Clifton Court Forebay Aquatic Weed and Algal Bloom Control Program

Aquatic weeds dominate CCF from late spring through fall. Surveys of the aquatic plant community in CCF show aquatic weeds were present in 91% of the forebay's surface area in 2014 compared to only 38% in 2006. In 2006, the aquatic weed community was dominated by *Egeria densa*. The results of a 2014 survey showed a mixed assemblage of mostly submersed plants dominated by Southern naiad (*Najas guadalupensis*), sago pondweed (*Potamogeton pectinalus*), American pondweed (P*otamogeton nodosus*), and curly-leaf pondweed (*Potamogeton crispus*). *P. crispus* was determined by CDFW to be a major invader in the Sacramento-San Joaquin Delta (CDFW 2015, and *P. crispus* and *E. densa* are targeted for control by DPR-DBW under the Submersed Aquatic Vegetation Control Program (CDPR 2018).

Excessive growth of submerged aquatic weeds in CCF can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of rooted plants break free, combine into "mats," and accumulate on the primary trashracks and secondary louvers. This mass of uprooted and fragmented vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the water pumping rate to prevent potential equipment damage through pump cavitation and excessive weight on louver array causing collapsed structure. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also block the passage of fish into the Skinner Fish Facility, thereby reducing the efficiency of fish salvage operations. Therefore, controlling aquatic vegetation will improve salvage efficiency and decrease debris management issues, both of which in turn will promote salmonid survival.

Mechanical methods are implemented to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trashracks. During high weed load periods in late summer and fall when the plants senesce and fragment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the Forebay and the intake channel upstream of the trashracks and louvers. The objective is to decrease the weed load on the trashracks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical machine ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading site, unsafe field conditions such as high winds, and equipment maintenance.

In addition, dense stands of aquatic weeds provide cover for unwanted predators that may prey on ESA-listed species within CCF. Submerged aquatic vegetation (SAV) has been linked with piscivorous fish densities since the mid-1990s (Grimaldo and Hymanson 1999). Thick stands of aquatic vegetation can create favorable habitat conditions for nonnative fish species that do well in warm, clear, slow-moving water (Nobriga et al. 2005; Ferrari et al. 2014; and Durand et al. 2016). These stands harbor invasive sunfish, including largemouth bass, bluegill, redear sunfish, and warmouth commonly found in CCF. Nobriga et al. (2007) concluded that restoration projects in the Delta need to discourage SAV because largemouth bass were observed to have a high per capita predatory influence and have become established primarily where SAV has proliferated. Furthermore, Ferrari et al. (2014) suggest that SAV and largemouth bass have the potential to interact synergistically to the detriment of native fish species. This information suggests that reducing SAV in CCF may reduce predation and subsequently reduce pre-screen loss of salmonids. Aquatic weed control is included as a conservation measure to reduce mortality of ESA-listed fish species within the CCF (see *Section 4.95.11.3 Skinner Fish Facility Improvements*).

Aquatic weed assemblages change from year to year in the CCF from predominantly *Egeria densa* to one dominated by curly-leaf pondweed, sago pondweed, and southern naiad. Depending upon the aquatic weed assemblage, DWR applies either copper-based herbicides to control *E. densa* or Aquathol K, an endothall-based aquatic herbicide, to control pondweed species. Treatment areas are typically about 900 acres, and no more than 50% of the 2,180 total surface acres.

Harmful algal blooms (HAB) in CCF are of concern as they degrade drinking water quality through the production of cyanotoxins that are harmful to both humans and wildlife and produce compounds that impart an unpleasant taste and odor to drinking water. The frequency of occurrence of HAB's is increasing world-wide, including in California and the Sacramento-San Joaquin Delta. There are many species of HAB-forming cyanobacteria present in the Delta and CCF, including Microcystis, Aphanizomenon, Dolichospermum, Planktothrix, Cuspidothrix, and Cylindrospermum that can produce cyantoxins including microcystins, cylindrospermopsin, anatoxin-a and saxitoxin.

One HAB-forming cyanobacterium of concern is Microcystis spp. Microcystis produces cyanotoxins, including the liver toxin microcystin, that can cause skin rashes, gastrointestinal distress, liver failure, and even death in humans, dogs and wildlife. Microcystis was first described in 1999 in the San Francisco Estuary (Lehman et al. 2013). Since its initial observation, Microcystis blooms have occurred every year in the Delta, typically starting in July and ending in October. Recent drought conditions caused enhanced Microcystis blooms in Delta waterways that lasted into December (Lehman et al. 2017). Blooms originate in the San Joaquin River and expand throughout most of the Delta and past the confluence of the Sacramento-San Joaquin rivers.

Some key abiotic drivers of Microcystis blooms are flow, water temperature, salinity, and nutrient concentrations. Microcystis blooms start when average daily water temperatures exceed 18°C and proliferate in aquatic environments when water temperatures are greater than 25°C. Toward the end of autumn, Microcystis blooms die off when water temperatures average below 15°C in the freshwater interior Delta. Therefore, changes in the timing and during of temperature ranges may influence Microcystis bloom in the Delta.

In 2015, the U.S. Environmental Protection Agency (EPA) published non-regulatory 10-day finished drinking water advisory levels for microcystins and cylindrospermopsin. These are established health-based advisory levels for concentrations at or below which adverse human health effects are not anticipated to occur over a 10-day exposure period (EPA 2015). In addition, EPA listed cyanotoxins including microcystin-LR, cylindrospermopsin, and anatoxin–a on the Contaminant Candidate Lists (CCL), which identify contaminants that may need regulation under the Safe Drinking Water Act. In 2016, the State Water Resources Control Board provided updated voluntary guidance on HABs in recreational waters and published recreational health advisory levels for microcystins, anatoxin-a, and cylindrospermopsin (California Cyanobacteria and Harmful Algal Blooms Network 2010).

DWR first began monitoring for cyanotoxins in the SWP in 2006 and began issuing recreational advisories in 2015. The SWP monitoring locations include the CCF inlet and Banks Pumping Plant, which pumps water from CCF into Bethany Reservoir and the California Aqueduct. Monitoring is typically conducted during the "algal bloom season" of April through October. A HAB within CCF may necessitate the application of an algaecide to halt the production of cyanotoxins and protect downstream drinking water sourcewaters.

Attached benthic cyanobacteria blooms have occurred in CCF that produce compounds that cause unpleasant tastes and odors to finished drinking water. The highest biomass of taste- and odor-producing cyanobacteria was present in the nearshore areas but not limited to shallow benthic zone. Geosmin and 2-methylisoborneol (MIB) are natural byproducts of algal chlorophyll production. The finished drinking water secondary maximum contaminant level (MCL) for taste and odor compounds is 10 ng/L of geosmin and 5 ng/L of MIB. Historically, copper sulfate was applied to the nearshore areas of CCF when results of solid phase microextraction analysis exceed the control tolerances (MIB < 5 ng/L and geosmin < 10 ng/L) (DWR 2013). Application areas varied considerably in past years based on the distribution of the benthic algal bloom in CCF.

Aquatic weed and algae treatments would occur on an as-needed basis dependent upon the level of vegetation biomass, the cyanotoxin concentration from the HAB, or concentration of taste and odor compounds. It is not possible to predict future CCF conditions with climate change. However, the frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year, as demonstrated by the history of past applications. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues; or later in the season, when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications.

DWR receives Clean Water Act pollutant discharge coverage under the National Pollutant Discharge Elimination System (NPDES) Permit No. CAG990005 (General Permit) issued by SWRCB for application of aquatic pesticides to the SWP's aqueducts, forebays, and reservoirs. SWRCB functions as the USEPA's non-federal representative for implementation of the Clean Water Act in California.

A Mitigated Negative Declaration was prepared by DWR to comply with CEQA requirements associated with regulatory requirements established by SWRCB. DWR, a public entity, was granted a Section 5.3 Exception by SWRCB (Water Quality Order 2004-0009-DWQ). Under the exception, DWR is not required to meet the copper limitation in receiving waters defined in DWR's Aquatic Pesticide Application Plan as occurring on an as-needed basis during the year, after other options have been exhausted.

To effectively treat a dynamic aquatic weed assemblage and harmful algal blooms, multiple aquatic pesticide compounds are required to control aquatic weeds and algal blooms in CCF. The preferred products are:

1) Aquathol K, an endothall-based aquatic herbicide, that is effective on pondweeds;
2) copper-based compounds that are effective on *E. densa* and cyanobacteria and green algae. The copper-based aquatic herbicides include copper sulfate pentahydrate and chelated copper herbicides; and
3) peroxygen-based algaecides (e.g., PAK 27) that are effective on cyanobacteria.

Aquathol K

The dipotassium salt of endothall is used for control of aquatic weeds and is the active ingredient in Aquathol® K (liquid formulation). Aquathol K is a widely used herbicide to control submerged weeds in lakes and ponds, and the short residual contact time (12-48 hours) makes it effective in both still and slow-moving water. Aquathol K is effective on many weeds, including hydrilla, milfoil, and curly-leaf pondweed, and begins working on contact to break down cell structure and inhibit protein synthesis. Without the ability to grow, the weed dies. Full kill takes place in 1 to 2 weeks. As weeds die, they sink to the bottom and decompose. Aquathol K is not effective at controlling *E. densa*.

Aquathol K is registered for use in California and has effectively controlled pondweeds and southern naiad in CCF and in other lakes. Endothall has low acute and chronic toxicity effects to fish. The LC_{50} for salmonids is 20-40 times greater than the maximum concentration allowed to treat aquatic weeds. The EPA maximum concentration allowed for Aquathol K is 5 parts per million (ppm). A recent study (Courter *et al.* 2012) of the effect of *Cascade*® (same endothall formulation as Aquathol K) on salmon and steelhead smolts showed no sublethal effects until exposed to 9-12 ppm, that is, 2-3 times greater than the 5 ppm maximum concentration allowed by the EPA and about 4-6 times greater than the 2-3 ppm applied in past CCF treatments. In the study, steelhead and salmon smolts showed no statistical difference in mean survival between the control group and treatment groups, however, steelhead showed slightly lower survival after 9 days at 9-12 ppm. Based on the studies with salmonids, Aquathol K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon, steelhead and other fish. No studies have assessed the exposure risk to green sturgeon.

When aquatic plant survey results indicate that pondweeds are the dominant species in CCF, Aquathol K will be selected due to its effectiveness in controlling these species. Aquathol K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and forebay depth. The target concentration of treatments will be 2-3 ppm, which is well below the concentration of 9-12 ppm where sublethal effects have been observed (Courter *et al.* 2012). DWR will monitor herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples will be submitted to a laboratory for analysis. There is no “real time” field test for endothall. No more than 50% of the surface area of CCF will be treated at one time. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to 24 hours to reduce the residual endothall concentration for NPDES compliance purposes.

<u>Copper-based Aquatic Herbicides and Algaecides</u>

Copper herbicides and algaecides include chelated copper products and copper sulfate pentahydrate crystals. When aquatic plant survey results indicate that *E. densa* is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. *E. densa* is not affected by application of Aquathol K. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Copper herbicides and algaecides will be applied in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume and the depth of the forebay. Applications of copper herbicides will be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR will monitor dissolved copper concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time will be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50% of the surface area of CCF will be treated at one time.

<u>Peroxygen-Based Algaecides</u>

PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI).

PAK 27 will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the surface area of CCF will be treated at one time.

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HAB), or concentration of taste and odor compounds. The following are operational procedures to minimize impacts on listed species during aquatic herbicide treatment for application of Aquathol K and copper-based products and algaecide treatment for application of peroxide-based algaecides in CCF:

- Apply Aquathol K and copper-based aquatic pesticides, as needed, from June 28 to August 31.

- Apply Aquathol K and copper-based aquatic pesticides, as needed, prior to June 28 or after August 31 if the average daily water temperature within CCF is at or above 25°C and if Delta smelt, salmonids and green sturgeon are not at additional risk from the treatment as conferred by NMFS and USFWS.
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, during periods of activated Delta Smelt and salmonid protective measures when average daily water temperature in CCF is below 25°C if the following conditions are met:
    - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
    - The herbicide application does not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within CCF (e.g. after predicted mortality has occurred due to predation or other factors) has been exceeded, and
    - The radial gates remain closed for 24 hours after the completion of the application, unless it is conferred that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present within the CCF.
- Apply peroxygen-based aquatic algaecides, as needed, year-round. There are no anticipated impacts on fish with the use of peroxygen-based aquatic algaecides in CCF during or following treatment.
- Monitor the salvage of listed fish at the Skinner Fish Facility prior to the application of the aquatic herbicides and algaecides in CCF.
- For Aquathol K and copper compounds, close the radial intake gates at the entrance to CCF prior to the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility and to prevent any possibility of aquatic pesticide diffusing into the Delta.
- For Aquathol K and copper compounds, the radial gates will remain closed for a minimum of 12 and up to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in the forebay, and to reduce residual endothall concentrations for drinking water compliance purposes. (Contact time is dependent upon pesticide type, applied concentration, and weed or algae assemblage). Radial gates would be reopened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure).
- For peroxide-based algaecides, the radial gates will be closed prior to the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may reopen immediately after the treatment as the required contact time is less than 1 minute and there is no residual by-product of concern.
- Application will be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Aquatic herbicides and algaecides will be applied by boat or by aircraft.

    - Boat applications will be by subsurface injection system for liquid formulations and boat-mounted hopper dispensing system for granular formulations. Applications would start at the shore and move systematically farther offshore, enabling fish to move out of the treatment area.
    - Aerial applications of granular and liquid formulations will be by helicopter or aircraft. No aerial spray applications will occur during windspeeds above 15 mph to prevent spray drift.

- Application would be to the smallest area possible that provides relief to SWP operations or water quality. No more than 50% of CCF will be treated at one time.
- Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per NPDES permit requirements, will be collected before, during and after application. Additional water quality samples may be collected during and following treatment for drinking water compliance purposes. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.
- No monitoring of peroxide concentration in the water column will occur during and after application as the reaction is immediate and there is no residual. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.
- A spill prevention plan will be implemented in the event of an accidental spill.

Aquatic weed and algae treatments would occur on an as-needed basis. The timing of application is an avoidance measure and is based on the life history of Chinook salmon and steelhead in the Central Valley's Delta region and of Delta smelt. Green sturgeon are present in the area year-round. Migrations of juvenile winter-run Chinook salmon and spring-run Chinook salmon primarily occur outside of the summer period in the Delta. Central Valley (CV) steelhead have a low probability of being in the South Delta during late June when water temperatures exceed 25°C through the first rainfall flush event, which can occur as late at December in some years (Grimaldo 2009). Delta smelt are not expected to be in CCF during this time period. Delta smelt are not likely to survive when water temperatures reach a daily average of 25°C, and they are not expected to occur in the Delta prior to the first flush event. Therefore, the likelihood of herbicide exposure to Chinook salmon, CV steelhead, and Delta smelt during the proposed herbicide treatment timeframe in CCF is low.

Additional protective measures will be implemented to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within CCF. The radial intake gates to CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed or algae assemblage. Additionally, following the gate closure and prior to aquatic herbicide the applications of Aquathol K and copper-based pesticides following gate closures, the water is drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, and it lowers the water level in the CCF to decrease the total amount of herbicide that would needed to be applied, per volume of water, and aides in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of CCF, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the California Aqueduct via Banks PP will reduce the exposure time of any ESA-listed fish species present in CCF.

Citations

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