Quality Assurance Project Plan for Lake Chlorophyll a and Sediment Nutrient Sampling in Clear Lake, CA

Lake County Water Resources Department

Supported by:
California Department of Water Resources
California Regional Water Quality Control Board

November 2018

Program and Project Director

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Project Manager

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Project Partners

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Holly Grover, Central Valley Regional Water Quality Control Board

This quality assurance project plan (QAPP) written by and for the County of Lake Water Resources Department and is intended to be part of a comprehensive document describing the planning, implementation, and assessment included in the County's water quality monitoring plan. Document guidelines follow the ANSI / ASQC E4-1994 specifications for Quality Systems for environmental data, which includes proper planning, implementing, and assessing data operations including the collection, handling, analysis and evaluation of data. The QAPP was organized following components of the *The Volunteer Monitor's Guide to Quality Assurance Project Plans (U.S. EPA 1996).*

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A. Program Organization and Distribution List

Table 1. Personnel Responsibilities and contact list

Name	Organization / Affiliation	Project Title / Responsibility	Contact (email and phone)
David Cowan	Lake County Water Resources	Program Manager	David.cowan@lakecountyca.gov (707) 263-2256
Angela De Palma-Dow		QA Officer and program oversight	Angela.Depalma-Dow@lakecountyca.gov (707) 263-2720
Patrick Jarrett	California Department of Water Resources	Field Technician / Environmental Scientist	Scott.McReynolds@water.ca.gov
Scott McReynolds		Project Oversight / Sr. Environmental Scientist	Patrick.Jarrett@water.ca.gov (530)528-7438
Holly Grover	Central Valley Water Quality Control Board	Project Administration	Holly.Grover@waterboards.ca.gov (916)464-4747
Tina Hammell	UC Davis Limnology Laboratory	Sediment Sample Lab Analyst and QA Officer	tlhammell@ucdavis.edu (530)752-2913
Todd Albertson	Caltest	Emily Volkmar	Todd_Albertson@CaltestLabs.com (707)258-4000
Mark Miller Scott Webb	Lake County Water Resources	Field Technician	Mark.Miller@lakecountyca.gov Scott.webb@lakecountyca.gov

B. Problem Definition / Background

Clear Lake has an extended history of water quality problems, primarily due to excess nutrients and the subsequent blue-green algal blooms. Intensive efforts initiated by Lake County and others have improved the quality of Clear Lake significantly since the 1950's. Secchi depths, an indicator of water clarity, in late summer have increased from less than one foot in the mid-1950's to a consistent 3-plus foot clarity in the 1990's. Wastewater, including septic discharges and treated effluent, has been diverted from Clear Lake. Improved erosion control and in-channel gravel mining management has also reduced the cultural eutrophication of Clear Lake. However, nuisance algal blooms continue to occur in the late summer/early fall, although they are not as severe. If management is ever going to be able to effectively manage Clear Lake, nutrient and productivity information must be monitored on a monthly basis.

This document will provide the needed information to successfully and credibly incorporate two valuable parameters, Chlorophyll A (here after referred to "Chl a"; a measure of algal growth representing primary productivity) and sediment nutrients (A measure of internal loading and loading potential) into the current Clear Lake monitoring program being conducted by the California Department of Water Resources (DWR), the Central Valley State Water Quality Control Board (CVSWQCB) and the Lake County Water Resources Department (LCWRD).

The monitoring program originally consisted of collecting samples at three locations, each in the approximate center of each Arm of the lake. This sampling started in the early 1970's. DWR conducted other sampling in Clear Lake in the 1960's. Most parameters are collected ten times per year, with trace metals being collected four times per year. Starting during October 2018, LCWRD requested the addition of a fourth site in the northern portion of the Upper Arm, adjacent to Rodman Slough, in order to capture water quality impacts caused by the Mendocino Complex Fires. With support of DWR and CVWQCB, the fourth site was added to the monitoring program with an end date To Be Determined. Currently DWR collects and analyses a wide suite of parameters including those listed in the Table 2. The purpose of LCWRD to participate in this program is to 1) provide local logistical support to DWR staff and 2) where possible to partner with the DWR and CVWQCB in sampling and analyzing specific water quality parameters that contribute to a comprehensive sampling program. Additional role of LCWRD is to work with CVWQCB in monitoring Clear Lake's Chl a concentrations relative to the established TMDL Chl a target of 73 ug/L.

Table 2. CDWR Parameter List for Clear Lake Sampling

Analyte	Frequency*	Analyte	Frequency*
Boron	10X / yr	Aluminum	4X / yr
Calcium	10X / yr	Arsenic	4X / yr
Magnesium	10X / yr	Cadmium	4X / yr
Potassium	10X / yr	Chromium	4X / yr
Sodium	10X / yr	Copper	4X / yr
Chloride	10X / yr	Iron	10X / yr
Nitrate	10X / yr	Lead	4X / yr
Sulfate	10X / yr	Manganese	4X / yr
Alkalinity	10X / yr	Nickel	4X / yr
Hardness	10X / yr	Selenium	4X / yr
Electrical conductivity	10X / yr	Silver	4X / yr
Total Dissolved Solids	10X / yr	Zinc	4X / yr
Ammonia Nitrogen, Total	10X / yr	Phytoplankton (Chl a)	10X / yr
Ammonia Nitrogen, Dissolved	10X / yr	pH	10X / yr
Total Kjeldahl Nitrogen	10X / yr	Conductivity	10X / yr
Organic Nitrogen	10X / yr	Temperature	10X / yr
Ortho-phosphate	10X / yr	Turbidity	10X / yr
Phosphorus	10X / yr	Dissolved Oxygen	10X / yr
Nitrite & Nitrate	10X / yr		

*Starting October 2018 All Parameters except trace metals will be sampled 12X / year as part of a post-fire monitoring plan.

B.1 Project objectives

i. Assist DWR with monthly water quality sampling by coordinating, managing, sampling, and shipping water samples for Chlorophyll A analysis from established sample sites on Clear Lake, CA.

ii. Complement data collected through DWR by coordinating, funding, collecting, and analyzing sediment nutrient data from established sample sites within Clear Lake, CA.

iii. Assure all SWAMP sample protocols are being followed and maintained and communicate with appropriate partners as needed during the project duration, including sharing data where applicable.

B.2 Data Usage

Chlorophyll A lake data generated by this project will be collected, stored, summarized, and stored by the CDWR. Data generated by the CDWR is publically available on the DVR Water Data Library located online at http://wdl.water.ca.gov/waterdatalibrary/.

Sediment sampling data will be analyzed by the UC Davis Tahoe Environmental Research Center and stored and analyzed by LCWRD. Data generated by the LCWRD can be accessed by submitting a data share request through electronic communication to water.resources@lakecountyca.gov or by hard copy request sent to Water Resources Department, County of Lake, 255 N. Forbes St., Lakeport, CA, 95453. Any hard copies and digital versions of data and summaries will be stored in safe, secure location on Lake County property and servers. Data and generated reports will be available to all partners, collaborators and the public via email immediately and eventually, the California Environmental Digital Exchange Network (CEDEN).

C. Program and Site Background

C.1 Project Timetable

Table 2: Project Timeline

Activity	Projected Start Date	Anticipated Date of Completion
Quality Assurance Plan Development and Review	October 2018	November 2018
Data Collection	November 2018	Ongoing
Sediment Sampling Contract Review and Renewal	December 2019	January 2020
Program and QAPP review	As Needed	As Needed

C.2 Sample Site locations

Water Quality monitoring sites are located in three sites, two in the upper arm, one in the Oaks Arm, and Lower Arm. Specific locations are provided in Figure 1.

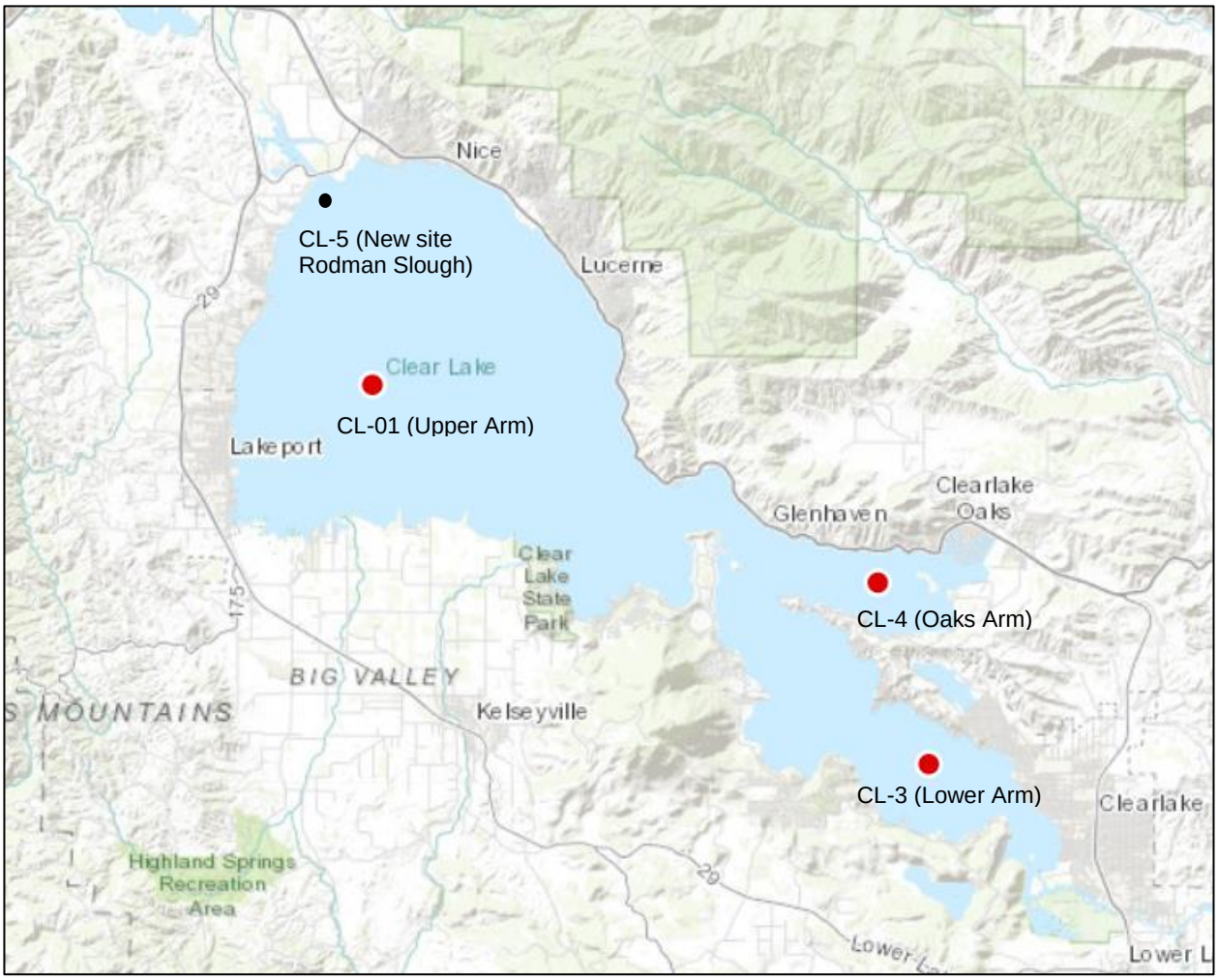


Figure 1. Geographic scope of Chl a and sediment sampling locations in Clear Lake, CA as of Fall 2018.

C.2 Parameters monitored

Table 3: Parameters measured

Parameter	Matrix	Units	Method	Equipment	Sample Notes
Chlorophyll A	Water	µg/L	SM 10200 H	Van Dorn Sampler provided by DWR	
Phosphorus, loosely bound	Sediment	µg/g, dry wt.	US EPA 365.2	Sediment Core Tool	While the sediment core tool was purchased by LCWRD, it is stored, maintained, cleaned, and transported by DWR.
Phosphorous, Calcium Bound					
Phosphorous, Iron Bound					
Total Phosphorus			US EPA 365.2		
Nitrogen, NO3 + NO4			US EPA 300.00		
Nitrogen, TKN			US EPA 351.3		
Total Nitrogen			Calculation of All N species		
Moisture Content	Sediment	%	SAAP of n Lyophilization		

C.3 Chlorophyll A Sample Description

Chlorophyll a (Chl a) is essentially measuring for the plant pigment chlorophyll a, which can provide information about the nutrient status of a lake. Chl a is mostly used to estimate phytoplankton biomass, which can be estimated by filtering the phytoplankton and then extracting the Chl a. High chlorophyll a results suggest an excess of nutrients, which may originate from anthropogenic inputs or natural eutrophication.

Sample collection will follow the protocols outlined in “SWAMP Bioassessment procedure 2009 - Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California” (June 2009) and in SWAMP Quality Assurance Program Plan (November 19, 2008). Prior to the beginning of sample collection at each site, GPS coordinates will be checked for accuracy. After collection, sample containers will be placed in ice chests with wet ice or dry ice. Proper precautions will be taken at all times in order to avoid transferring invasive organisms and pathogens between sites. Samples containers will be labeled with site identification code, collection and date time, and sampler’s ID. After collection, samples will be delivered to the lab as soon as possible (e.g. same day) to meet all designated holding time requirements.

Chl a grab samples are collected at 3 m incremental depths at each sample location, starting at 0.5 meters reaching the bottom. Water is collected with a Van Dom style 2.2 liter bottle which collects samples at discreet depths in the water column. One Liter amber plastic bottles are filled from the Van Dorn bottle. Each bottle is labeled with a specific site number and depth reference and packed for shipping and analysis.

Chl a samples will be rushed delivered to Caltest Analytical Laboratories and filtered within 24 hours of sample collection. Chl a samples will be processed according to SM 10200H.

LCWRD will make every effort to complete all required paperwork, secure sample containers and coolers, and drop samples at the shipping location within an hour after getting off the lake. The shipping location is located halfway between the LCWRD office and the ramp used to launch the LCWRD research vessel.

C.4 Sediment Nutrient Sample Description

Sediment sampling is an important component to any limnological study and lake monitoring program. Nutrient concentrations, especially for shallow, eutrophic lakes, much like Clear Lake, are good indicators of internal loading processes and nutrient accumulation and budgets within lakes.

Sediment is currently monitored for phosphorus and nitrogen concentrations and types in 10 cm cores collected at each of the established DWR sample sites. At each site a sediment corer is lowered to the benthic zone, submerged into the sediment to approximately 1 foot depth. A stopper is dropped on the corer to create negative displacement which holds the sediment within the core tube so it can be safely brought to the surface. Once at the surface, the sediment material is pushed out the top of the corer so it can be harvested. The top 1 cm of material is discarded and every subsequent 2cm is pushed up, scraped into a clean, labeled, quart-sized zip-top plastic bag (Figure 2). At each sample site a total of five sediment layers are placed together in one labeled gallon size zip-top bag and stored in a small cooler with ice packs and shipped to the lab at the UC Davis Limnology Laboratory in Davis, CA.

Immediately upon arrival at the UCD lab in 3117 Wickson Hall all sediment core samples are stored at 4 degrees C. Once the extraction process has begun the Nitrogen and Phosphorus bound forms are analyzed within 48 hours of each extraction, which include Loosely Bound, Iron Bound and Calcium Bound phosphorus, as well as NO3-N. Total Kjedahl Nitrogen is analyzed within 28 days. NO3-N and TKN concentrations are added for the Total Nitrogen concentration. The initial wet sediment core samples are held 30 days and up to 9 months prior to the extraction process.

For Total Phosphorus a separate sample set is weighed and dried in a drying oven @ 110° C for 24-48 hours. This sample set is used for percentage moisture as well as the Total Phosphorus digestion and calculation. The dried sample is analyzed within 28 days.

One sample duplicate and sample spike are analyzed for each sediment core set. An SRM at two concentrations near the sample average as well as DI blanks are also analyzed for each sample set.

LCWRD will make every effort to complete all required paperwork, secure sample containers and coolers, and drop samples at the shipping location within an hour after getting off the lake. The shipping location is located halfway between the LCWRD office and the ramp used to launch the LCWRD research vessel.

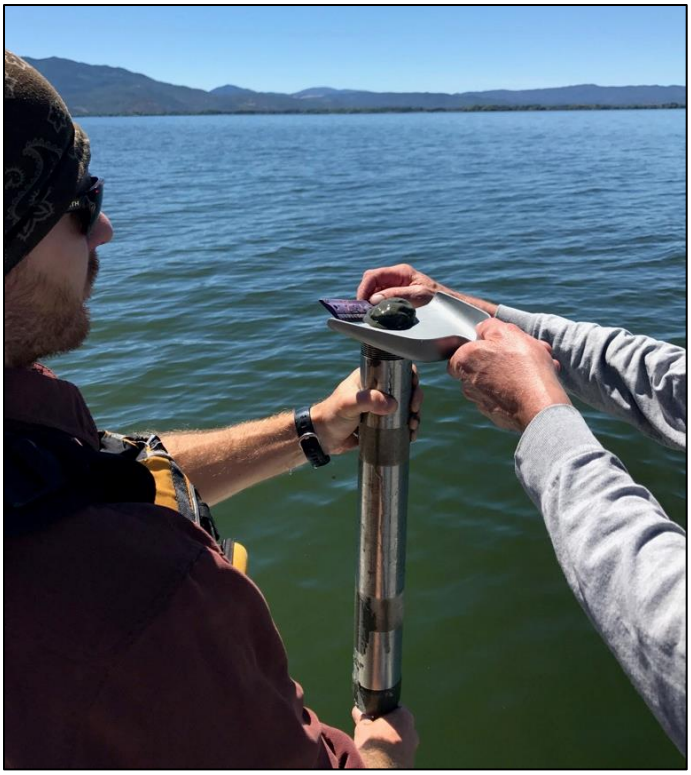


Figure 2. Field technicians Patrick and Scott collect sediment core samples from Clear Lake.

D. Measurement Quality Objectives

D.1 Collection containers, preservation and holding times

Sample type	Matrix	Container	Storage temp/ preservative / filtering	Holding /Storage time	Notes
Chl a	Water	Minimum 1 L poly, amber	Keep at temps; 0-6º C unfiltered, -20ºC filtered	48 hours before filtering, 28 days after filtering	
Sediment Nutrients	Sediment	Plastic bag with zip top	Stored at 4ºC	Maximum 9 months frozen	

D. 1 Precision, accuracy, and measurement range

Precision is the degree to which repeated measures “match” or agree when a sample is collected from the same place at the same time in the same manner or method. (EPA 1996).

Precision reflects the consistency of the sampling procedure. At one of the lake sites (CL-1) surface, DWR takes a duplicate sample, which is used to test precision of the collection methods and results.

Accuracy is the measure of confidence, or proximity to the "true" value. Accuracy can be calculated by subtracting an observed value from an accepted (average) value and dividing by the accepted/average value and multiplying by 100 to provide a percentage. This result will tell you how accurate the observed value is compared to some standard or accepted value. Monitoring samples for both precise and accurate when they are measured and recorded is the best way to assure that the data being collected is accurate and a true reflection of real world conditions. The accepted levels for precision, accuracy, and measurement range for the representative water quality monitoring parameters are listed in Table 4. For Chl, data sent to DWR and the project contact at CVWQCB will be tracking accuracy accounting.

Table 4: Water Quality Parameters Precision, Accuracy, and Measurement Range

Parameter	Accuracy	Precision	Recovery	Target Reporting Limits	Completeness
Chlorophyll A[1]	No SWAMP requirement – suggest ±30% of standard reference material (SRM)	No SWAMP requirement – suggest duplicate ± 25% Relative Percent Different (RPD)	Identification and counts – action limits are not applicable	No SWAMP requirement; suggest 10 µg/L	90 %
Sediment, Phosphorus	No SWAMP method - suggest 25% of SRM	No SWAMP method - suggest duplicate at 25% of RPD	SRM at two concentrations near the sample average	None established	90 %
Sediment nitrogen	No SWAMP method - suggest 25% of SRM	No SWAMP method - suggest duplicate at 25% of RPD	SRM at two concentrations near the sample average	None established	90 %

[1] This information is provided by the SWAMP QAPP for Harmful cyanobacteria booms and their toxins in Clear Lake and the Delta (California) Document # 10-058-150 Table 7-3 (page 28).

D.2 Chain-of-custody procedures for Chl a

Chain-of-custody procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of analytical results. A complete chain-of-custody form is to accompany the transfer of samples to the analyzing laboratory.

A sample is considered under custody if:

- it is in actual possession;
- it is in view after in physical possession;
- it is placed in a secure area (accessible by or under the scrutiny of authorized personnel only after in possession)

Samples will remain in the control of the LCWRD and DWR sampling crew until delivery of the samples to the shipper or courier located in downtown Lakeport. The sampling crew will maintain control of the samples in the field after collection by keeping samples in an insulated cooler filled with ice, in a locked vehicle or refrigerator at the office of the LCWRD. Chain-of-custody forms are provided by the lab conducting the analysis and will accompany the sample bottle shipment to the LCWRD prior to any sampling event.

D.3 Data representativeness

Representativeness will be addressed through appropriate choice in sample locations selection and rationale (details provided section B). Sample locations were chosen to best represent the specific environment of each arm and the heterogeneity of the overall pelagic habitat. In the past, DWR had sampled more than three / four locations within Clear Lake, but the current level of sites was determined to be the best representative locations for the entire lake and maximized the appropriate amount of staff effort and available funding.

E. Training Requirements

To maintain consistency, LCWRD will prioritize designated staff for conducting water quality sampling, data entry and any subsequent analysis. Any LCWRD staff or conducting water quality sampling will receive hands-on instruction and training by the project's quality assurance officer. Additionally, staff can further develop their skill level and familiarity with water quality monitoring and SWAMP protocols by completing the online SWAMP Field Method Course modules (available at: https://www.waterboards.ca.gov/water_issues/programs/swamp/cdrom.shtml). LCWRD staff will be strongly encouraged to complete this online training and become familiar with limnological methods and parameters by reading the USGS Lake Monitoring Field Manual (Nevers and Whitman) document # 1253b.

Currently, LCWRD and partners do not have plans for volunteers or citizens to be collecting water samples in this program, but if situations change in the future this document will be updated to reflect the additional training and QA component that will be needed to accommodate volunteers with little to no background in water sampling.

F. Safety: Injury and Illness Prevention

All DWR employees are to be training and follow their department's required safety plan.

Only experienced and trained staff at LCWRD will be responsible for conducting water quality sampling as part of this project. Any safety hazard or issued discovered while in the field will be reported to the Program director immediately.

All LCWRD staff and technicians involved in boating activities and the water quality field sampling will be provided the LCWRD staff operating a motorized boat will be required to obtain a California State Parks Division of Boating and Waterways California Boater Card (http://californiaboatercard.com/) by January 1, 2019.

G. Reporting

Any significant findings (i.e. elevated nutrient levels or abnormal conditions) will be highlighted and included in any relevant reports and communicated with partners as soon as possible.

H: Sources

1. Alaska Department of Environmental Conservation Division of Water. 2011. Generic Tier 2 Quality Assurance Project Plan For Water Quality Monitoring Sampling and Analysis Activities. 33 pp. Available at: https://pubs.usgs.gov/of/2014/1182/pdf/ofr2014-1182_Generic_Tier_2_WQ_QAPP_Rev1.pdf

2. Lake County Watershed Protection District. 2005. Clear Lake Mercury and Nutrients total Maximum Daily Load Monitoring Project. PID 03-237-555-0. 115 pp.

3. MiCorps. 2015. *Quality Assurance Project Plan for the Cooperative Lakes Monitoring Program.* Michigan Department of Environmental Quality. 78 pp.

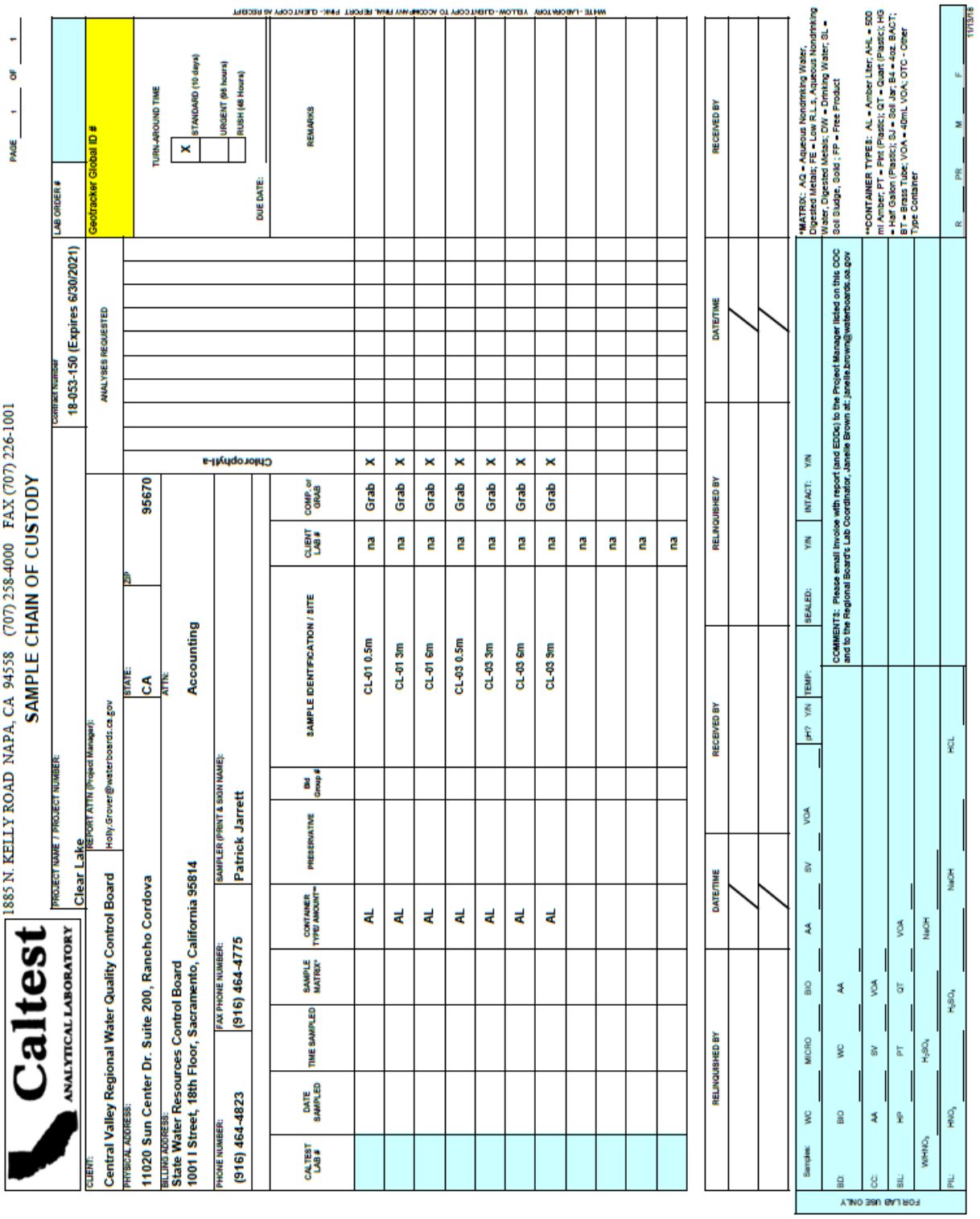
4. Mioni, C. 2011. Quality Assurance Project Plan for Harmful cyanobacteria blooms and their toxins in Clear Lake and Delta (California). PID 10-058-150. Available at: https://www.waterboards.ca.gov/rwqcb5/water_issues/swamp/sacramento_river_basin/cyano_qapp.pdf

5. Nevers, M.B. and R.L. Whitman. Lake Monitoring Field Manual. 92 pp. Available at: https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/1253b.pdf

6. U.S. Environmental Protection Agency. 1996. *The Volunteer Monitor's Guide to Quality Assurance Project Plans*. EPA 841-B-96-003. 59 pp

7. Wetzel, R. G. (2001). *Limnology: Lake and River Ecosystems (3rd ed.)*. San Diego, CA: Academic Press.

Appendix



1885 N. KELLY ROAD NAPA, CA 94558 (707) 258-4000 FAX (707) 226-1001

Caltest ANALYTICAL LABORATORY

SAMPLE CHAIN OF CUSTODY

PAGE 1 OF 1

PROJECT NAME / PROJECT NUMBER: Clear Lake

Contract Number: 18-053-150 (Expires 6/30/2021)

LAB ORDER #

CLIENT: Central Valley Regional Water Quality Control Board

REPORT ATTN (Project Manager): Holly.Grover@waterboards.ca.gov

ANALYSES REQUESTED: GeoTracker Global ID #

PHYSICAL ADDRESS: 11020 Sun Center Dr. Suite 200, Rancho Cordova | STATE: CA | ZIP: 95670

BILLING ADDRESS: State Water Resources Control Board, 1001 I Street, 18th Floor, Sacramento, California 95814 | ATTN: Accounting

PHONE NUMBER: (916) 464-4823 | FAX PHONE NUMBER: (916) 464-4775 | SAMPLER (PRINT & SIGN NAME): Patrick Jarrett

TURN-AROUND TIME: X STANDARD (10 days); URGENT (96 hours); RUSH (48 Hours); DUE DATE:

WHITE - LABORATORY YELLOW - CLIENT COPY TO ACCOMPANY FINAL REPORT PINK - CLIENT COPY AS RECEIPT

CALTEST LAB #	DATE SAMPLED	TIME SAMPLED	SAMPLE MATRIX*	CONTAINER TYPE/ AMOUNT**	PRESERVATIVE	Bill Group #	SAMPLE IDENTIFICATION / SITE	CLIENT LAB #	COMP. or GRAB	Chlorophyll-a	REMARKS
				AL			CL-01 0.5m	na	Grab	X	
				AL			CL-01 3m	na	Grab	X	
				AL			CL-01 6m	na	Grab	X	
				AL			CL-03 0.5m	na	Grab	X	
				AL			CL-03 3m	na	Grab	X	
				AL			CL-03 6m	na	Grab	X	
				AL			CL-03 3m	na	Grab	X	
								na			
								na			
								na			
								na			

RELINQUISHED BY	DATE/TIME	RECEIVED BY	RELINQUISHED BY	DATE/TIME	RECEIVED BY
	/			/	
	/			/	
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FOR LAB USE ONLY

Samples: WC ___ MICRO ___ BIO ___ AA ___ SV ___ VOA ___ pH? Y/N ___ TEMP: ___ SEALED: Y/N ___ INTACT: Y/N ___

BD: BIO ___ WC ___ AA ___

CC: AA ___ SV ___ VOA ___

SIL: HP ___ PT ___ QT ___ VOA ___

PIL: HNO_3 ___ $WHNO_3$ ___ H_2SO_4 ___ NaOH ___ HCL ___

COMMENTS: Please email invoice with report (and EDDs) to the Project Manager listed on this COC and to the Regional Board's Lab Coordinator, Janelle Brown at: Janelle.brown@waterboards.ca.gov

R ___ PR ___ M ___ F ___

*MATRIX: AQ = Aqueous Nondrinking Water, Digested Metals; FE = Low R.L.s, Aqueous Nondrinking Water, Digested Metals; DW = Drinking Water; SL = Soil Sludge, Solid ; FP = Free Product

**CONTAINER TYPES: AL = Amber Liter; AHL = 500 ml Amber; PT = Pint (Plastic); QT = Quart (Plastic); HG = Half Gallon (Plastic); BJ = Soil Jar; B4 = 4oz. BACT; BT = Brass Tube; VOA = 40mL VOA; OTC - Other Type Container

11/13/18

COC Form for Caltest, the lab that analyses Chl A samples. There is no COC form for UC Davis Limnology Lab for sediment analysis.