LOWER CACHE CREEK OFF-CHANNEL MINING MERCURY MONITORING PROTOCOLS

2021 Revision

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in consultation with the
Yolo County Cache Creek Technical Advisory Committee

Introduction and Background

Cache Creek is known to be a mercury-impacted watershed, dating from extensive mercury mining activities in the upper watershed from the mid-1800s through the mid-1900s. In the course of mining and refining mercury in the upper watershed throughout that period, some mercury was also lost into the downstream watershed. Additional mercury continues to discharge from the historic mercury mining areas. The historic and ongoing mercury movement downstream has created an elevated mercury environment in and around lower Cache Creek.

Since the 1800s, the lower creek has also been the source of aggregate rock and gravel material for a range of construction activities in the region and beyond. In 1996/1997, Yolo County partnered with the aggregate industry to move mining of aggregate rock material out of the Cache Creek channel, to adjacent floodplain areas.

As these off-channel mining operations proceed, consistent with permits granted by the County, they will extract the feasibly accessible aggregate material available within each mining area. As mining is completed, reclamation will occur. In many cases, reclamation will be to a lake or pond with surrounding habitat, adjacent to Cache Creek. These monitoring protocols address the issue of potential mercury contamination in aggregate mining ponds adjacent to Cache Creek, both during and after aggregate mining.

A large amount of research and monitoring has been directed at Cache Creek in relation to its mercury legacy. This includes a 'Baseline Study' that was conducted in 2011-2012 in the lower creek, adjacent to the off-channel aggregate-mining zone (Slotton and Ayers 2013). In that work, a series of large fish, small fish, and aquatic invertebrates were collected and analyzed for mercury. The most prevalent species were sampled, with a particular focus on species most likely to inhabit or move into the off-channel ponds. The 2011-2012 study was completed pursuant to requirements of Section 10-5.517 of the County's Reclamation Ordinance that were in effect at that time. This section of the County code regulates mercury bioaccumulation in wildlife. A major purpose of that baseline in-creek work was to provide updated ambient mercury concentration information for the County that could be used to compare to future testing of

mercury conditions in off-channel mining ponds (also called "wet pits") following their initial creation and subsequent reclamation. The 2013 report also compiled other existing data from this region of Cache Creek, from four earlier studies:

- A 1996 report entitled "Off-Channel Gravel Pit Lakes – Mercury Considerations, Lower Cache Creek, Yolo County, California" (Slotton et al. 1996, study and report)
- The original lower Cache Creek baseline study (Slotton et al. 1997, study and report)
- A pilot study in and around the Cache Creek Nature Preserve (conducted 2000-2004, reported in Slotton and Ayers 2004)
- A watershed-wide study for the State's CalFed program (conducted in 1998-2000, reported in Slotton et al. 2004).

Since that time, a large, multi-year study was conducted by the US Geological Survey and others, downstream of the study area in the Cache Creek Settling Basin (Brown et al. 2015).

These other data are useful as reference levels for similar data that may be collected in off-channel gravel-mining ponds. However, most of these projects had different objectives, often providing incomplete, disconnected, or old data in relation to current off-channel pond monitoring. The 2011-2012 creek baseline study (reported in Slotton and Ayers 2013) currently provides the most comprehensive and relevant comparison data base. An updated, 10-year Baseline Study of comparison mercury levels in lower Cache Creek is scheduled for 2021 (the 2020 wildfires and Covid-19 interrupted planned collections in 2020).

The original Yolo County regulations in relation to mercury bioaccumulation were drafted in 1996. Based on ongoing monitoring and mercury studies in the watershed, the requirements were revised and updated in December 2019. The subject mercury monitoring guidelines that follow here provide updated protocols for mercury-related testing in the off-channel wet pits, consistent with the County's recently updated regulations.

NEW MERCURY ORDINANCE PROVISIONS – 1-Page Summary

Section 10-5.517 of the County's Reclamation Ordinance, as updated in December 2019

- **Occasional Revision/Update of Protocols**
  Section (a) – (this document)

- **Ambient Cache Creek Fish Mercury Assessment** (once every 10 years)
  Section (b) – Determine comparison fish mercury levels in adjacent Cache Creek, targeting fish species found in or likely to occur in off-channel aggregate mining ponds.

- **Routine Annual Monitoring** (each year, for first 5 years of wet pit)
  Section (c)(1) – Fish-based testing, targeting 30 large fish of 1-4 species, as available, for fillet muscle mercury analyses from a human health perspective. Priority on 'top-of-the-food-chain' predator species like Largemouth Bass, for up to 20 of the samples.
  Also, for wildlife consumption concerns and as a more sensitive short-term measure of mercury exposure conditions, collect small (minnow-sized) young-of year fish. Collect 4 multiple-fish, whole fish composite samples from each of 3 species (12 composites total).
  Water column profiles: During the summer, measure temperature, oxygen, and a series of water parameters that can affect mercury cycling, every meter from surface to bottom.

- **Post-Reclamation Routine Biennial Monitoring** (every 2 years, for 10 years)
  Section (c)(3) – as above, but on a less frequent schedule of every other year.

- **Associated Data Reporting Guidelines**
  Section (d)

- **Response Thresholds and Actions –** *Sections (e-g)* – ***If fish mercury is found to be significantly elevated over Creek Ambient in 3 of 5 monitoring years:***

  - **Posting / Fish Consumption Advisory –** *Section (e)(1)*

  - **Extend Routine Monitoring**
    Section (e)(2) – if fish mercury is found to be significantly elevated over Creek Ambient in 3 of 5 of the first 5 years of annual monitoring, extend annual monitoring by 5 years.
    Section (e)(3) – if fish mercury is found to be significantly elevated in 3 of 5 of the post-reclamation biennial (every 2 years) samplings, extend biennial monitoring by 10 years.

  - **Expanded Analyses**
    Section (f) – Expand water column profiling to at least 5 events/yr across the warm season, to understand the annual cycle. Collect bottom sediments (once) to assess general mercury levels. Conduct other sampling as needed to guide remediation.

  - **Develop and Implement a Mercury Management/Remediation Plan**
    Section (g)(1)(A) – Prepare a lake management plan to address mercury concerns.
    OR *(g)(1)(A)* – revise the reclamation plan, to fill the pit with suitable soil.
    Section (g)(2) – Implementation obligations and operator options.

Revised/Updated (2021) Protocols for Mercury-Related Monitoring and Management of Lower Cache Creek Off-Channel Aggregate-Mining Ponds

The requirements from the recently updated Ordinance are provided verbatim below in blue text, one section at a time, as a framework for presenting the protocols. Much of it is self-explanatory as-is, particularly the last sections. Where additional implementation details or discussion is called for, that will follow the corresponding Ordinance excerpt, in black text. After this chapter, the 2019-revised Ordinance is also presented uninterrupted, as Appendix A.

YOLO COUNTY RECLAMATION ORDINANCE, MERCURY MONITORING PROGRAM PROTOCOLS

Section 10.5.517. Mercury Bioaccumulation in Fish.
As part of each approved long-term mining plan involving wet pit mining to be reclaimed to a permanent pond, lake, or water feature, the operator shall maintain, monitor, and report to the Director according to the standards given in this section. Requirements and restrictions are distinguished by phase of operation as described below.

(a) **Mercury Protocols.** The Director shall issue and update as needed "Lower Cache Creek Off-Channel Pits Mercury Monitoring Protocols" (Protocols), which shall provide detailed requirements for mercury monitoring activities. The Protocols shall include procedures for monitoring conditions in each pit lake, and for monitoring ambient mercury level in the lower Cache Creek channel within the CCAP planning area, as described below. The Protocols shall be developed and implemented by a qualified aquatic scientist or equivalent professional acceptable to the Director. The Protocols shall identify minimum laboratory analytical reporting limits, which may not exceed the applicable response threshold identified in subsection (e) below. Data produced from implementing the Protocols shall meet or exceed applicable standards in the industry.

This document constitutes the protocols.

(b) **Ambient Mercury Level.** The determination of the ambient or "baseline" fish mercury level shall be undertaken by the County every ten years in years ending in 0. This analysis shall be undertaken by the County for use as a baseline of comparison for fish mercury testing conducted in individual wet mining pits. The work to establish this baseline every ten years shall be conducted by a qualified aquatic systems scientist acceptable to the Director and provided in the form of a report to the Director. It shall be paid for by the mining permit operators on a fair-share basis. The results of monitoring and evaluation of available data shall be provided in the report to substantiate the conclusions regarding ambient concentrations of mercury in fish within the lower Cache Creek channel within the CCAP planning area.

Ambient/Baseline fish mercury levels in lower Cache Creek, for comparison purposes with off-channel mining pits, were first tested in 1997 (Slotton et al. 1997, study and report). A second 'Baseline' round of creek fish monitoring was done in 2011-2012 (Slotton and Ayers 2013). The schedule of every ten years was then shifted to a timing of each year that ends in a '0' (2020, 2030, etc). A baseline round of creek fish monitoring was planned for 2020, but the wildfires and Covid-19 threw off the timing and access. The updated ten-year creek baseline fish monitoring is re-scheduled for 2021.

Baseline/Ambient fish testing in the creek should include statistically meaningful samples of all species likely to be, or known to be, present in the off-channel aggregate ponds. This includes fillet muscle mercury testing of individual large (angling-size) fish including, as available:

- Bass (Largemouth and/or Smallmouth) x up to 20 each – the top priority in this watershed
- Catfish (White and/or Channel) x 10-15 each
- Carp and/or Sacramento Sucker x 10-15
- Green Sunfish x 10-15
- Bluegill Sunfish x 10-15

Large fish samples should span the range of adult sizes present. Sample preparation is described in section (c) below.

Baseline/Ambient fish testing in the creek shall also include composite, whole-fish, multiple individual samples of small, 'minnow-sized', young-of-year fish – also focusing on species likely to be, or known to be, present in the off-channel aggregate ponds, including, as available:

- Mosquitofish
- juvenile Green Sunfish
- juvenile Bluegill Sunfish
- juvenile Bass
- Red Shiner

Each small fish species should be characterized with four or more multi-individual whole fish composites. Each composite should ideally include five or more individuals, with the four composites spanning the range of typical sizes present, but with the individuals within each composite being closely matched in size (for example, for red shiners: 5-10 at 35-40 mm, 5-10 at 40-45 mm, 5-10 at 45-50 mm, and 5-10 at 50-55 mm). Sample preparation is described in section (c) below.

(c) **Pit Monitoring.**

(1) Mining Phase (including during idle periods as defined in SMARA).

The operator shall monitor fish and water column profiles in each pit lake once every year during the period generally between September and November for the first five years after a pit lake is created. Fish monitoring should include sport fish where possible, together with other representative species that have comparison samples from the creek

> and/or other monitored ponds. Sport fish are defined as predatory, trophic level four fish such as bass, which are likely to be primary angling targets and have the highest relative mercury levels. The requirements of this subsection apply to any pit lake that is permanently wet and navigable by a monitoring vessel. If, in the initial five years after the pit lake is created, the applicable response threshold identified in subsection (e) is exceeded in any three of five monitoring years, the operator shall, solely at their own expense, undertake expanded analysis pursuant to subsection (f) and preparation of a lake management plan pursuant to subsection (g).

This section includes the routine mercury monitoring program for the first 5 years after each pit lake is created, in the course of aggregate mining. It involves the **annual testing** of large fish and small young-of-year fish, and the profiling of pond water constituents throughout the water column.

Large fish sampling will include the collection of fillet muscle samples for mercury analysis, from up to 30 separate individual adult, angling-size (≥ app. 6") fish, from multiple species as available. Based on past trends, these are likely to include:

- Bass, the top priority in this watershed, x up to 20, depending on presence of other species
- Other predator fish species like Catfish (White and/or Channel)
- Mid-water panfish such as Green Sunfish and Bluegill Sunfish
- Carp

If multiple species are present, target at least ten individual bass (if present), and ≥ 5 each of 2-3 additional species from different food-chain groups as listed above. If there are many species, it is better to collect statistically strong samples (higher numbers of individuals) from a few species rather than small numbers from many species. For each species sampled, try to span the range of adult sizes present.

Large fish may be collected with a variety of methods, including seining, baited set lines, gill netting, and angling. Extra fish not needed for analysis should be quickly released, to avoid unnecessary mortality. For fish chosen for mercury analysis, it is critical that they be weighed and measured before processing.

It is also critical, if analytical samples will be taken later in the laboratory, that the field samples be protected from freezer desiccation ("freezer burn"), as this is one of the largest potential sources of analytical error. If the fish are to be sacrificed and retained whole, they should be sealed in freezer-weight zip-close bags with all air removed before storing on ice for transport and then in a laboratory freezer. Later, after thawing, the analytical portion should be dissected from the thickest part of the fillet, sometimes called the "shoulder" area, above the lateral line and behind the gills. Alternatively, in the field or at the laboratory, a piece of fillet muscle may be taken and stored for later dissection of the analytical sample. In that case, the piece should be taken from the thickest part of the fillet and be at least 2 cm x 2 cm in cross section, the skin should be left on, and the sample should be sealed in plastic wrap and then in a freezer weight bag with all air removed. At the laboratory, after thawing for analysis, the analytical portion should be dissected out of the center of the fillet piece. In either case, the objective is to obtain a clean sample of fillet muscle

tissue (no skin etc.). Another good approach, developed at UC Davis, is to directly field-collect small biopsy samples of fillet muscle, allowing the live release of sampled fish and requiring no further sub-sampling of the tissue. This requires careful sealing of biopsy samples into pre-weighed vials; analytical sample weight is then calculated by re-weighing the vial with sample. The sample can later be analyzed directly for muscle mercury, on a fresh-wet weight basis.

Small fish are the most relevant samples in relation to wildlife exposure, because they are what most fish-eating birds and other fish-eating animals consume. Additionally, because small, young-of-year fish, by definition, track methylmercury exposure conditions specifically of the year sampled, each new year's crop will show an immediate change if exposure conditions change between years. As wildlife consume fish whole, mercury analyses of these samples should be done on a whole-fish basis, consistent with the baseline collections in the creek.

Small fish sampling should target three prevalent species, as available. These should be characterized with four multi-individual, whole fish composite samples for each species. This will result in up to 12 small fish composite samples. Each composite should ideally include at least five similar-sized individuals. The four composites should span the range of typical sizes present, but the individuals within each composite should be closely matched in size (for example, for red shiners: 5-10 at 35-40 mm, 5-10 at 40-45 mm, 5-10 at 45-50 mm, and 5-10 at 50-55 mm).

Small fish may be collected with a variety of methods, including seining, trapping, electro-fishing, and with dip-nets. To protect from desiccation, they should be held in water in the field and, during transport, on ice in sealed zip-close bags with air removed. Moisture is best maintained by keeping the sampled individuals together in one bag for each small fish species. In the laboratory, if samples are to be stored in a freezer, it is critical that they be frozen with water surrounding the fish, to avoid freezer desiccation and maintain fresh consistency. Using freezer-weight zip-close bags, add enough water to surround each set of bagged fish, and remove all air while sealing. Then seal into a second freezer-weight outer bag to avoid leaks, and place in the freezer. Alternatively, this can be done directly in the field, using dry ice in an ice chest.

Preparation for analysis will involve thawing the samples, arranging into composite groups, recording length and weight, and carefully homogenizing each composite. Rinse/clean the fish and arrange the individuals by size. Place into desired composite groupings. Measure and record fish lengths. Obtain fresh, wet weight of each composite group: lightly remove surface moisture by rolling on a paper towel; quickly place composite individuals into a pre-weighed weighing pan and obtain the composite wet/fresh weight. Average individual weight of the fish in each composite is calculated by dividing the composite weight by the number of fish. With multiple whole fish, an even mix is best achieved by first drying the samples and then grinding to an even powder. As the samples will be analyzed dry, it will be necessary to calculate the fresh sample moisture percentage, so that the dry weight mercury concentration analyzed can be converted to the corresponding natural, wet/fresh mercury concentration. Sample moisture percentage can be determined through sequential weighings of the weighing container, the container with fresh sample and, finally, the container with stabilized dry sample following 48 hours in a laboratory oven at 50-60 °C.

For all mercury analyses, a reputable mercury laboratory should be used and there must be a

sufficient amount of **quality assurance / quality control (QA/QC)** samples to assure that the data are reliable. This QA/QC should include method blanks, replicate analyses of some of the fish samples, mercury-spiked samples, and samples of reference materials containing certified levels of mercury. Results from the QA/QC samples must fall within acceptable ranges before the fish sample data can be treated as reliable. Acceptable QA/QC sample numbers and ranges include, for every 15 field samples, at least:

- One Laboratory Blank; ≤ 5 ng/g equivalent (well below typical Cache area sample ranges)
- One Duplicate Field Sample; Relative Percent Difference (RPD) ≤ 20%
- One Mercury-Spiked Field Sample; Recovery within 80-120%
- One Duplicate Mercury-Spiked Field Sample; Recovery within 80-120% and RPD ≤ 20%
- One Standard Reference Material (SRM) in sample matrix; ; Recovery within 80-120%
- One Duplicate SRM Continuing Calibration Value (CCV); Recovery within 80-120% and RPD ≤ 20%
- One aqueous mercury Laboratory Control Sample (LCS); Recovery within 80-120%

Additionally, a Level of Detection must be established that is well below the typical range of field sample mercury levels from this watershed, i.e. < 0.01 ppm.
For the most consistent analytical results and for inter-comparison, ideally a single laboratory with a strong track record should be used for the monitoring, including baseline creek analyses.

Water column profiling refers to lowering various water quality probes through the water, from surface to near bottom, recording levels of the different parameters at a series of depths. This should be done from a boat or other platform positioned over the deepest part of the pond. Use a depth-finder to assess general bottom contours of the entire pond and to find the deepest consistent (flat) bottom location to use as an index site. Use a reliable set of probes/meters and carefully calibrate each function within several days before use in the field. Water quality measures to be tested are those understood to influence the methylmercury cycle of water bodies, and include:

- Water Temperature
- Dissolved Oxygen: absolute concentration, and percent of saturation
- Conductivity
- pH and Oxidation-Reduction Potential (ORP)
- Turbidity or Total Suspended Solids
- Dissolved Organic Matter (DOC or DOM, FDOM)
- Algal Density by Chlorophyll and/or Phycocyanin.

Positioned over the deepest part of the pond, readings of these measures should be taken at approximately 1m intervals, or less, from just below the surface to just above the bottom sediments. The probes should be given time to equilibrate fully at each new depth, with readings taken only after they have stabilized at the new levels.

Profiling events should also include the recording bottom depth, and a measurement of general water clarity – by Secchi Depth: lowering a weighted white disk to the point that it loses visibility from above; recording that depth.

Timing of water column profiling, for routine once-per-year testing, should be mid-summer (typically early-mid August). This is because one of the largest potential drivers of elevated methylmercury production and movement into the food chain is seasonal oxygen depletion in the bottom water layers. If this may be occurring at a given pond, mid-summer profiling will best reveal it.

Additions to routine monitoring – During the initial five year period of routine monitoring, if there are three or more years of significantly elevated fish mercury, relative to ambient, the monitoring will be expanded with:

- extension of annual monitoring by five years.
- addition of expanded analyses, as described in subsection (f) below.
- preparation of a lake management plan, as described in subsection (g) below.

(2) Reclamation Phase.
No monitoring is required after mining has concluded, during the period that an approved reclamation plan is being implemented, provided reclamation is completed within the time specified by SMARA or the project approval, whichever is sooner.

No routine monitoring is required during the reclamation period – for ponds that have been found to not exceed ambient creek fish mercury levels. For ponds that do significantly exceed ambient levels in three or more monitoring years out of five, the reclamation phase will include expanded analyses and the preparation and implementation of a lake management plan, all requiring monitoring/testing as described in subsections (f) and (g) below.

(3) Post-Reclamation Phase.
After reclamation is completed, the operator shall monitor fish and water column profiles in each pit lake at least once every two years during the period of September-November for ten years following reclamation. Monitoring shall commence in the first calendar year following completion of reclamation activities. If fish monitoring results from the post-reclamation period exceed the applicable response threshold described in subsection (e) or, for ponds that have implemented mitigation management, results do not exhibit a general decline in mercury levels, the operator shall, solely at their own expense, undertake expanded analysis pursuant to subsection (f) and preparation of a lake management plan pursuant to subsection (g).

After reclamation, there will be a ten-year period of monitoring, as described in (c)(1) above, but once each two years rather than every year.

Additions to routine monitoring – As in (c)(1), if there are three or more years of significantly elevated fish mercury, relative to ambient, the monitoring will be expanded with:

- extension of biennial (every two years) monitoring by ten years.
- addition of expanded analyses, as described in subsection (f) below.
- preparation of a lake management plan, as described in subsection (g) below.

(4) Other Monitoring Obligation.
If monitoring conducted during both the mining and post-reclamation phase did not identify any exceedances of the ambient mercury level for a particular pit lake, and at the sole discretion of the Director no other relevant factors substantially support that continued monitoring is merited, the operator shall have no further obligations.

(d) Reporting.

(1) Pit Monitoring Results.
Reporting and evaluating of subsection (c) pit monitoring results shall be conducted by a qualified aquatic scientist or equivalent professional acceptable to the Director. Monitoring activities and results shall be summarized in a single report (addressing all wet pit lakes) and submitted to the Director within six months following each annual monitoring event. The report shall include, at a minimum: (1) results from subsection (b) (pit monitoring), in relation to subsection (a) (ambient mercury levels).

Routine, fish-based mercury monitoring has been conducted at the existing aggregate mining pits since 2015, with annual reports prepared after each year's work. This is ongoing.

(2) Expanded Analysis Results.
Reporting and evaluation of subsection (f) expanded analysis shall be conducted by a qualified aquatic scientist or equivalent professional acceptable to the Director. Results shall be summarized in a single report (addressing all affected wet pit lakes) and submitted to the Director within six months following each annual monitoring event. The report shall include, at a minimum, the results of the expanded analysis undertaken pursuant subsection (f).

After the first years of routine monitoring, three of the current wet pits were identified for expanded analyses to help identify possible reasons for the elevated fish mercury levels and to help identify possible management/remediation approaches, as detailed below in section (f). This included expanded water column profiling of a variety of parameters and testing of bottom sediments. This work began at three identified ponds plus one lower mercury control pond in 2018, with annual reports following each year of expanded testing.

(3) Data Sharing.
For pit lakes open to the public, the Director may submit the data on mercury concentrations in pit lake fish to the state Office of Environmental Health Hazard Assessment (or its successor) for developing site-specific fish consumption advisories.

As of March 2021, none of the aggregate mining ponds are open to the public.

(e) Response Thresholds.

(1) Fish Consumption Advisory.

If at any time during any phase of monitoring the pit lake's average sport fish tissue mercury concentration exceeds the Sport Fish Water Quality Objective, as it may be modified by the state over time (as of 2019, the level was 0.2 mg/kg), the operator shall post fish consumption advisory signs at access points around the lake and around the lake perimeter. Catch-and-release fishing may still be allowed. Unless site-specific guidance has been developed by the state's Office of Health Hazard Assessment or the County, statewide fish consumption guidance shall be provided.

The ponds that were identified as elevated in fish mercury have been or are being posted with warnings not to eat the fish. As noted above, as of January 2021 none of the ponds have been opened to the public.

(2) Mining Phase Results.
If, during the mining phase of monitoring, the pit lake's average fish tissue mercury concentration exceeds the ambient mercury level for any three of five monitoring years, annual monitoring shall continue for an additional five years, and the operator shall undertake expanded analysis pursuant to subsection (f) and preparation of a lake management plan pursuant to subsection (g).

Ponds identified as elevated in fish mercury during three or more of the initial five years of routine monitoring shall continue annual, fish-based monitoring for another five years, and begin expanded analyses to help identify possible reasons for the elevated fish mercury levels and to help identify possible management/remediation approaches, as detailed below in section (f), and to use this information to develop and implement corresponding management/remediation, as in (g) below.

(3) Post-Reclamation Phase Results.
If during the first ten years of the post-reclamation phase of monitoring, the pit lake's average fish tissue mercury concentration exceeds the ambient mercury level for any three of five monitoring years, biennial monitoring shall continue for an additional ten years, and the operator shall undertake expanded analysis pursuant to subsection(f) and preparation of a lake management plan pursuant to subsection(g).

Similar to (e)(2) above, findings of elevated fish mercury status in three of five monitoring years during the post-reclamation ten years of testing every other year shall lead to expanded analyses and the development and implementation of a management/remediation plan, as below in (f) and (g)

(f) Expanded Analysis.

(1) General.
If during the mining or post-reclamation phase, any pit lake's average fish tissue mercury concentration exceeds the ambient mercury level for any three years, the operator shall undertake expanded analyses. The analysis shall include expanded lake water column

profiling (a minimum of five profiles per affected wet pit lake plus one or more nonaffected lakes for control purposes) conducted during the warm season (generally May through October) in an appropriate deep profiling location for each pit lake. The following water quality parameters shall be collected at regular depth intervals, from surface to bottom of each lake, following protocols identified in subsection (a): temperature, dissolved oxygen, conductivity, pH and oxidation-reduction potential (ORP), turbidity or total suspended solids, dissolved organic matter, and algal density by Chlorophyll or Phycocyanin. The initial analysis shall also include one-time collections of fine grained (clay/silt) bottom sediments from a minimum of six well distributed locations for each affected lake, and from one or more non-affected lakes for control purposes, to be analyzed for mercury and organic content.

Pond water profiling is expanded to five or more different profiling events per year, spread across the general warm season (May-October) when most biological activity occurs and when there can also be important shifts in water chemistry. Between these months, California water bodies typically stratify (separate) into warm, oxygenated surface layers and isolated cool bottom water. This can result in a series of changes in water chemistry in the different layers – that can influence the mercury cycle. In contrast, in the cool season months of approximately November through March-April, ponds normally cool to a uniform temperature and remain well-mixed and oxygenated top to bottom. Warm season profiling should provide the best evidence to help guide lake management.

(2) Scope of Analysis.
The purpose of the expanded analyses is to identify and assess potential factors linked to elevated methylmercury production and/or bioaccumulation in each pit lake. The scope of the expanded analyses shall include monitoring and analysis appropriate to fulfill this purpose, invoking best practices in the industry. In addition to the analyses described in subsection (f)(1) above, the analysis should also consider such factors as: electrical conductivity, bathymetry (maximum and average depths, depth-to-surface area ratios, etc.), and trophic status indicators (concentrations, Secchi depth, chlorophyll a, fish assemblages, etc.). Additional types of testing may be indicated and appropriate if initial results are inconclusive.

(The Ordinance language is self-explanatory from here on)

(3) Use of Results. The results of the expanded analyses undertaken pursuant to this subsection shall be used to inform the preparation of a lake management plan described below under subsection (g).

(g) Lake Management Activities

(1) General.
If monitoring conducted during the mining or post-reclamation phases triggers the requirement to undertake expanded analysis and prepare and implement a lake management plan, the operator shall implement lake management activities designed by a

qualified aquatic scientist or equivalent professional acceptable to the Director, informed by the results of subsection (f). Options for addressing elevated mercury levels may include (A) and/or (B) below at the Director's sole discretion and at the operator's sole expense.

(A) *Lake Management Plan*.
Prepare a lake management plan that provides a feasible, adaptive management approach to reducing fish tissue mercury concentrations to at or below the ambient mercury level. Potential mercury control methods could include, for example: addition of oxygen to or physical mixing of anoxic bottom waters; alteration of water chemistry (modify pH or organic carbon concentration); and/or removal or replacement of affected fish populations. The lake management plan may be subject to external peer review at the discretion of the Director. Lake management activities shall be appropriate to the phase of the operation (e.g., during mining or post-reclamation). The Lake Management Plan shall include a recommendation for continued monitoring and reporting. All costs associated with preparation and implementation of the lake management plan shall be solely those of the operator. Upon acceptance by the Director, the operator shall immediately implement the plan. The lake management plan shall generally be implemented within three years of reported results from the expanded analyses resulting from subsection (f). If lake management does not achieve acceptable results and/or demonstrate declining mercury levels after a maximum of three years of implementation, at the sole discretion of the Director, the operator may prepare an alternate management plan with reasonable likelihood of mitigating the conditions.

(B) *Revised Reclamation Plan*.
As an alternative to (A), or if (A) does not achieve acceptable results and/or demonstrate declining mercury levels after a maximum of three years of implementation, at the sole discretion of the Director, the operator shall prepare and submit revisions to the reclamation plan (including appropriate applications and information for permit amendment) to fill the pit lake with suitable fill material to a level no less than five (5) feet above the average seasonal high groundwater level, and modify the end use to agriculture, habitat, or open space at the discretion of the Director, subject to Article 6 of the Mining Ordinance and/or Article 8 of the Reclamation Ordinance as may be applicable.

(2) Implementation Obligations.

(A) If a lake management plan is triggered during the mining or post-reclamation phase and the subsequent lake management activities do not achieve acceptable results and/or demonstrate declining mercury levels, the operator may propose different or additional measures for consideration by the Director and implementation by the operator, or the Director may direct the operator to proceed to modify the reclamation plan as described in subsection (g)(1)(B).

(B) Notwithstanding the results of monitoring and/or lake management activities during the mining phase, the operator shall, during the post-reclamation phase, conduct the required ten years of biennial monitoring.

(C) If monitoring conducted during the post-reclamation phase identifies three monitoring years of mercury concentrations exceeding the ambient mercury level, the operator shall implement expanded analyses as in subsection (f), to help prepare and implement a lake management plan and associated monitoring.

(D) If subsequent monitoring after implementation of lake management activities, during the post-reclamation phase, demonstrates levels of fish tissue mercury at or below the ambient mercury level for any three monitoring years (i.e., the management plan is effective), the operator shall be obligated to continue implementation of the plan and continue monitoring, or provide adequate funding for the County to do both, in perpetuity.

References Cited

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APPENDIX A

YOLO COUNTY RECLAMATION ORDINANCE, SEC. 10-5.517 MERCURY BIOACCUMULATION IN FISH

– December 2019 Revision –

(as adopted)

YOLO COUNTY RECLAMATION ORDINANCE

Section 10.5.517. Mercury Bioaccumulation in Fish.
As part of each approved long-term mining plan involving wet pit mining to be reclaimed to a permanent pond, lake, or water feature, the operator shall maintain, monitor, and report to the Director according to the standards given in this section. Requirements and restrictions are distinguished by phase of operation as described below.

(a) **Mercury Protocols.** The Director shall issue and update as needed "Lower Cache Creek Off-Channel Pits Mercury Monitoring Protocols" (Protocols), which shall provide detailed requirements for mercury monitoring activities. The Protocols shall include procedures for monitoring conditions in each pit lake, and for monitoring ambient mercury level in the lower Cache Creek channel within the CCAP planning area, as described below. The Protocols shall be developed and implemented by a qualified aquatic scientist or equivalent professional acceptable to the Director. The Protocols shall identify minimum laboratory analytical reporting limits, which may not exceed the applicable response threshold identified in subsection (e) below. Data produced from implementing the Protocols shall meet or exceed applicable standards in the industry.

(b) **Ambient Mercury Level.** The determination of the ambient or "baseline" fish mercury level shall be undertaken by the County every ten years in years ending in 0. This analysis shall be undertaken by the County for use as a baseline of comparison for fish mercury testing conducted in individual wet mining pits. The work to establish this baseline every ten years shall be conducted by a qualified aquatic systems scientist acceptable to the Director and provided in the form of a report to the Director. It shall be paid for by the mining permit operators on a fair-share basis. The results of monitoring and evaluation of available data shall be provided in the report to substantiate the conclusions regarding ambient concentrations of mercury in fish within the lower Cache Creek channel within the CCAP planning area.

(c) **Pit Monitoring.**

(1) Mining Phase (including during idle periods as defined in SMARA).
The operator shall monitor fish and water column profiles in each pit lake once every year during the period generally between September and November for the first five years after a pit lake is created. Fish monitoring should include sport fish where possible, together with other representative species that have comparison samples from the creek and/or other monitored ponds. Sport fish are defined as predatory, trophic level four fish such as bass, which are likely to be primary angling targets and have the highest relative mercury levels. The requirements of this subsection apply to any pit lake that is permanently wet and navigable by a monitoring vessel. If, in the initial five years after the pit lake is created, the applicable response threshold identified in subsection (e) is exceeded in any three of five monitoring years, the operator shall, solely at their own expense, undertake expanded analysis pursuant to subsection (f) and preparation of a lake management plan pursuant to subsection (g).

(2) Reclamation Phase.
No monitoring is required after mining has concluded, during the period that an approved reclamation plan is being implemented, provided reclamation is completed within the time specified by SMARA or the project approval, whichever is sooner.

(3) Post-Reclamation Phase.
After reclamation is completed, the operator shall monitor fish and water column profiles in each pit lake at least once every two years during the period of September-November for ten years following reclamation. Monitoring shall commence in the first calendar year following completion of reclamation activities. If fish monitoring results from the post-reclamation period exceed the applicable response threshold described in subsection (e) or, for ponds that have implemented mitigation management, results do not exhibit a general decline in mercury levels, the operator shall, solely at their own expense, undertake expanded analysis pursuant to subsection (f) and preparation of a lake management plan pursuant to subsection (g).

(4) Other Monitoring Obligation.
If monitoring conducted during both the mining and post-reclamation phase did not identify any exceedances of the ambient mercury level for a particular pit lake, and at the sole discretion of the Director no other relevant factors substantially support that continued monitoring is merited, the operator shall have no further obligations.

(d) Reporting.

(1) Pit Monitoring Results.
Reporting and evaluating of subsection (c) pit monitoring results shall be conducted by a qualified aquatic scientist or equivalent professional acceptable to the Director. Monitoring activities and results shall be summarized in a single report (addressing all wet pit lakes) and submitted to the Director within six months following each annual monitoring event. The report shall include, at a minimum: (1) results from subsection (b) (pit monitoring), in relation to subsection (a) (ambient mercury levels).

(2) Expanded Analysis Results.
Reporting and evaluation of subsection (f) expanded analysis shall be conducted by a qualified aquatic scientist or equivalent professional acceptable to the Director. Results shall be summarized in a single report (addressing all affected wet pit lakes) and submitted to the Director within six months following each annual monitoring event. The report shall include, at a minimum, the results of the expanded analysis undertaken pursuant subsection (f).

(3) Data Sharing.
For pit lakes open to the public, the Director may submit the data on mercury concentrations in pit lake fish to the state Office of Environmental Health Hazard Assessment (or its successor) for developing site-specific fish consumption advisories.

(e) Response Thresholds.

(1) Fish Consumption Advisory.
If at any time during any phase of monitoring the pit lake's average sport fish tissue mercury concentration exceeds the Sport Fish Water Quality Objective, as it may be modified by the state over time (as of 2019, the level was 0.2 mg/kg), the operator shall post fish consumption advisory signs at access points around the lake and around the lake perimeter. Catch-and-release fishing may still be allowed. Unless site-specific guidance has been developed by the state's Office of Health Hazard Assessment or the County, statewide fish consumption guidance shall be provided.

(2) Mining Phase Results.
If, during the mining phase of monitoring, the pit lake's average fish tissue mercury concentration exceeds the ambient mercury level for any three of five monitoring years, annual monitoring shall continue for an additional five years, and the operator shall undertake expanded analysis pursuant to subsection (f) and preparation of a lake management plan pursuant to subsection (g).

(3) Post-Reclamation Phase Results.
If during the first ten years of the post-reclamation phase of monitoring, the pit lake's average fish tissue mercury concentration exceeds the ambient mercury level for any three of five monitoring years, biennial monitoring shall continue for an additional ten years, and the operator shall undertake expanded analysis pursuant to subsection(f) and preparation of a lake management plan pursuant to subsection(g).

(f) Expanded Analysis.

(1) General.
If during the mining or post-reclamation phase, any pit lake's average fish tissue mercury concentration exceeds the ambient mercury level for any three years, the operator shall undertake expanded analyses. The analysis shall include expanded lake water column profiling (a minimum of five profiles per affected wet pit lake plus one or more nonaffected lakes for control purposes) conducted during the warm season (generally May through October) in an appropriate deep profiling location for each pit lake. The following water quality parameters shall be collected at regular depth intervals, from surface to bottom of each lake, following protocols identified in subsection (a): temperature, dissolved oxygen, conductivity, pH and oxidation-reduction potential (ORP), turbidity or total suspended solids, dissolved organic matter, and algal density by Chlorophyll or Phycocyanin. The initial analysis shall also include one-time collections of fine grained (clay/silt) bottom sediments from a minimum of six well distributed locations for each affected lake, and from one or more non-affected lakes for control purposes, to be analyzed for mercury and organic content.

(2) Scope of Analysis.
The purpose of the expanded analyses is to identify and assess potential factors linked to elevated methylmercury production and/or bioaccumulation in each pit lake. The scope of the expanded analyses shall include monitoring and analysis appropriate to fulfill this purpose, invoking best practices in the industry. In addition to the analyses described in subsection (f)(1) above, the analysis should also consider such factors as: electrical conductivity, bathymetry (maximum and average depths, depth-to-surface area ratios, etc.), and trophic status indicators (concentrations, Secchi depth, chlorophyll a, fish assemblages, etc.). Additional types of testing may be indicated and appropriate if initial results are inconclusive.

(3) Use of Results. The results of the expanded analyses undertaken pursuant to this subsection shall be used to inform the preparation of a lake management plan described below under subsection (g).

(g) Lake Management Activities

(1) General.
If monitoring conducted during the mining or post-reclamation phases triggers the requirement to undertake expanded analysis and prepare and implement a lake management plan, the operator shall implement lake management activities designed by a qualified aquatic scientist or equivalent professional acceptable to the Director, informed by the results of subsection (f). Options for addressing elevated mercury levels may include (A) and/or (B) below at the Director's sole discretion and at the operator's sole expense.

(A) *Lake Management Plan*.
Prepare a lake management plan that provides a feasible, adaptive management approach to reducing fish tissue mercury concentrations to at or below the ambient mercury level. Potential mercury control methods could include, for example: addition of oxygen to or physical mixing of anoxic bottom waters; alteration of water chemistry (modify pH or organic carbon concentration); and/or removal or replacement of affected fish populations. The lake management plan may be subject to external peer review at the discretion of the Director. Lake management activities shall be appropriate to the phase of the operation (e.g., during mining or post-reclamation). The Lake Management Plan shall include a recommendation for continued monitoring and reporting. All costs associated with preparation and implementation of the lake management plan shall be solely those of the operator. Upon acceptance by the Director, the operator shall immediately implement the plan. The lake management plan shall generally be implemented within three years of reported results from the expanded analyses resulting from subsection (f). If lake management does not achieve acceptable results and/or demonstrate declining mercury levels after a maximum of three years of implementation, at the sole discretion of the Director, the operator may prepare an alternate management plan with reasonable likelihood of mitigating the conditions.

(B) *Revised Reclamation Plan*.
As an alternative to (A), or if (A) does not achieve acceptable results and/or demonstrate declining mercury levels after a maximum of three years of implementation, at the sole discretion of the Director, the operator shall prepare and submit revisions to the reclamation plan (including appropriate applications and information for permit amendment) to fill the pit lake with suitable fill material to a level no less than five (5) feet above the average seasonal high groundwater level, and modify the end use to agriculture, habitat, or open space at the discretion of the Director, subject to Article 6 of the Mining Ordinance and/or Article 8 of the Reclamation Ordinance as may be applicable.

(2) Implementation Obligations.

(A) If a lake management plan is triggered during the mining or post-reclamation phase and the subsequent lake management activities do not achieve acceptable results and/or demonstrate declining mercury levels, the operator may propose different or additional measures for consideration by the Director and implementation by the operator, or the Director may direct the operator to proceed to modify the reclamation plan as described in subsection (g)(1)(B).

(B) Notwithstanding the results of monitoring and/or lake management activities during the mining phase, the operator shall, during the post-reclamation phase, conduct the required ten years of biennial monitoring.

(C) If monitoring conducted during the post-reclamation phase identifies three monitoring years of mercury concentrations exceeding the ambient mercury level, the operator shall implement expanded analyses as in subsection (f), to help prepare and implement a lake management plan and associated monitoring.

(D) If subsequent monitoring after implementation of lake management activities, during the post-reclamation phase, demonstrates levels of fish tissue mercury at or below the ambient mercury level for any three monitoring years (i.e., the management plan is effective), the operator shall be obligated to continue implementation of the plan and continue monitoring, or provide adequate funding for the County to do both, in perpetuity.