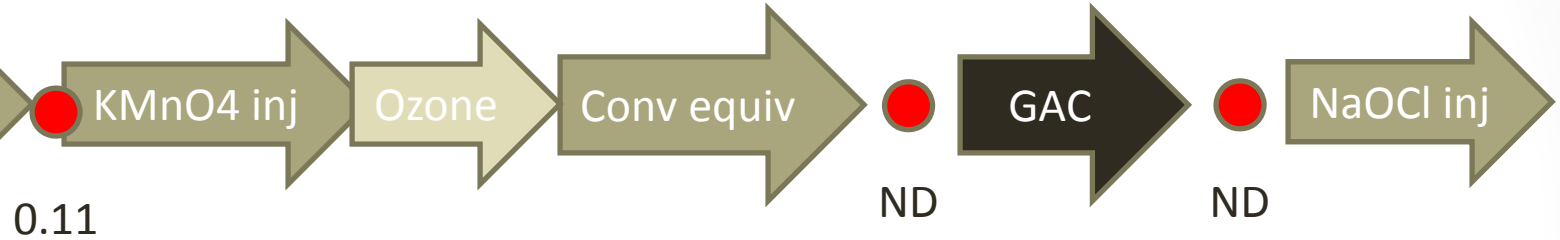






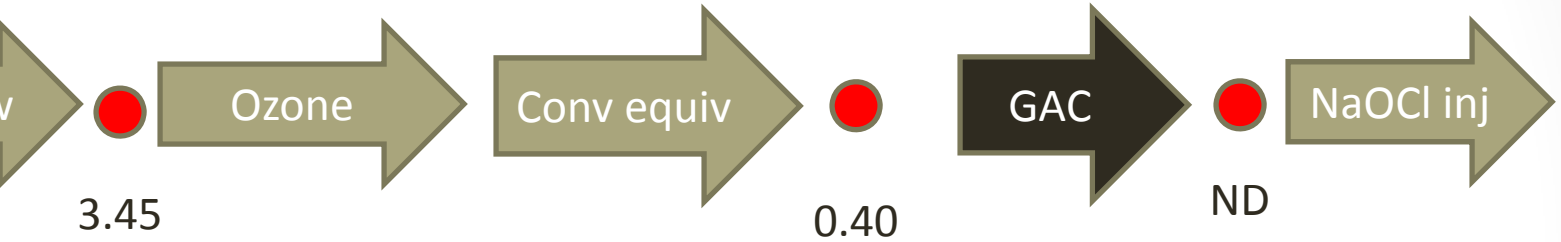
ample Locations

Lake County CSA 20 – Soda Bay



ample Locations

Clearlake Oaks County Water District



Conclusion

On September 8, 2011 water treatment plants were effective in reducing the microcystin variant concentrations detected in source waters to levels below laboratory detection at the entrance to the distribution system for drinking water around Clear Lake, CA

Why? And, What is Next?

Attribute success to:

- Taste and odor complaints driving treatment improvements

What's next?

- Jar testing training late August 2012
- "Recommendations for a Cyanotoxin Monitoring Plan and Treatment Approach for Surface Water Treatment Plants around Clear Lake, CA"
- Continuously monitoring *chlorophyll a* at Highlands MWC with approval from Lake County director using a fluorometer – in process
- Continue using fluorometer as a tool to identify when cells are lysed
- Phaeophytin:*chlorophyll a* ratio – evaluate whether this can provide clues on best treatment approach at different stages of each bloom – in particular pre-oxidation strategies
- Empty bed contact time in GAC filters?

ield Day

Duplicate samples: 125 mL amber glass and 1 L plastic

3 rinses and collect samples to less than 50% volume

35 minute buffer in the entire schedule – no wiggle room

Marianne Watada assisted

Communication with water systems:

- Target visit window (+/- 15 minutes)
- Must locate water treatment plant, representative and sample points, need limited work space
- Plant must be operating
- Must limit to 30 minute visit maximum

September 8, 2011

Methods

30 Bottles – clean 125 mL amber glass and 1 L plastic

Transport/Storage until analysis: frozen with dry ice (-20° C)

Sample preparation

- Triplicate freeze/thaw cycles
- Solid phase sample extraction

Quantitative Analysis

- LC-MS-MS
  - Quantitation and Confirming Transitions
  - Internal Standard (Monolinuron) and Surrogate (Monuron)
- Reverse Phased Column (C_8)
- Methanol-Water Gradient (w/Acetic Acid & Ammonium Format Additives)

Methods continued…

Quality Assurances

- Surrogate Recovery Determined in each sample
- Analyzed blanks, duplicate and fortified samples

Reporting Limits (ug/L or ppb):

MC Variant	MCRR	MCLR	MCYR	MCLA	MCLW	MCLF
eporting mit	0.1	0.1	0.1	0.1	0.2	0.2

- Dr. Kudela performed a split analyses (on 125 mL)

pecial Thank Yous

William Draper, Richmond Lab Director (CDPH)

Donald Wijekoon, Research Scientist

Dr. Raphael Kudela, UCSC Professor

Marianne Watada, Associate Sanitary Engineer (CDPH)

Cooperation with Water Systems: Darin McCosker (Clearlake Oaks), Ellen Pearson (Buckingham Park), Chuck Davis (Westwind), Dean Eichelmann (Soda Bay), Dan Strechfus (Richmond Park), Norm Birdsey (Highlands), Dave Fultz (Nice), Michael Ruest (Clearwater), Sam Lambert (Crescent Bay), Gay Guidotti/Ryan Jensen (Lucerne)

Clear Lake BGA Work Group participants:

- Carolyn Ruttan, Susan Keydel, Raphael Kudela, Cecile Mioni, Ray Ruminski, Jim Brown, Tom Smythe, Karen Tait, Gary, Chris White, David Mezzara, William Draper, Stefan Cajina, Robin Hook and Bruce Macler

Questions like us? Contact Us

it acceptable to report results for total microcystin
oncentration?

William Draper, Chief
rinking Water and Radiation Laboratory Branch
510) 620-2915
/illiam.Draper@cdph.ca.gov
Amy Little, Associate Sanitary Engineer
Mendocino District Field Office Branch
707) 576-2147
my.little@cdph.ca.gov