Algaecide Application

Lake(s): Lake Elsinore and Canyon Lake

Description:

The application of an algaecide directly to the lake surface kills algae and prevents algal blooms from forming. PAK® 27 is an algaecide that works through an oxidation process, releasing hydrogen peroxide into the water supply. This algaecide allows for selective treatment for cyanobacteria and is non-toxic to other forms of aquatic life. Other algaecides could also be considered that may be more effective for all types of algae, but potentially more toxic to other aquatic species after repeated usage over multiple years (e.g., copper sulfate). Algaecides may be used on an as-needed basis or as part of a treatment train with alum or other treatment methods. California has a statewide general NPDES permit for use of algaecides or aquatic herbicides registered for use in California (Water Quality Order No. 2013-0002-DWQ). Costs were estimated for a single application, but multiple applications per year, timed around historical algal blooms, would provide the greatest benefit.

Photo of algaecide application

Source: http://www.peroxygensolutions.com/pak-27/how-to-apply

Water Quality Benefits:

Control of algae growth and impairments caused by eutrophication

Constraints and Limitations:

Repeated use of some algaecides can cause elevated levels of toxins in the lake bottom. Given that nutrients are not addressed, new algae blooms may arise shortly after an algaecide treatment. The frequency of application required to achieve effective results is unknown and will require additional study.

Assumptions:

The analysis assumes the top four feet of both Lake Elsinore and Canyon Lake are treated annually with PAK27 at an application rate of 30 lbs/Acre Foot (AF). The cost per pound is assumed at $1.30, based on discussions with a leading algaecide provider. Additional costs are assumed for shipping and application by lake staff.

Costs:

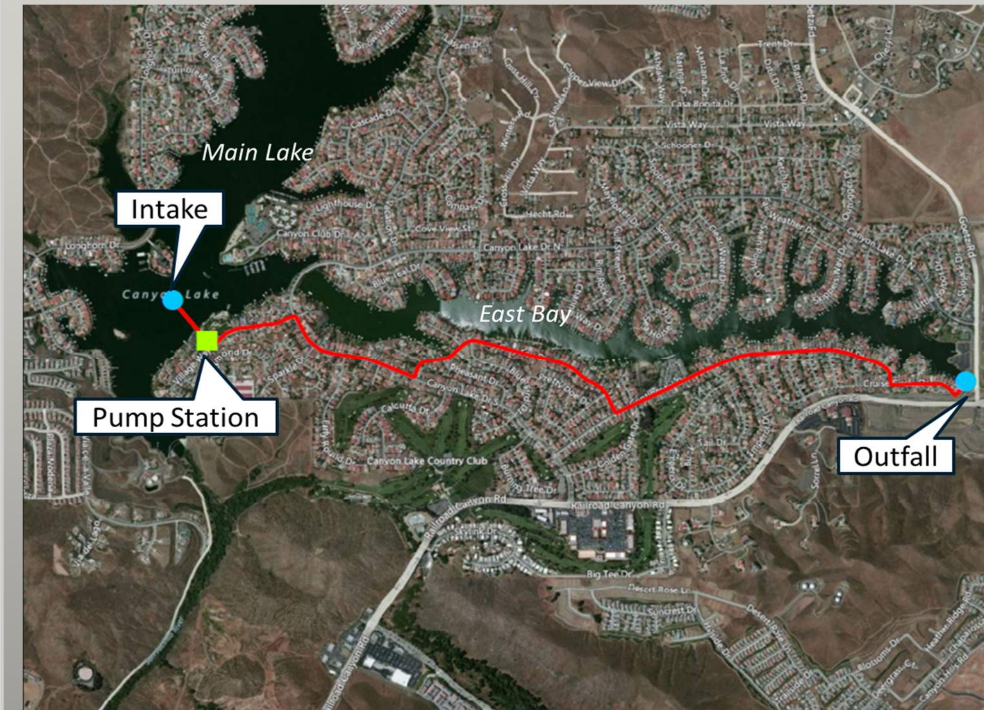
Per Application Cost Items	Canyon Lake	Lake Elsinore
Surface Acres	500	3,000
Volume of Treatment (AF)[1]	2,000	12,000
Algaecide application (lbs/event)	60,000	360,000
Total Annual Algaecide Product Cost ($/event) [2]	$78,000	$470,000
Shipping and Application Labor ($/event) [2]	$3,000	$5,000
Total Cost ($/event)	$81,000	$475,000

1) Treated volume is top 4 feet of water column
2) Costs rounded to the nearest thousand

Artificial Recirculation in Canyon Lake

Lake(s): Canyon Lake Main Lake and East Bay

Plan view of project concept



Description:

This project would recirculate oxygen depleted, nutrient rich water from the hypolimnion in Canyon Lake Main Lake through East Bay and back to the Main Lake. The transfer of water from the hypolimnion in Main Lake to East Bay would be expected to cause a rise in DO at the sediment interface; a reduction of internal loads of TP and TN may also be realized. For East Bay, water delivered from the Main Lake would be reaerated through the process of discharge and flushing through the shallow East Bay. This activity would facilitate flushing of nutrients out of East Bay to reduce the duration of algal blooms. Over time, the reduced cycling of nutrient within East Bay would limit sediment nutrient flux and thereby the concentration of bioavailable nutrients flushed to Main Lake. A conceptual facility plan for this option includes:

- 16,000-ft, 30-inch pipeline
- 400 HP Pump Station
- Riser Intake with mechanical sluice gates

Potential Water Quality / Other Benefits:

The recirculation would result in a net reduction of internal nutrient load and net increase in DO. Algae blooms will be shortened in duration within East Bay and conditions with DO > 5 mg/L would extend deeper in the water column in the Main Lake. Also, the project would improve raw water quality at the EVMWD water treatment plant.

Potential Implementation Issues:

Although a net reduction in nutrients is expected, there may be periods when high concentrations of bioavailable nutrients in the hypolimnion of Canyon Lake Main Lake cause an increase in nutrient concentrations within East Bay. One alternative would involve incorporation of treatment for the recirculated water.

Sizing Assumptions:

A simulation using the Simplified Lake Analysis Model (SLAM) determined that a rate of recirculation of ~10 MGD of Main Lake water, or roughly one month to completely flush East Bay water into the Main Lake, would yield significant water quality improvement. SLAM is a single dimensional model; estimates of water quality benefits from increased flushing are determined by adjusting terms in an empirical phytoplankton growth estimation. Sizing criteria for preliminary designs should be developed based on results of a more spatially rigorous three-dimensional model of Canyon Lake, such as ELCOM-CEADYM.

Estimated Cost

Facilities	Capital Cost ($)	O&M ($/yr)[1]	Net Present Value for 25 years ($)	Annualized Cost ($/yr)[2]
Intake, pipeline (16,000’, 30” diameter)[3]	$8,450,000	$170,000	$11,410,000	$660,000
Pump Station (400 HP)[4]	$1,200,000	$20,000	$1,550,000	$90,000
Total	$10,150,000	$200,000	$13,630,000	$780,000

1) Assumes 2% of capital for annual O&M including power to run pumps and facility maintenance
2) Assumes 3% inflation rate and a 25-year period
3) Pipeline (30” diameter) cost assumed $528 per linear foot (Carollo 2017)
4) Pump station cost assumes $3,000 per HP (Carollo 2017)

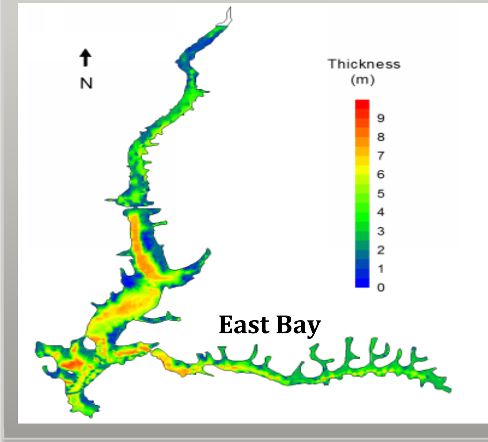
Dredging at East Bay

Lake(s): Canyon Lake East Bay

Description:

A project to remove bottom material from Canyon Lake East Bay would reduce the pool of potentially mobile nutrients and thereby reduce internal loads. Incubation chamber studies from Canyon Lake in 2001, 2006, and 2014, show that sites in the East Bay have some of the greatest rates of diffusive flux from the lake bottom sediments (Anderson 2016a). In 2006/2007, a dredging project was initiated, The project removed approximately 21,000 cubic yards (CY) of sediment, but was ceased (for non-technical reasons) before reaching the sediment removal goal of 182,000 CY. A potential project to dredge bottom sediments in Canyon Lake East Bay could provide significant water quality improvement. The most downstream end of East Bay near the causeway to the Main Lake would be a key target area for dredging.

Canyon Lake Bottom Sediment Thickness (Anderson 2016a)



Potential Water Quality / Other Benefits:

Reduction of internal diffusive sediment nutrient flux for both TP and TN that will improve water quality in East Bay. Other benefits include addition of flood storage capacity and extension of the lifespan of Canyon Lake reservoir.

Potential Implementation Issues:

The long-term benefits remain limited, since the bioavailable P loading would resume after dredging. Without a local disposal area, costs are significant.

Estimated Cost

For this cost estimate, dredging was assumed to focus on the top two feet of the lake bottom sediment (consistent with the 2003 dredge project), and to extend over ~50 acres in areas with the greatest thickness of bottom sediments, based on the recent hydroacoustic survey analysis (see figure). The analysis assumes $20 per CY for 200,000 CY of sediment removal from East Bay. The 2005 cost estimate for dredging at East Bay was ~$11 per CY. Escalated to 2018 dollars using the Corps CWCCIS for Navigation, Ports, and Harbors (ACOE 2017), this comes to ~$14 per CY. Originally, the Canyon Lake POA intended to manage the dredging operations. However, if fully contracted, these costs are likely to increase, thus $20 per CY was assumed.[1] Additionally, the 2005 cost estimate states that sediment disposal to a landfill would cost $9 million, or $13.0 million in 2018 dollars. Thus, disposal cost is estimated at $65 per CY. Disposal cost would be drastically reduced if a local disposal area was identified. Dredging is assumed to occur once, with no annual O&M.

Costs:

Cost Item	($)[1]
Excavation Cost	$4,000,000
Landfill Disposal Cost	$13,000,000
Total Net Present Value[2]	$17,000,000
Annualized Cost[2]	$940,000

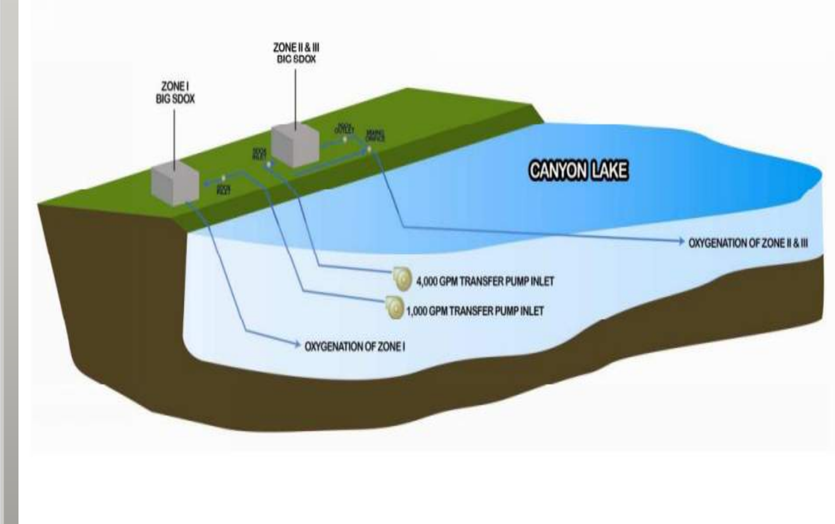
1) Costs rounded to the nearest thousand
2) Assumes 3% inflation rate and a 25-year period

[1] Note that Machado Lake hydraulic dredging costs were estimated at $20 per cubic yard and included setup, operation, pumping, and all associated labor. https://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/64_New/08_0423/doc_4.pdf

Hypolimnetic Oxygenation System

Lake(s): Canyon Lake – Main Lake

Configuration of Potential HOS in Canyon Lake



Source: Pace (2011) for Option 10b

Description:

A hypolimnetic oxygenation system (HOS) is used to inject liquid oxygen into lake water within a pressurized chamber. This pumped lake water becomes oxygen enriched in the chamber and is then piped to the anoxic water layer overlying the sediment, which can rapidly increase DO concentrations throughout the hypolimnion. The increase in DO greatly reduces the diffusive flux rates of phosphorus and nitrogen from the sediment into the water column. A Canyon Lake HOS would deliver a greater amount of oxygen to the lake bottom than could be achieved with an aeration system and is thereby a more effective method for suppressing sediment nutrient flux. In the case of the Main Lake of Canyon Lake, thermal stratification is a naturally occurring process that serves to limit the pool of bioavailable nutrients in the photic zone over much of the year. HOS would maintain thermal stratification while delivering oxygen rich water into the hypolimnion. PACE (2011) developed a preliminary design for a HOS system in Canyon Lake. This system was considered for inclusion in the CNRP and AgNMP, but ultimately the Task Force decided to pursue alum addition as the primary in-lake nutrient control strategy. A key decision factor was the fact that HOS would not provide water quality benefits within East Bay. If alum additions in the Main Lake do not provide sufficient water quality improvement to meet the revised TMDL response target CDFs for DO, chlorophyll-*a* and ammonia, then HOS may be a supplemental project to consider.

Potential Water Quality / Other Benefits:

HOS would directly increase DO in the lake bottom and would be able to create a condition that is significantly more oxygen rich than estimated for a reference condition. Reduction in sediment nutrient flux would reduce nutrients in the water column potentially available to support excess algae growth. Lastly, increased DO in the lake bottom would support increased rates of nitrification of ammonia released from the lake bottom to the less toxic nitrate form.

Potential Implementation Issues:

HOS would require shoreline disturbance and underwater construction activities.

Sizing Assumptions:

To evaluate the economic cost of this potential supplemental project, the recommended alternative 10b in the PACE preliminary design report was assumed (PACE 2011). This alternative included two shoreline oxygen generation locations, ~10,000 feet of underwater oxygen delivery pipe along lake bottom, pumps, and other equipment. Costs were updated to reflect 2018 dollars using standard ENR index.

Estimated Cost:

Cost Item	Cost ($)
Total Capital Cost	$3,380,000
Annual O&M	$140,000
Net Present Value[1]	$5,530,000
Annualized Cost[1]	$320,000

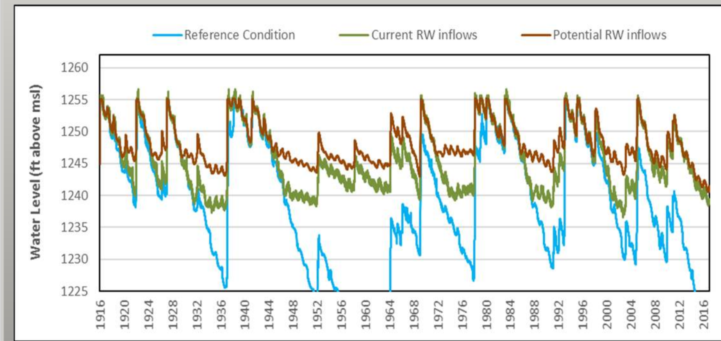
1) Assumes 3% inflation rate and a 25-year period with annual O&M in all years

Increased Reclaimed Water Addition

Lake(s): Lake Elsinore

Description:

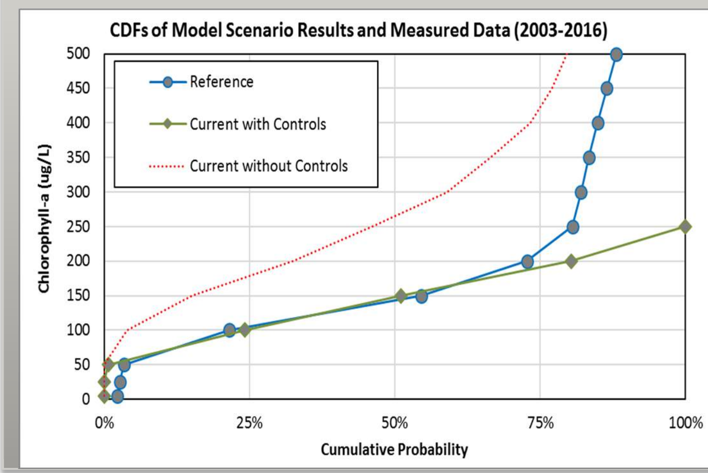
Modeled lake level for 100-yr simulation with and without reclaimed water addition



EVMWD and the City of Lake Elsinore entered into an agreement in 2003 (replacing prior agreements), which requires EVMWD to maintain water levels in Lake Elsinore at 1240' in order to divert water from Canyon Lake for water treatment.[1] A total of ~50,000 AF of supplemental water has been added since 2007, which is estimated to have prevented the lake from a desiccation event sometime in 2015. However, these reclaimed water additions were not able to offset evaporative losses during the extended drought, and lake level fell to 1232'. The TMDL linkage analysis shows that increased inflow rates to 7.5 MGD would be sufficient to maintain lake levels above 1240' based on 1916-2016 hydrology (see green line in adjacent figure). Currently, EVMWD produces ~6.0 mgd of reclaimed water (5.5 mgd available for discharge to Lake Elsinore; 0.5 MGD to Temescal Wash). In the 2016 Regional WRF Expansion Master Plan, EVMWD projects 7.5 MGD (~8,400 AFY in dry years) will be available for discharge to Lake Elsinore by 2020 (EVMWD, 2015). Beyond 2020, EVMWD plans to continue to make reclaimed water available for lake level stabilization up to 9 MGD (~10,000 AFY in dry years). Also, it may be possible to allow for reclaimed water additional during periods when lake levels are between 1240'-1247', a recommendation in the 2003 agreement. This additional increment would allow for maintenance of lake levels above 1241.5' at all times and keep levels closer to 1245' in most years (see red line in adjacent figure).

Potential Water Quality / Other Benefits:

Modeled chlorophyll-a for reference and current conditions



Reclaimed water represents an additional external source of nutrient loads in excess of reference conditions, despite the relatively low effluent nutrient concentration from EVMWD's Regional WRF (TP ~ 0.4 mg/L; TN~3.0 mg/L). Thus, there is a potential for increased eutrophication relative to the reference watershed condition. The linkage analysis was used to evaluate the balance of increased nutrient loads against the benefits of increased water volume in Lake Elsinore, including reducing wind driven sediment resuspension, facilitating aquatic vegetation on shorelines, and diluting TDS under most conditions. The adjacent figure shows that implementation of other existing controls (watershed BMPs, levee, LEAMS, and fishery management) along with projected increases of reclaimed water addition to 7.5 MGD is expected to reduce eutrophication to levels better than reference condition in all but ~3 percent of the time.

Reclaimed water additions have unquestionably prevented a lakebed desiccation event for Lake Elsinore, clearly providing better protection of recreational uses than would be realized in a reference condition. Moreover, other

[1] Lake Elsinore Comprehensive Water Management Agreement between City of Lake Elsinore, Lake Elsinore Redevelopment Agency and the Elsinore Valley Municipal Water District, March 1, 2003.

public health issues associated with periods of lakebed desiccation, such as severe gnat infestations and dust are prevented with reclaimed water addition.

Water agencies have developed ways to increase capture of surface runoff for groundwater basin recharge in the upper watershed, which has resulted in a decline in Canyon Lake overflows. Thus, increasing EVMWD reclaimed water additions to Lake Elsinore will play a greater role in maintaining water levels above 1240', indirectly allowing for increased potable water supplies from Canyon Lake and groundwater recharge for the region.

Lastly, the greatest potential impact of climate change to Lake Elsinore would involve increased evaporative losses and more severe extended droughts. Enhanced reclaimed water additions make Lake Elsinore more resilient to potential climate change impacts.

Potential Implementation Issues:

There is potential for localized flooding along the lakeshore that may occur in wet years if reclaimed water were to be added to the lake when levels are between 1240'-1247'.

Estimated Cost

The current cost to produce tertiary treated effluent at EVMWD's Regional WRF for discharge to Lake Elsinore is approximately $350 per AF. The cost estimate below accounts for only the incremental increase from current expenditures for reclaimed water (RW) addition. Current costs are ~$1.4 million/year.

Cost Basis	RW Addition 7.5 MGD up to 1240'	RW Addition 9.0 MGD up to 1247'
Maximum RW addition (AF/yr)	8,400	10,000
Maximum Annual Incremental[1] Cost ($million)	$1,500,000	$2,100,000
Long-Term Average RW incremental[1] addition (AF/yr)	700	1500
Long-Term Average Annual Incremental[1] Cost ($million)	$250,000	$500,000

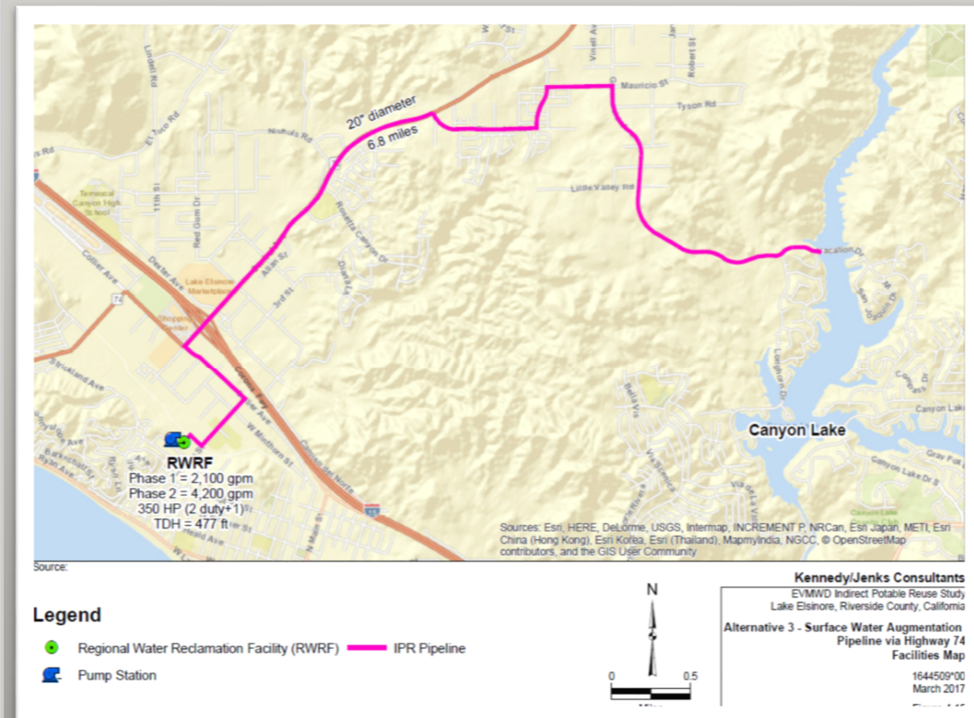
1) The incremental cost is in addition to the current $1.4 million spent per year on reclaimed water addition

Indirect Potable Reuse at Canyon Lake

Lake(s): Canyon Lake Main Lake

Description:

Plan view of project concept



Source: EVMWD, 2017

This project would rely on the use of Canyon Lake as an environmental buffer to support indirect potable reuse (IPR) by EVMWD (EVMWD 2017). Advanced treated reclaimed water would be discharged at the upstream end of the lake to maximize residence time prior to water being withdrawn for treatment at the Canyon Lake Water Treatment Plant at the lower end of Canyon Lake. This indirect potable reuse approach, involving reservoir augmentation, was evaluated against other methods such as groundwater recharge and recovery (EVMWD 2017).

While the primary objective of this project is not to improve lake-wide water quality, the addition of advanced treated reclaimed water would serve to dilute nutrients in the lake. Continuous inflows would also reduce water level fluctuations that occur under current operations during the dry season. By maintaining water levels in advance of the wet season, storm event overflows from Canyon Lake to Lake Elsinore would occur more frequently and increase downstream transport of water and associated nutrients.

Potential Water Quality / Other Benefits:

The most significant benefit is the development of a new source of local potable waters supply. The project will also reduce TP and TN concentrations in the water column and increase downstream transport of nutrients out of Canyon Lake.

Potential Implementation Issues:

Even with the expected improvements to water quality from advanced treated wastewater, there may be times when conditions are sufficient to influence the treatability of water that could require temporary shutdowns of EVMWD's WTP. Water quality in the lake may limit the amount of reclaimed water than can be diverted for potable supply. Operation of the system during the wet season may be less reliable given water quality and capacity limitations. Public acceptance of the discharge of treated reclaimed water to the lake by local homeowners and users of the lake for recreation is a potentially major obstacle to implementing the IPR project.

Sizing Assumptions:

The sizing and cost estimates are based on Alternative 3 presented in EVMWD (2017). The facilities include construction of an Advanced Water Treatment Facility (AWTF) to produce water from RWRF tertiary effluent, disposal of brine, and conveyance of the product water to the discharge location in Canyon Lake. The AWTF capacity is 3.0 mgd in Phase 1 and expanded to 6.0 mgd in Phase 2. The planned water pipeline from the RWRF to the AWTF to be constructed in Phase 1 is 6.8 miles in length. Costs presented in the table below represent the incremental difference between Alternative 3 (surface water augmentation) and Alternative 1 (injection wells) or ~$2.2 million in capital and a total of $9 million for life cycle cost.

Estimated Cost:

Cost Item	Alternative 3 (Canyon Lake Augmentation)	Alternative 1 (Injection Wells)	Incremental Cost (Alt3 – Alt 1)
AWTF	$53,200,000	$52,000,000	$1,200,000
Brine Disposal	$520,000	$520,000	$0
Product Water Pump Station	$2,430,000	$520,000	$1,910,000
Product Water Pipeline	$12,800,000	$9,460,000	$3,340,000
Injection Wells	N/A	$8,590,000	(- $8,590,000)
Capital Cost Subtotal	$69,000,000	$71,200,000	(- $2,200,000)
O&M (25 years)[1]	$111,000,000	$99,000,000	$12,000,000
Net Present Value [1]	$180,000,000	$171,000,000	$9,000,000
Annualized Cost			$660,000

1. Assumes a general inflation rate of 3%, energy inflation of 4%, and a 25-year period of analysis.

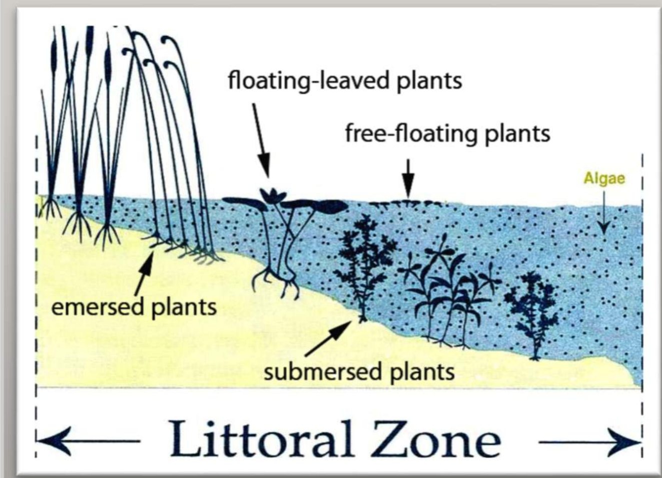
Lakeshore Vegetation Management

Lake(s): Lake Elsinore

Description:

This project would establish a community of emergent and submerged aquatic vegetation in the littoral zone that can take up nutrients and release oxygen to the water column. These plants can compete for limited nutrients and light with algae thereby providing a potential control on growth of nuisance algae.

Lakeshore vegetation management



Source: https://plants.ifas.ufl.edu/manage/why-manage-plants/aquatic-and-wetland-plants-in-florida/

Potential Water Quality / Other Benefits:

Established lakeshore vegetative cover would reduce bank erosion and physical resuspension of sediments. Submerged plants take up phosphorus and nitrogen, thereby reducing the pool of bioavailable nutrients to fuel algae growth. Some lakeshore vegetation can provide shade and some reduction in localized water temperatures. Other benefits include the creation of habitat areas for fish and wildlife.

Potential Implementation Issues:

Efforts to establish submerged aquatic vegetation may not be successful. Water level fluctuations can kill vegetation by either desiccation or drowning. In the case of Lake Elsinore, fluctuations in salinity may stress plants, so the selection of salt tolerant species will be important.

Sizing Assumptions:

The analysis assumes vegetation establishment, including labor, installation, and plant cost, is approximately ~ $35,000 per converted acre based on an analysis performed for the San Francisco Bay Joint Venture.[1] For this conceptual estimate, 100 acres of shoreline in Lake Elsinore was assumed to be candidate for establishment of macrophytes. No extensive O&M is assumed once the plants are established.

Estimated Cost:

The estimated cost for plants and installation activities over 100 acres of shoreline in $3,500,000. If annualized, assuming 3% inflation rate over a 25-year period, this would amount to a cost of ~$200,000/yr.

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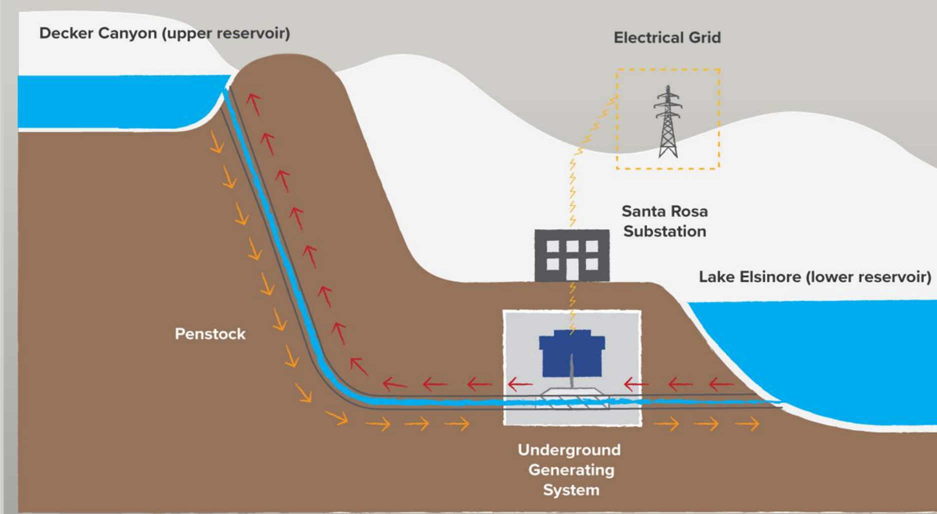
[1] https://www.st.nmfs.noaa.gov/st5/Salmon_Workshop/23_Steere.pdf

LEAPS – Modification for Water Quality Control

Lake(s): Lake Elsinore

Profile of project concept



Source: Nevada Hydro, http://leapshydro.com/#leaps

Description:

The Lake Elsinore Advanced Pumping System (LEAPS) is a renewable energy generation hydropower project that will involve construction of a 200' tall dam and new 50 to 100-acre concrete lined reservoir with a spill elevation of ~2,800' in the Cleveland National Forest southwest of Lake Elsinore. On average, 5,000 AF of water would be pumped from Lake Elsinore to the new 'upper' reservoir. Return of the water would generate hydroelectric power in turbines between the new upper reservoir and Lake Elsinore, the 'lower' reservoir. There may be an opportunity to incorporate water quality controls into this project to improve water quality in Lake Elsinore. This concept considers two potential options to improve water quality:

- Repurpose the LEAMS diffusor lines to facilitate addition of oxygen saturated return flows from the LEAPS upper reservoir at the lake bottom. This would provide a greater amount of oxygen than currently achieved with operation of LEAMS, which could provide greater suppression of sediment nutrient flux.
- Routine additions of alum to water within the upper reservoir to form an aluminum hydroxide floc to bind phosphorus. Sufficient time to allow for settling of the floc to the reservoir bottom would prevent the floc from being redeposited within Lake Elsinore. The water returned to Lake Elsinore would have a low TP concentration.

Potential Water Quality / Other Benefits:

The most significant benefit of the LEAPS project is the generation of renewable energy to be added to the electrical grid. In addition, the LEAPS project proponents would purchase 5,000 AF of supplemental water prior to start up of the project to offset water level declines during periods when the upper reservoir is filled and would continue to purchase water annually to make up for evaporative losses associated with the project. This supplemental water would provide some dilution of ambient nutrients and TDS in Lake Elsinore. Additional indirect water quality benefits in Lake Elsinore that could be achieved from modifications to the LEAPS project could include:

(1) An influx of DO saturated water at the lake bottom has the potential to significantly reduce sediment nutrient flux (the greatest nutrient load to Lake Elsinore) and dramatically reduce risk of fish kills to better than reference conditions.

(2) Routine alum additions in the upper reservoir would serve to remove phosphorous from the system, and in turn limit algae growth in Lake Elsinore.

Potential Implementation Issues:

The ambient pH in Lake Elsinore is frequently higher than the range most effective for aluminum hydroxide floc to form (6-8), especially near the water surface. Jar tests would be valuable to determine how effective different dose levels of alum could be for phosphorous removal. If it is feasible to divert water from deeper in the water column, where pH is relatively lower, alum additions in the upper reservoir could be more effective.

Sizing Assumptions:

Alum addition could be incorporated into the operation of LEAPS after that project is implemented. Routine alum additions via surface spreading within the upper reservoir are assumed to be conducted bimonthly (6 per year) and involve an alum dose of 30 mg/L (equal to dose currently applied to Canyon Lake East Bay). The amount of phosphorous removal that may be achieved may be diminished during periods when ambient pH is greater than 8.0. A conservative estimate suggests that alum addition could remove as much as 1,000 kg of TP from Lake Elsinore annually.

The concept involving repurposing LEAMS diffusers will require more detailed hydraulic modeling as well as coordination between the project proponent and EVMWD, i.e., for this element to be implemented it will need to be evaluated as part of the development and construction of LEAPS. Thus, facility details are not available at this time for developing cost estimates.

Estimated Cost

Cost Basis	Value
Upper Reservoir Volume (AF)	5,000
Alum Dose (mg/L as alum)	30
Material (kg/event as dry alum)	185,000
Frequency of Alum Additions per year	6
Total Cost of Alum Material per year[1]	$920,000
O&M ($/yr)[2]	$300,000
Annualized Cost	$1,220,000

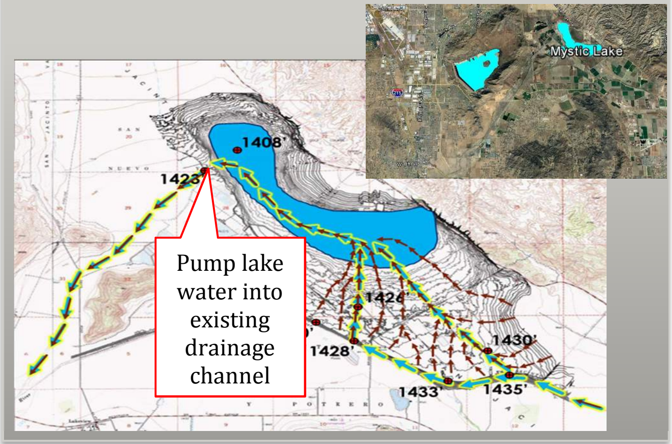
1) Cost of delivered alum for Canyon Lake alum additions, provided by General Chemical $0.83/kg dry alum delivered

2) Cost includes spreading of material, upper reservoir debris mainenance and general program oversight

Mystic Lake Drawdown

Lake(s): Lake Elsinore, Canyon Lake Main Lake

Plan view of project concept



Description:

Mystic Lake is a depression in the upper San Jacinto River (SJR) watershed that captures all runoff from the upper SJR watershed via a breach in the levee on the north side of the river near Bridge Street. Most runoff that does reach Mystic Lake is retained and subsequently lost via evaporation. A potential project would involve pumping stored runoff out of Mystic Lake to the lower SJR, thereby increasing overflows of lower TDS water from Canyon Lake to Lake Elsinore.

Few data exist on the flow that reaches Mystic Lake. USGS operates a gauge on SJR at State Street, about 4 miles upstream of the levee breach, and average annual volume is ~13,000 AFY. Much of this runoff is lost by channel bottom recharge, as evidenced by a flow volume at State Street of ~34,000 AFY in the 2004-05 wet season, yet field observations documented no overflows of Mystic Lake (~17,000 AF storage). The watershed model conservatively estimated an annual average inflow to Mystic Lake of ~4000 AFY, with many years having zero and many years over 10,000 AF. While intermittent, this water may have a significant value for EVMWD water supply (at Canyon Lake) and for water quality in both lakes (providing both flushing and dilution with low TDS water).

Potential Water Quality / Other Benefits:

Increased flushing of nutrients and algae out of Canyon Lake, dilution of TDS in overflows from Canyon Lake to Lake Elsinore, and increased runoff volume to stabilize lake levels in Lake Elsinore. The project would improve raw water quality for treatment by EVMWD, and serve to limit flooding impacts to farms and other properties near Mystic Lake.

Potential Implementation Issues:

Water from Mystic Lake would be available in wetter hydrologic years, when Lake Elsinore may need it least. However, Mystic Lake would detain runoff, allowing for drawdown to extend for months or years following large rain events. Also, the use of existing overflow ditch for more consistent flow must be evaluated. Lastly, movement of the water downstream may impact local water rights.

Sizing Assumptions:

For the Mystic Lake drawdown option, several options were evaluated involving different pump horsepower and required conveyance facilities. The lowest cost option is presented below. By limiting the drawdown rate to 5 cfs (~4000 AFY), it may be feasible to use the existing overflow ditch to route the water to the SJR mainstem. Higher flows would involve construction of pipelines, which could increase the capital cost to $16 million.

Estimated Cost

Facilities	Capital Cost ($) [1]	O&M ($/yr) [2]	Net Present Value for 25 years ($)	Annualized Cost ($/yr) [3]
Intake pipeline (2,500’, 12” diameter) [4]	$1,200,000	$24,000	$1,680,000	$130,000
Pump Station (25 HP) [5]	$125,000	$2,500	$180,000	$10,000
Discharge pipeline (500’, 12” diameter) [6]	$120,000	$2,400	$170,000	$10,000
Total	$1,445,000	$28,900	$2,020,000	$160,000

1) Assumes 2% of capital for annual O&M including power to run pumps and facility maintenance
2) Assumes 5% inflation rate and a 20-year period
3) Pipeline cost assumes $480 per linear foot for trenchless construction – 2X open trench cost basis
4) Pump station cost assumes $5,000 per HP (Carollo, 2017)
5) Pipeline cost assumes $240 per linear foot for open trench construciton (Carollo, 2017)[1]

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[1] Carollo, 2017. One Water Los Angeles, Technical Memorandum 5.1 – Appendix G Cost Assumptions Information, August 2017.

Physical Harvesting of Algal Biomass

Lake(s): Lake Elsinore and Canyon Lake Main Lake

Floating Barge used in Upper Klamath Lake

Source: Simplexity Health Inc

Description:

Several technologies exist that remove algal biomass from lakes using screens, filters, or flotation/separation processes. In the 66,000-acre Upper Klamath Lake, physical harvesting of algae in conducted commercially to produce a dietary supplement from nitrogen-fixing cyanobacterium *Aphanizomenon flos-aquae* (AFA). AFA production from Upper Klamath Lake is currently conducted using two methods, a lakeshore filtration system and a floating barge equipped with algal screens.

A floating barge system could be used to removal algal biomass from Lake Elsinore and/or Canyon Lake. Instead of producing AFA dietary supplements, other potential uses of the harvested algae from the lakes could include production of biofuels or soil amendments. Alternatively, harvested algae could be disposed in a composting facility.

Potential Water Quality / Other Benefits:

Physical removal of algae will reduce concentrations of chlorophyll-a in lake water, reduce potential for release of cyanotoxins, and remove nitrogen and phosphorus mass from the system. The harvested algae may be useful to other entities in the region to reduce operational costs by providing a sustainable source for production of biofuels or in composting operations.

Potential Implementation Issues:

Due to the limited lake surface area and narrow configuration, it may be difficult to conduct algal biomass removal in Canyon Lake East Bay by floating barge. If algal toxins are present at high levels in collected biomass, this may constitute a hazardous waste and involve additional disposal requirements. Lastly, the regular operation of a floating barge may disturb recreational use within the lakes.

Sizing Assumptions:

Cost estimates were developed based on the assumption used in estimating potential costs to expand commercial AFA harvesting in Klamath Lake to target all algal species and operate on a more regular 100 day per year schedule.[1] Costs were updated to reflect 2018 dollars using standard ENR index. Potential disposal costs are not included in this estimate.

Estimated Cost

Cost Item	Cost ($)
Total Capital Cost[1]	$360,000
Annual O&M[2]	$340,000
Net Present Value[3]	$7,640,000
Annualized Cost[1]	$440,000

1) Cost of filtration barge and off-load tender estimated for Klamath Lake, escalated to 2018 dollars
2) O&M cost include fuel, labor, and maintenance involved in 100 days of operation per year
3) Assumes 3% inflation rate and a 25-year period with annual O&M in all years

[1] Stillwater Sciences, Riverbend Sciences, Aquatic Ecosystem Sciences, Atkins, Tetra Tech, NSI/Biohabitats, and Jones & Trimiew Design. 2012. Klamath River pollutant reduction workshop—information packet. Revised. Prepared for California State Coastal Conservancy, Oakland, California.

Ultrasonic Algae Control

Lake(s): Canyon Lake – East Bay

Photo of ultrasonic application

Source: SonicSolutions ®
http://www.sonicsolutionsllc.com/

Description:

Many species of cyanobacteria contain gas vacuoles that provide a competitive advantage by allowing algae cells to regulate their position in the water column. However, gas vacuoles make cyanobacteria more susceptible to cavitation, and research has been conducted to evaluate the potential to control them by sonication. Deployment of devices that emit directional ultrasonic waves are effective in killing cyanobacteria by causing cavitation. Multiple studies have shown sonication to significantly reduce growth of cyanobacteria (Rajasekhar et al. 2012).

Sound waves produced by sonication have a limited area of influence (~8 acres); therefore, this potential project is generally envisioned only for Canyon Lake East Bay. , However, this option could be incorporated as an element of other in-lake controls where isolated locations (e.g., near intakes) would benefit from reduced concentrations of cyanobacteria.

Potential Water Quality / Other Benefits:

Control of algae growth and preferential reduction of cyanobacteria species. Reduction in cyanobacteria would in turn reduce levels of cyanotoxins, thereby reducing the risk of exposure for swimmers.

Potential Implementation Issues:

Sonication has been proven effective over a small area but may require many devices to impact larger zones. Impacts to other non-target aquatic species is an important consideration.

Sizing Assumptions:

Each ultrasonic unit provides sufficient wave signals to kill algae over roughly 8 acres. Twelve units are assumed for East Bay at a cost of $4,795 each (quote provided by Sonic Solutions, June 2016). The units can be powered in different ways, but for this estimate three floating solar units were assumed at a cost of $7,510 each. Shipping and installation costs are estimated. Per the unit owner's manuals, ultrasonic units require monthly maintenance, estimated at 1 hour each per month. The units have a useful equipment life of 10 years; thus, reinvestment is assumed at year 11.

Estimated Cost:

Cost Item	Cost ($)
Total Equipment Cost	$81,000
Shipping and Installation	$11,000
Total Capital Cost	$94,000
Annual O&M	$10,000
Net Present Value[2]	$270,000
Annualized Cost[2]	$21,000

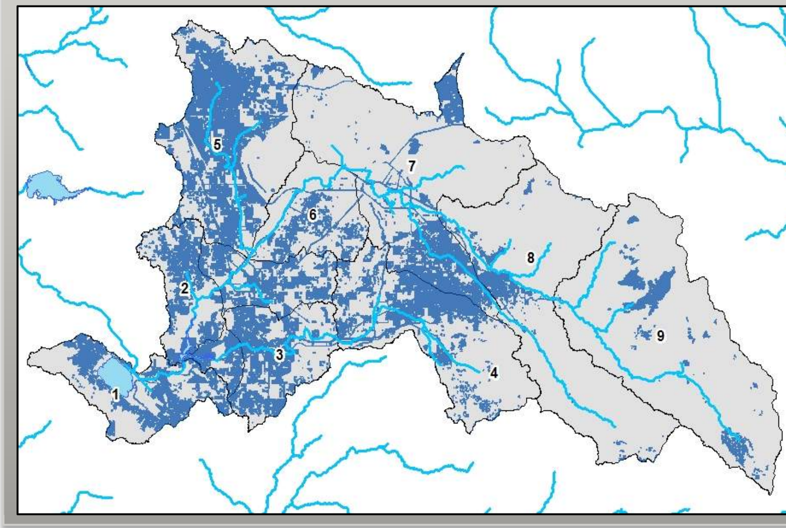
1) Assumes 3% inflation rate and a 25-year period with annual O&M in all years except year 11 when reinvestment is needed

Watershed BMPs in Urban Drainage Areas

Lake(s): Lake Elsinore, Canyon Lake Main Lake and East Bay

Description:

Urban Drainage Areas in SJR watershed



Watershed runoff and associated excess nutrient loads could be captured and infiltrated or treated prior to reaching Canyon Lake and Lake Elsinore with watershed-wide deployment of low impact development (LID) BMPs. Examples of LID BMPs include bioretention facilities, porous pavement, detention basins, media filtration, and regional infiltration basins. Such projects are required in new urban development within the SJR watershed since 2004 (SARWQB Order R8-2004-080, Order R8-2001-0034). Collectively, MS4 permittees have overseen the construction of numerous LID BMPs within ~7,000 acres of new development in the SJR watershed. These LID BMPs are designed to capture at a minimum, all runoff from storms events up to the 85^{th} percentile depth. In the case of controlling watershed nutrients loads to Canyon Lake and Lake Elsinore, it is larger storm events (>5year return period) that must be controlled to protect downstream waters. These events occur infrequently, but are responsible for the majority of total watershed nutrient loading. The nutrients ultimately settle to the bottom of Canyon Lake and Lake Elsinore, where data analysis suggests cycling between the sediment, water column, and phytoplankton pools proceed over multiple decades[1].

Jurisdictions could retrofit other urbanized areas in the SJR watershed (up to ~90,000 acres, see adjacent map) with similar water quality controls; however, costs to deploy LID BMPs in existing urban land use areas are much greater than in new development. For some jurisdictions with limited drainage area and potential for downstream sites, watershed BMPs to capture excess nutrient loads from large storms may be a viable alternative path to compliance.

Potential Water Quality / Other Benefits:

Reduction of nutrient loads from MS4 drainage areas to Canyon Lake and Lake Elsinore.

Potential Implementation Issues:

Land availability, technical feasibility, environmental impacts from construction activities, reduction in runoff volume delivered to lakes that support uses such as municipal supply in Canyon Lake and recreation in Lake Elsinore.

Sizing Assumptions:

The watershed model developed for the source assessment in the revised TMDLs estimated that runoff capture of ~16 AF would be sufficient to capture and infiltrate or treat excess nutrients from a typical 500-acre urban drainage area from a five-year return period rainfall event (~3.2 inches). For costing purposes, three types of watershed BMPs were evaluated, including regional BMPs on public land, bioretention, and permeable pavement. Simplifying assumptions about import sizing criteria were as follows;

- Maximum depth of ponded water in regional BMP (6.0 feet), in bioretention (1.5 feet), and zero for permeable pavement
- Depth of gravel sublayer: 1 foot in regional BMP, bioretention, and permeable pavement

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[1] Anderson, 2011. Technical Memorandum – Estimate Rate At Which Phosphorus is Rendered No Longer Bioavailable in Sediments, December 31.

Estimated Cost

This cost estimate is developed for deployment of three typical categories of urban LID BMPs to achieve WLAs for a typical 500-acre urban drainage area. There are significant differences in potential costs depending upon the types of BMPs that may be feasible for a given watershed, with regional BMPs on public lands being the most cost effective; ~$3 million capital and $200,000 per year in O&M. In some cases, regional watershed BMPs costs could be further reduced if there are existing facilities that could be repurposed for runoff capture. Permeable pavement is the most cost prohibitive and would not be reasonable to implement at a subwatershed scale. Lastly, individual opportunities for these or other types of watershed BMPs may be realized at lower costs when incorporated as features within other public infrastructure projects.

Costs to Control 5yr, 24hr Storm from 500-acre urban drainage area	Regional BMP on Public Land ($)	Bioretention (million $)	Permeable Pavement (million $)
Capital [1]	$3,090,000	$7,120,000	$17,660,000
O&M ($/year)[1]	$220,000	$1,180,000	$1,200,000
Total Net Present Value[2]	$6,230,000	$23,750,000	$34,750,000
Annualized Cost[3]	$440,000	$1,690,000	$2,470,000

1) Capital and O&M cost based on functions developed for LA County, extracted from https://www.waterboards.ca.gov/wqcb4/water_issues/programs/stormwater/municipal/watershedmanagement/los_angeles/upper_losangeles/20160127/UpperLARiver_mainbody_revEWMP_Jan2016.pdf

2) Assumes 3% inflation rate and a 25-year period