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FROM: Marc Beutel, Ph.D., P.E.,
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DATE: September 2, 2019

SUBJECT: PEER REVIEW OF THE SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD'S DRAFT BASIN PLAN AMENDMENT TO INCORPORATE REVISED TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR NUTRIENTS IN LAKE ELSINORE, CANYON LAKE, AND THE SAN JACINTO RIVER WATERSHED, RIVERSIDE COUNTY, CA

Dear Dr. Bowes,

Thank you for the opportunity to review documents related to the Lake Elsinore/Canyon Lake TMDL. As requested in your Invitation to Review dated July 18, I focused on Conclusions 3-6. With limited time at hand, I focused on reviewing sections 3, 4, 6, 7 and 8 of the Peer Review Document 3, Technical Report: Revision to the Lake Elsinore and Canyon Lake Nutrient TMDLs. I also reviewed Sections ES, 1 and 2 of the Technical Report. I found the Report somewhat difficult to follow and this made the review of the document a challenge. As described below, I had problems understanding some fundamental details of the TMDL development including how the load allocation was developed. In particular, there needs to be a clearer and more transparent presentation linking nutrient loading estimated under reference conditions with allowable nutrient loading to the lakes, which in turn drive load allocation. **1**

Sections ES, 1 and 2

1. I would like to highlight and support the TMDL's provision for adding highly treated recycled water from Elsinore Valley Municipal Water District to Lake Elsinore. This approach is both creative and sound practice. This water is an acknowledged source of nutrient and salt loading to the lake. But without this water we can conclusively say that Lake Elsinore would have dried out during the recent drought. A dry lake, obviously, has no potential to provide beneficial uses. I consider this a real success story in Southern California water resources management. **2**

2. I would like to highlight and support the TMDL's encouragement of implementing in-lake management strategies (e.g., alum treatment in Canyon Lake), in addition to traditional source control measures, as noted on page ES-5. This approach is both creative and sound practice. There is a growing body of evidence that in-lake measures to limit internal nutrient loading can be cost-competitive when compared to watershed best management practices. **3**

3. The Technical Report presents an impressive water quality dataset from 2001-2016, which is a solid foundation and provides sound scientific knowledge on which to develop a revised TMDL. The fact that **4**

this data set is incorporated in the California Environmental Data Exchange Network is indicative of a good quality data set. I do have some minor comments on pages 2-33 to 2-36.

- Note water clarity is not measured in 1-m intervals (bottom of page 2-33). 5

- Regarding the reliance on the single station LEE2, and how representative it is of the lake, at the
top of page 2-34 the Report should more explicitly show that LEE2 is representative of water quality 6
in the lake as a whole (e.g., R^2 of liner regression of concentration collected at same time at LEE2 vs LEE1 and LEE2 vs LEE3).

- Near the bottom of page 2-35 and/or on the top of page 2-36, the Report should clarify that TP in many cases is measuring phytoplankton biomass. Some forget when we measure TP in the water
column of a eutrophic lake, much of what we are measuring is P in algal biomass. Highlight the 7
connection between organic matter and total N in the organic N discussion too on page 2-37.

- Not sure what is meant by “two” in “trends between the two are tightly coupled” – TP and organic form? Maybe here you mean TP and organic matter (i.e., algal biomass)?

4. On page 2-38, the current Report oversells the usefulness of average water column TN:TP ratios in informing specific control measures. The cited USEPA 1999 document notes that this approach is a “first cut” and “a qualitative assessment.” More study would be needed (e.g., seasonal nutrient limitation assays) if a recommendation was to be made to focus specifically on P or N control. That said, in the context of Lake Elsinore and Canyon Lake, the focus on controlling both P and N is based upon sound scientific knowledge. Qualitatively, Lake Elsinore exhibits a wide range of TN:TP ratios, and water column TP is a poor predictor of Chl A in the lake (page 2-42), undermining the conventional paradigm of P limitation in freshwaters. Experts in cyanobacterial ecology advocate for dual management of P and N
(e.g., Paerl et al. 2016, It takes two to tango: When and where dual nutrient (N & P) reductions are 8
needed to protect lakes and downstream ecosystems, Environmental Science & Technology 50; Paerl et al. 2011, Controlling harmful cyanobacterial blooms in a hyper-eutrophic lake: the need for a dual nutrient (N & P) management strategy, Water Research 45). And co-limitation in lakes by both P and N is more common that many recognize (e.g., Wurtsbaugh et al. 2019, Nutrients, eutrophication and harmful algal blooms along the freshwater to marine continuum. Wiley Interdisciplinary Reviews: Water 6). Management of both P and N is the right path forward for Lake Elsinore and Canyon Lake. To confirm the benefits of reducing P and N in the context of Lake Elsinore and Canyon Lake, future scientific studies should include nutrient limitation assays, both conventional nutrient addition assays and biodilution assays that assess algal response to lower P and/or N (see Paerl and Bowles 1987, Dilution bioassays: Their application to assessments of nutrient limitation. Hydrobiologia, 146).

5. In the first sentence on page 2-39, note that ammonification occurs under both anoxic AND oxic conditions. But ammonia does tend to accumulate under anoxic conditions, since a lack of oxygen
inhibits nitrification, which in turn can stimulate denitrification and loss of N from aquatic ecosystems. 9
This issue arises again in the last bullet on page 3-3 which incorrectly links ammonification to only anaerobic decomposition. And again at the bottom of 4-30 where the report states that anoxic conditions increase rates of diagenesis. Anoxia stimulates ammonia accumulation and release, but not necessarily diagenesis.

6. I would like to highlight and support the Technical Report’s discussion of biomanipulation as an important in-lake management strategy to improve water quality in Lake Elsinore. This approach is
recognized as a sound and relatively low-cost management practice, especially in the recovery of 10
shallow lakes. Continued focus on this issue is particularly important with the Report on page 2-46 that >95% of fish assessed in April 2015 were small (< 3.5 cm). These small fish likely exert intense predation

pressure on large-bodied cladocerans (e.g. daphnia), thereby alleviating predation pressure on phytoplankton. Discussion at bottom of page 2-70 is good.

7. On the bullet at the end of page 2-48, the toxin microcystin and the algal species Mycrosystis appear
to be conflated. Text alludes to a “dominant cyanobacteria” while figure 2-29 shows toxin 11
concentration.

8. On third paragraph on page 2-56 the Report states, “As in Lake Elsinore, a majority of the
phosphorus in the water column in Canyon Lake exists in soluble reactive form (Ortho-P).” The Lake 12
Elsinore section states that in Lake Elsinore TP is mostly in the organic form.

9. My most significant critique of this section is the use depth-integrated nutrient data in evaluating and
presenting water quality in Canyon Lake. While this may be required for the TMDL framework, it seems
like an awkward fit to me, and not the soundest of approaches. Clearly, the main basin of Canyon Lake
thermally stratifies and exhibits hypolimnetic anoxia, which in turn promotes sediment release of
ammonia, phosphate, iron and manganese. Indeed, manganese accumulation in bottom waters affects
the ability of Canyon Lake Water Treatment Plant to treat raw water (page 2-53). I am not convinced,
without a clearer presentation of the data, of the validity of the following comment on page 2-65: “A
review of historic data indicates that stratification of nutrients is generally limited overall in Canyon
Lake, though trends are apparent occasionally.” Based on my experience, summertime bottom water 13
samples near the dam likely accumulate significant amounts of ammonia and manganese, and
potentially iron and sulfide. These water also historically likely accumulated phosphate – that is why
alum treatment was implemented. See model results in Fig. 5-28 and 5-29. Some presentation of the
seasonal and spatial patterns of nutrients is merited. Even if this is not required in the context of the
TMDL, this information is needed to inform in-lake management strategies aimed at controlling internal
nutrient loading in Canyon Lake.

10. I disagree with the comment at the bottom of page 2-59 that limiting N availability in situ is more
difficult compared to limiting P availability. Bottom water oxygenation, using pure oxygen rather than
air, has the potential to limit ammonia accumulation in bottom water with modest infrastructure (e.g.,
Beutel, 2006. Inhibition of ammonia release from anoxic profundal sediments in lakes using 14
hypolimnetic oxygenation. Ecological Engineering 28). Oxygenation is also extremely effective at
inhibiting manganese accumulation in bottom waters and would be a good fit with Canyon Lake,
synergizing with current in situ P control efforts via alum addition. In my opinion, oxygenation should be
a priority for implementation in Canyon Lake, since it will have the multiple benefits of reducing internal
loading of N, P and manganese, while improving pelagic habitat for fish and zooplankton.

11. The statement on page 2-63, “This stratification of DO is a natural condition for 15
most lakes” is not correct. This is typically a HUMAN INDUCED condition in EUTROPHIC lakes.

12. The conceptual model for Canyon Lake presented on page 2-36, in which nutrients released from
anoxic sediment build up in bottom waters until they are finally mixed into surface waters at fall
overturn, seems off the mark to me for this relatively small and not especially deep reservoir. In much of
the reservoir, modest depths will result in both anoxia induced sediment release of nutrients and mixing 16
of these nutrients in to surface waters during wind-induced partial mixing events. This in part may
explain the Report comment discussed in comment 9. The Osgood index (mean depth in meters divided
by square root of area in km^2) is a measure of a lake’s tendency to mix during the summer. Values below
6 indicate weak thermal stratification while values above 8 indicate strong thermal stratification. The

value for Canyon Lake is ~4 (5.34 m/sqrt 2.02 km). Thus the lake, while it thermally stratifies, is also susceptible to partial mixing and internal nutrient loading. This is an additional argument to continue alum treatment and implement hypolimnetic oxygenation in Canyon Lake. 16

13. While drought may indeed be irritated by fluctuating water delivery to Lake Elsinore, I think you mean exacerbate rather than exasperate in second to last paragraph in page 2-71. 17

14. I want to make a final comment in support of the ammonia analysis in the Technical Report. My initial concern with the unionized ammonia (UIA) assessment was the fact that in the highly productive waters of Canyon Lake, and particularly Lake Elsinore, there are diel swings in pH, with pH likely peaking in early afternoon with the onset of peak photosynthetic activity. While the Report acknowledges that temporal patterns of pH can drive ammonia toxicity, this issue was not explicitly addressed in the calculation of UIA concentrations, which do not systematically include all "worst case" conditions of afternoon high pH conditions. But the findings that UIA concentrations based on integrated water concentrations from the existing data are relatively low, and the observation that fish kills have not generally been associated with ammonia toxicity (page 2-70), support the general conclusion that ammonia toxicity is not a significant concern at Canyon Lake or Lake Elsinore. In this context, the current approach of using integrated water concentrations from the existing data set is practical and sound. 18

Conclusion 3/Section 3 – Numeric Targets

The general approach used in this section to develop and use cumulative distribution frequencies developed on modeled watershed reference conditions, including concentration-based CDFs for chlorophyll a and ammonia, and spatial-based CDFs for dissolved oxygen, as a "numerical target" is creative, appropriate and scientifically sound. The use of reference CDFs are a scientifically sound tool to assess future lake water quality conditions and attainment of the revised TMDL. But I do have some concerns related to the development of the presented CDFs as described below. 19

1. I do not understand the rationale for using chlorophyll a concentrations in the upper 1 meter of the water column as noted on page 3-4. The Report seems to argue that since light does not penetrate much deeper than 1 meter into hypereutrophic waters, that algae must be in the upper 1 meter. Vertical mixing and algal buoyance, not light penetration, control algal distribution in the water column. In addition, I doubt the modeling effort, while one-dimensional in nature, accurately models algal content in the upper 1 meter, which in reality will be dynamic in space and time. For example, algae may be distributed throughout the water column during windy afternoon conditions but be concentrated in upper waters during calm morning conditions. The 1-meter focus seems like a mismatch with both sampling and modeling efforts. A more appropriate approach for the chlorophyll a CDF is to use a water-column average. 20

2. In section 3.1.3, do high manganese concentrations associated with hypolimnetic anoxia in Canyon Lake also impair the MUN beneficial use designation? 21

3. Regarding the reference conditions, I agree that the full area of Lake Elsinore should be used, but I do not necessarily agree that the existence of Canyon Lake should also be included. How can one assess the ecological quality of the original Lake Elsinore ecosystem when including Canyon Lake upstream? Canyon Lake is a significant sink for nutrients and water that significantly alters nutrient loading to Lake Elsinore. While I understand that "reference" is a relative term, I do not really understand the relevance 22

of proposed reference conditions (original Lake Elsinore but with upstream Canyon Lake) used to develop the CDFs.

4. The water quality data set summarized on page 3-17 needs to be more comprehensively presented, as is done for stormwater monitoring in Table 4-6. While median concentrations are presented for TP and TN, no reference to the USFS report is provided. 23

5. I am particularly confused as to how internal nutrient loading was incorporated into the development of the CDFs. Following sections include discussion about the importance of internal nutrient loading, yet it is not explicitly explained in this section if and how "reference" internal nutrient loading was addressed. If it was not included as a nutrient input in the context of the modeling effort, CDFs are likely underestimating the frequency of impaired water quality. 24

Conclusion 4/Section 4 – Source Assessment

The source assessment presented in the Technical Report was comprehensive and was generally scientifically justifiable. The assessment of internal nutrient loading in both Lake Elsinore and Canyon Lake was also well done. The presented measured versus modeled mass balances for annual average flow (Fig. 4-13) and average annual nutrient loading (Fig. 4-19) reinforce the adequacy of the source assessment. That said, I highlight some concerns below. 25

1. The reader would benefit from more interpretation of Fig. 4-22, which currently is hard to understand. The scenarios labeled "reference," "current, no controls", and "current, with controls" need to be defined in the text. I presume the "current, no controls" is modeling release from the original lake bed? What is meant by "rough approximation" with regards to the reference. Presumably this reference level of internal nutrient loading needs to be included in the reference water quality model (see comment 5 above for Section 3). If it is part of the development of CDFs key to the assessment of future water quality conditions, it needs to be more than a rough approximation. As you read further, this issue is discussed on page 4-36. I guess the bottom line here is current internal loading rates were discounted by half in both Lake Elsinore and Canyon Lake, though internal load values presented in Table 4-12 did not seem to reflect this 50% decrease for TN, perhaps because of averaging of mass loading over a long-term series. The presentation of internal loading in this section, while encapsulating sound science, was hard to follow. 26

2. I am having trouble understanding, based on information previously presented in the Report, the nutrient load values presented in Table 4-14. This key summary table should be easy to interpret and transparent in how the values were developed. Atmospheric deposition and supplemental water are easy enough to assess and for the most part match data earlier presented. But values for watershed runoff and internal loading do not match values presented earlier in Table 4-9 (watershed nutrient loading) and Table 4-12 (internal nutrient loading). On a more fundamental level, this analysis has me confused because I am not seeing here, or in following sections, an explicit comparison between current nutrient loading (Table 4-14) and modeled reference nutrient loading. What am I missing here? How can the implication of a load allocation when the difference between current nutrient loading and modeled reference loading is not clearly defined? 27

Conclusion 5/Section 6 – Source Assessment

In general, I agree that the approach to developing the load allocations presented in Section 6 is scientifically defensible and provides a reasonable and justifiable method for controlling nutrient loading to Lake Elsinore and Canyon Lake. I only wish the Report was clearer in its presentation of how the ultimate load allocations were developed relative to reference conditions. 28

1. While reference conditions were modeled as described in Section 5.4.6, I do not see an explicit description of the annual average nutrient loading for the reference conditions comparable to Table 4-14 which summarizes nutrient loads under current conditions. As a result, I am having trouble digesting the waste load allocation section. I guess these values are at the bottom of Table 6-2. Presumably, the load allocations from Table 6-3 plus the required load reductions from Table 6-3 equals the total current nutrient loading to the lakes, taking into account other nutrient sources including supplemental water, internal loading and deposition. The sum of these values roughly match the values for "Watershed Runoff" in Table 4-14. Greater transparency and a clearer discussion of how the numerical values presented in Tables 6-2 and 6-3 were developed would be helpful. 29

2. Because of the unclear presentation of nutrient loading for reference watershed conditions, I do not understand how nutrient loading from supplemental water addition, internal loads and deposition fit into the overall reference versus existing conditions for annual mass loading. Presumably, the total of loads presented in Table 6-7 should equal the load for the reference condition. The Report needs to better link values in Table 6-7 back to reference conditions. The Report should present a parallel table to Table 6-7, using the same categories while presenting the loading for the reference conditions. The total nutrient loading in both tables being the same, since nutrient loading in reference conditions should equal allowable nutrient loading. 30

Conclusion 6/Section 7 – Implementation; Section 8 – Monitoring Requirements

I agree that the implementation and monitoring requirements in the revised TMDL provide a reasonable, practicable and feasible plan to, over the long term, facilitate and assess the return of Lake Elsinore and Canyon Lake to reference conditions. I find the list of studies, planning efforts and implemented projects quite impressive. Modeling results for chlorophyll a CDFs under reference versus control and non-control scenarios (Fig. 7-7) suggest that efforts to data have improved water quality. The phased implementation plan and associated 15-20 year implementation period outlined in Table 7-11 is well thought out and reasonable, especially when considering the time scale involved with implementing watershed BMPs and the response time of shallow lake ecosystems to decreases in external loading. Some comments related to implementation and monitoring are included below. 31

1. Presentation of CDFs in Figure 7-7 and associated Table 7-8 were quite effective, in contrast to some of the earlier sections of the Report. Modeled results are promising and paint a picture of near attainment of the TMDL. But I think these modeling results could use a reality check with actual data. What do CDFs look like based on actual monitoring data. What do recent versus past years look like? Let's not paint an overly optimistic picture of current water quality conditions in Lake Elsinore, unless real-world data is confirming that picture. 32

2. Regarding implementation projects and studies, I have the following recommendations: 33

(1) I am surprised that the use of natural treatment systems such as vegetated surface-flow treatment wetlands has not been considered to sustainably remove P and N from EVMWD recycled

water before input to Lake Elsinore. As one of the more well-defined and continuous point sources to the lake, treatment of this inflow should be a priority, especially if there are long-term plans to increase recycled water inflow rate. 33

(2) Oxygenation of Canyon Lake should also be a high priority as it would synergize with alum to further lower internal loading of P, while also lowering N internal loading and help meet MUNI beneficial uses by lowering manganese concentrations and lessening fall algal blooms. 34

(3) A significant focus should be put into fisheries management. The small paragraph on page 7-42 was not too inspiring. As noted earlier, recent studies have shown that most of the biomass in the lake is small fish that predate on zooplankton. Without some decreases in the number of small fish, zooplankton grazing pressure will be unacceptably low. 35

(4) Coupled with (2) I recommend a nutrient limitation study, as discussed earlier, to better understand what role N and P play in controlling algal productivity. Results will likely confirm that a focus on both P and N for both Lake Elsinore and Canyon Lake is warranted. 36

(5) Coupled with (3) I recommend a mesocosm study to assess how removal of small fish from the waters of Lake Elsinore affect zooplankton grazing pressure on algae and subsequent water clarity and chlorophyll a concentration. This could be an important step in showing lakes managers the important connection between high small fish biomass and high algal biomass. 37

3. Regarding monitoring, I have the following comments and recommendations:

(1) The enhancements to stormwater monitoring are good. Additional sites and lower storm mobilization criteria are appropriate. Detailing pollutant inputs from the watershed is fundamental to the TMDL process and should be thought of as a key investment in the long-term management of Lake Elsinore and Canyon Lake. 38

(2) At both Lake Elsinore and Canyon Lake, I strongly recommend monthly sampling. The cost of monitoring is minor compared to the financial investments, past and future, made to improve water quality. Yet the benefit is substantial in that monitoring data dictate more costly management projects. The more money spent on monitoring, the more informed and strategic will be the expenditures on management. 39

(3) In-lake water quality sonde measurements must include pH to assess potential for ammonia toxicity. While this was clear for Canyon Lake, it was not a clear for Lake Elsinore. Confirm pH will be measured in Lake Elsinore as part of sonde deployment, especially considering that diurnal monitoring will be discontinued. 40

(4) At least once per year in the summer, all three stations at Lake Elsinore should be monitored for water quality to continue to build the data base confirming that LEE2 is representative of the entire lake. 41

(5) The focus on using satellite remote sensing to assess chlorophyll a in surface waters in both lakes is a very good idea, and can yield meaningful data that can inform management at low cost. Coupled with this, every effort should be made by field staff to collect water samples at nearly the exact time that target satellites are overhead. Only by coupling remote sensing data with lake water quality, will you be able to make meaningful use of remote sensing data. Note since water quantity is patchy and changes with time and space, especially in Lake Elsinore, it is not enough to collect samples around the time the satellite is overhead (e.g. same day, or day before). Sampling time relative to satellite passover is critical. 42

(6) I am surprised to not see pathogens as part of the monitoring plan. Please confirm this is not a needed part of this monitoring program. 43

(7) While integrated water column sampling for water quality (e.g., nutrients) is appropriate for Lake Elsinore and the shallower arms of Canyon Lake, it is not for the deeper station in Canyon Lake (CL07). Perhaps integrated samples are needed at this station from the perspective of how the TMDL is developed and assessed. But in addition, discrete water samples should be collected during thermal 44

stratification at this deep-water station. This data is critical to assess trends in internal loading in the lake. At the minimum, I recommend sampling 4 samples down the water column (surface, thermocline, upper hypolimnion, lower hypolimnion) bi-monthly during the spring/summer (May, July, September).

(8) Regarding climate change, one tricky issue not addressed in the report is that in a warming climate, past environmental conditions do not predict future environmental conditions. In the context of this TMDL, the CDF numeric targets were developed on a model using past flow and water quality data. Yet, moving forward we will be managing Lake Elsinore and Canyon Lake in a warming climate, one that is generally acknowledged to favor cyanobacteria in nutrient rich and shallow lake ecosystems. Are we fated with comparing future environmental conditions to unrealistically stringent past conditions when it comes to managing water quality in shallow eutrophic lakes like Lake Elsinore? **45**

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Date of review submission: 19 August 2019

General comments:

The focus of my review are Conclusions 1 – 5 and am able to address these with confidence based on my expertise and experience.

This is detailed and comprehensive technical revision to the Lake Elsinore and Canyon Lake Nutrient Total maximum Daily Loads (TMDL). The team has executed and compiled an impressive array of different field measures and modeling efforts. The unusual hydrologic setting, historic and current surrounding land use practices and layers of historical and current direct management of hydrology and nutrient dynamics make this a highly complex and difficult system to project future states and manage for them. While lake Elsinore represents southern California's largest "natural" lake, Canyon Lake is a constructed reservoir. The authors make abundantly clear that Lake Elsinore was subject to wildly fluctuating water levels and was naturally prone to eutrophication prior to extensive watershed modification. This observation is key to their subsequent findings and management recommendations. It is clear that the historical management scenarios and the current TMDL revisions are designed to achieve and sustain water quality, 46 hydro-ecological and biogeochemical features that are totally artificial, engineered and without natural analog for the watershed. Given that Lake Elsinore has no natural outflows and nutrient exports, the revised TMDL are obviously motivated by recreation, agricultural water, esthetics and local quality of life rather than downstream ecosystem consequences. This makes it somewhat challenging to assess the new approach of using reference watershed conditions given the near complete artificiality of the ecosystem and its introduced non-native fish fauna. My sense is that this team has put together an overall very solid and well-researched report. The report does however raise some fundamental general and specific issues that will be detailed below in response to the Conclusions.

First, and perhaps most fundamental, the choice of reference watershed values and their implementation in CDFs (rather than a single value) is somewhat confusing and seems 47 inconsistent. Further the nutrient concentrations values from the Cranston guard station are outstandingly high for naturally vegetated ecosystems I am familiar with and compared to those form other natural watersheds in Southern California (references below).

Second, regards mass balance. It is difficult to ascertain the degree to which adoption of reference-based TMDL and reduction in nutrient inputs will actually affect lake nutrient availability and algal production given that, as the authors conclude, the vast majority of nutrient flows are from internal lake-water recycling. If this is the case, at first glance this would seem to obviate much of the entire motivation of reducing watershed inputs. While reducing N and P loads into the lakes should certainly decrease further accumulation of sediment-bound nutrients, it is entirely unclear what the turnover times for the existing sediment pools are and how much new loading contributes to them, especially since there are no outflows from Elsinore. Though sediment half times are listed for organic P and TN in section 2.4.3. it is unclear how these were calculated under non-steady state conditions and what the turnover times for all N and P species are given that there are virtually no losses, especially from Elsinore. Thus it seems that alum application is the transient remedy for P, but without removal, and with no gaseous loss, the pool should increase over time. Without excavation, this would seem to be an intractable and permanent problem. Similarly, there is only one mention of biological N fixation and not a single mention that I could find of gaseous N losses in the entire report. N fixation is fundamental to redressing N limitation in many lakes and this lake has reportedly been N limited given the N:P ratios. 48

Second, the choice of reference watershed values and their implementation in CDFs (rather than a single value) is somewhat confusing and seems inconsistent. Further the nutrient concentrations values from the Cranston guard station are outstandingly high for naturally vegetated ecosystems I am familiar with and compared to those form other natural watersheds in Southern California (references below). 49

Third, while the simulation models seem to visually match the recent historical data reasonably well this is insufficient as there are no statistics on goodness of fit nor sensitivity analysis of parameters. It is also unclear exactly how the CDFs are incorporated into the model. In some places it is stated that a median is used but in others that the target is for the reference CDF to be well below the contemporary CDF. Finally, the calibration exercise is good but I expected to see future 50 simulations and the sensitivity to various watershed management scenarios. This would be a more robust way to analyze Margin of Safety rather than simply applying a range of values above and below the median to calculate a percent deviation. 50

Fourth, and related to above, there are only a couple mentions of climate change in the report. Given the projections for the area it would seem unreasonable to assume stationarity in the CDFs, the underlying climate drivers and the underlying interactions in the model. 51

1. Conclusion 1 – *The revised Problem Statement provides a scientifically defensible description of the water quality problems in the Lakes related to excessive algae caused by waste discharges.*

The team provides an excellent description of the natural history of Lake Elsinore and Canyon Lake. Through their monitoring efforts they provide data that demonstrates that total N, P and chlorophyll concentrations consistently exceeded the existing TMDLs over the 2002-2016 period. Thus, they adequately motivate the need for revised TMDL. However, given that their measurements and modeling point to internal recycling coupled with climate-driven hydrologic variation as the main culprit, it is unclear whether they actually specifically did "provide a scientifically defensible description of water quality problems…*caused by waste discharges*". It would seem that many of the findings imply that internal sediment pools are sufficiently stable and long lasting that current waste discharges are relatively minor contributors. Of course they ultimately have to contribute just due to mas balance but these long-term dynamics have not been sufficiently disentangled in this report. Clearly, freshwater inputs, aeration and alum treatments have been critical but subsequent depth-integrated simulations of current TMDL and proposed reference condition lake nutrient distributions look almost indistinguishable. 52

Specifics:

Table 2-15: The TKN/P ratios would appear to be miscalculated here. How does one calculated and NP ratio when the mean TKN in the same table is "NA"? The maximum should be ~8.1 rather than the listed 15.7 correct? 53

2. Conclusion 2 – *The establishment of a revised Watershed Reference Condition based on the asymmetric 99-year hydrologic record and no anthropogenic discharges of nutrient wastes, provides a scientifically sound basis for establishing the following Numeric Targets for the Lakes and establishing a scientifically justifiable method for establishing the TMDLs, WLAs, and Las, as well as the reductions in the waste discharges of Total Nitrogen & Phosphorous from the watershed runoff to the Lakes.*

The proposed revised TMDL Numeric targets have been modified to focus on CDFs of chlorophyll, lake water volume and ammonia and have now eliminated numeric targets for TN and TP. The justification for this appears to be that numerous process can affect critical N:P ratios and absolute availability of these nutrients which trigger algal blooms. However, this raises a few concerns with regard to the adoption and implementation of the Watershed Reference Condition standards. **54**

While the claim that "No watersheds comparable to Canyon Lake or Lake Elsinore exist in southern California or other areas with similar climatic regimes. As such it is not possible to establish allowable pollutant loads using another watershed/downstream waterbody combination as a means to describe an expected reference condition." may be strictly true, the choice of the single location (the Guard station) seems problematic. It is unclear exactly how the concentration and load data will be used given that virtually all direct manipulation to manage nutrient loads are within-lake (water level, oxygen, alum) and that the reference N and P concertation appear not to differ substantially between intensively managed and reference conditions shown in figures 4-17 and 4-18 (although impossible to determine without statistical tests). **55**

Further, a quick literature search indicates that the reference condition nutrient concentrations appear to be remarkably high compared to similar watersheds in southern California, raising the question about how representative the sites are. For example Klose et al. (Freshwater Science 2012) found stream DIN to be on average < 100 ug/L and SRP to <10ug/L in the upper Ventura River. Yoon and Stein (J. of Env. Engineering 2008) conducted a cross basin measures of stream nutrients in southern California and found nitrate-N to average < 400ug/L, TKN < 1.2 mg/L and **56**

TP ~30 ug/L. Similarly, Gabet et al. (JGR 2005) estimated sediment nutrient fluxes from hillslopes to be ~1.5 kg N ha-1 yr-1 and ~0.8 kg P ha-1 yr-1. 56

Details: Fig 3-6: The time series would appear to be considerably shorter than 100 years. 57

3. Conclusion 3 – Numeric Targets

Finding & Assumption 3a – *The revised TMDLs set revised Numeric Targets are based on a scientifically justifiable assumption that excessive algae growth in the lakes is that which would occur under a watershed reference condition without the inputs of any nutrient waste discharges by humans, and that nutrient waste discharges to the Lakes will be controlled to be no more than the reference watershed nutrient runoff.*

At the heart of this conclusion is the assumption that the reference conditions used here are actually valid. As stated above, the concentrations seem too high for watersheds under natural vegetation and little anthropogenic loading. Again, without the detailed mass balance and life cycle analysis of the time scale of external of nutrient loading, incorporation into sediments and subsequent turnover, it is difficult to determine whether with the new TMDL excessive algae growth would be that which would occur under the refence condition. Figure 4-14 and 4-15 help think about this visually but still beg the question as whether the source reductions are sufficient. 58

In section 3.2.2.3 it is stated that the median nutrient concentrations at Cranston guard station were 0.32 mg TP/L and 0.92 mg TN/L. These concentrations are huge and appear to be very similar to that draining urban and agricultural lands. Thus, assuming equivalent water runoff, the “reference” conditions are essentially what is loading into the lake system now. It is also stated that the basis for choosing these median values is “conservative” but why isn’t the same CDF approach used for this analysis? The range of values from other undeveloped lands reported here (TP: 1.0 – 13.0 mg/L; TN: 3.5 – 16.9 mg/L TN) are enormous. 59

Comparison TP and TN loads to Canyon Lake shown in Fig. 4-14 with the total watershed TP and TN load reduction necessary under "reference" conditions reveal the assumptions of using the reference values as I understand them. Fig. 4-14 shows loads into Canyon lake of TP: 5000-35,000kg/yr, and TN 10,000-130,00 kg/yr fig 4-14). By comparison, total watershed reductions required are 767 kg TP/yr and 4,516 kg TN/yr which represent a small fraction of total loading. While the new approach is estimated to yield lower TN and TP loading than the previous TMDL it is uncertain whether it will be sufficient to significantly modulate algae blooms given the proposed reference criteria. **60**

Finding & Assumption 3b – *The use of Cumulative Distribution Frequencies (CDFs) for the Numeric Targets for the Lakes will provide for the return of the Lakes to the modeled WRC.*

The use of CDF does seem to be a superior approach than simply applying a static number. However, the description of how they will be implemented is hard to follow. As I understand it, the CDFs will only be strictly applied to within lake measures of chlorophyll, water and NH3. What is less clear is how the model input (the watershed loads of TN and TP) actually feed into the model simulations for lake dynamics and the lake CDFs ultimately evaluated. Part of the difficulty is that the reader cannot peer under the hood of the model. **61**

Finding & Assumption 3c – *The model used provides a scientifically defensible method for approximating the response of the Lakes to watershed discharges of nutrient wastes and the internal flux of nutrients from the sediment in the Lakes*

I spent some time going through CAEYDM-v2. Though unfamiliar with it previously, The model seems sound and powerful with increasing application. My concern is not with the model itself but with how the model calibration was evaluated and compared against reference conditions. First, no alternative models were compared to evaluate model fit and parameter space. No parameter sensitivity analysis was performed, or at least presented. And statistical goodness of fit tests were not performed. While the model seems to perform reasonably well by visual inspection in comparison to the calibration data period, the reference modeled conditions for TN and TP and **62** chlorophyll seem virtually identical for lake Elsinore (fig 5-15) and canyon lake (fig 5-24, 5-28, 5-29) suggesting low sensitivity to adopting the new reference condition approach.

Further, the team should incorporate projected climate change into the model runs and not just how the lake model will change to these changes but the entire watershed. In this case the reference systems may behave differently than the lake. This would seem critical to establishing robust margin of safety bounds. 63

Finding & Assumption 3d – *The use of CDFs in the Lakes, as lake nutrient response targets to the watershed discharges of nutrients, and to set the TMDLs, WLAs, LAs and nutrient reduction requirements to control discharges of nutrients from the watershed to the lakes will assure compliance with Narrative Water Quality Objective for algae for the lakes, that "waste discharges shall not contribute to excessive algae growth in receiving waters", using a scientifically justifiable method for controlling nutrient waste discharges to be controlled to be no more than that which would occur during the modeled WRC. And, that discharges of nutrients from the watershed to the Lakes will still occur at levels that would occur under the reference watershed condition.*

See responses above.

4. Conclusion 4 – Source Assessment

Finding & Assumption 4a – *The revised TMDLs includes a revised nutrient discharge source assessment, based on a scientifically justifiable assumption in the Tech Report that excessive nutrients which are discharged to the Lakes will be controlled to be no more than the reference watershed nutrient runoff, that is based on a 99-year hydrologic record and nutrient wash off rates from the watershed under the natural WRC without any anthropogenic inputs of nutrients by nutrient waste discharges.*

The team has done a good job at mapping out source contributions within the watershed. As detailed above, however, this conclusion seems almost a certainty given the assumptions of the reference watershed conditions and how they are fed into the model simulations. **64**

Finding & Assumptions 4b – The revised TMDLs include a revised nutrient discharge source assessment, based on a scientifically justifiable analysis in the Tech Report, that estimates the waste discharge of nutrients from the land use categories in the analysis. The source assessment provides a justifiable means to model and calculate the TMDL, SWA, Las and required nutrient reductions in Section G of Attachment A for each acre of land in each land use category, supported by the source assessment.

As above, the total reductions seem to be a very low proportion of annual nutrient loads received by the lakes. Given the range and magnitude of nutrients retained annually and the release time of these nutrients in the water column it would seem that the source reductions would be inadequate to control excessive algae growth given the hydrologic and management context. **65**

5. Conclusion 5 – *The revised TMDLs for nutrients in the lakes, using the Numeric Targets, Source Analysis, and Linkage Analysis, provide scientifically defensible revised TMDLs for nutrients in Lake Elsinore and Canyon Lake*

Given the concerns raised above, there is considerable uncertainty as to whether this conclusion is sound. This opinion is based on uncertainty in the reference condition assumptions and modeling and the elimination of in-lake TN and TP criteria as stated:

"In-lake nutrient concentrations for TN or total TP were not included as causal numeric targets in the revised TMDLs. There are multiple combinations of these two nutrients that would effectively limit algal productivity to cause a return to reference levels for beneficial use impairment indicators (algae, DO, ammonia) higher in the hierarchy. Thus, in-lake nutrients will be evaluated in the implementation section. For example, one implementation alternative could involve reduction of TP below reference levels to ensure it is the growth limiting nutrient and to achieve reference conditions for chlorophyll-a with or without returning TN to reference levels." **66**

What exactly are these "multiple combinations" True, there are. But it would seem that the reliance on the current reference watershed conditions essentially punts the problem to within-lake management without requiring significant source reductions from the watershed. **66**

6. Conclusion 6 – *Implementation Plan and TMDL Compliance Monitoring Plan*

Values in 6-9p and 6-9q3 would seem to be in conflict: 2620 of P and 7533 of N versus 3050 of P and 8753 of N. **67**

7. Conclusion 7 – *The economic analysis provides a sound and supportable evaluation of the potential costs of compliance, as required.*

NA

8. Conclusion 8 – *The revised TMDLs findings are supported by the environmental impact analysis provided, and the evidence in the Tech Report and references.*

NA

9. Conclusion 9 – *The references for the revised TMDLs support the analysis and conclusions of the Tech Report and the proposed revised TMDLs.*

References provided are generally adequate expect for reference conditions cited above **68**

The Big Picture

1. *In reading the staff technical reports and proposed implementation language, are there any additional scientific issues that are part of the scientific basis of the proposed rule not described above? If so, please comment with respect to the statute language given above.*

I found no additional scientific issues other than those described above.

2. *Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?*

In general the scientific portion of the proposed rule *is* based upon sound scientific knowledge, methods, and practices. However, as addressed above, it is my finding that the fundamental basis for the proposed rule change—the *reference watershed condition*—is not adequately justified nor is how
it will be implemented adequately explained. In particular, how the cumulative distribution functions 69
will actually be used is unclear. The reference conditions described assume exceptionally high background nutrient loading. Therefore, because the entire proposed rule change is predicated on these nutrient levels, this would seem to obviate substantial intervention in controlling watershed nutrient loading to the lake system. In effect this just shifts the burden onto within-lake intervention almost entirely.

Review of draft Basin Plan Amendment to Incorporate Revised Total Maximum Daily Loads (TMDLs) for Nutrients in Lake Elsinore, Canyon Lake, and the San Jacinto River Watershed, Riverside County, Ca.

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August 9, 2019

This review focuses on **Conclusion 8** for the California Regional Water Quality Control Board Santa Ana Region TENTATIVE RESOLUTION NO. R8-2019-0041; Resolution Amending the Water Quality Control Plan for the Santa Ana River Basin to Revise the Nutrient Total Maximum Daily Loads (TMDLs) for Lake Elsinore and Canyon Lake, in the San Jacinto River Watershed, Riverside County California. Broader comments on the overall documents are provided.

I read the Technical Report (Document 3), Documents 1—2 and the Tentative Resolution draft fully. I also consulted and read some of the provided secondary references, specifically those that pertained to the reference model development, and others as needed to answer a particular question. Where appropriate I have consulted codes and regulations.

I am able to address the findings and conclusions with confidence based on my research expertise in soil and water sciences and experience as past director of a Water Resources graduate program which integrates science, management, policy and law.

Comments on the overall Finding:

The stated Finding and Assumption for Section 10 is: *The revised TMDLs findings are supported by the environmental impact analysis provided, and the evidence in the Tech Report and references.*

My judgement, after reviewing all documents, is that if one accepts that the reference watershed approach to revision of TMDLs is correct, then the findings in the report and proposed changes to the Basin Plan are based on sound scientific knowledge, methods, and practices; and that the assumptions, findings, and general conclusions are justified on that basis.

Comments on Specific Findings:

The findings are discussed in order as presented in the draft TENTATIVE RESOLUTION NO. R8-2019-0041. Findings Nos 29—32 are actions that partially cannot start until after the scientific review process; my comments will therefore address only whether these actions are the correct steps towards approval of the amendment.

> *25. In preparing the SED, the Santa Ana Water Board has considered the requirements of Public Resources section 21159 and section 15187 of title 14 of the California Code of Regulations and intends this document to serve as a tier one environmental review. This analysis is not intended to be an exhaustive analysis of every conceivable impact, but an analysis of the reasonably foreseeable consequences of the adoption of this regulation from a programmatic perspective. Project level analysis, as necessary, will need to be considered in any subsequent environmental analysis performed by other public agencies pursuant to Public Resources Code section 21159.2.*

I concur that this is a Phase I document, and that applicable requirements have been met. The actions of the Santa Ana Regional Water Quality Control Board as the lead agency are compliant with Public Resources Code section 21159 and section 15187 of title 14 of the California Code of Regulations. Specifically, the Technical Report includes the required environmental analysis and the discussion of alternatives is limited to a discussion of alternative means of compliance.

26. The Lake Elsinore and Canyon Lake TMDLs SED concludes that there is no fair argument that the project or the reasonably foreseeable methods of compliance will result in any reasonably foreseeable adverse environmental impacts, either individually or cumulatively. In particular, the revised TMDL acknowledges the importance of encouraging innovative compliance strategies to preserve and enhance aquatic habitat in Lake Elsinore and Canyon Lake. Accordingly, no mitigation measures or alternative to the project are identified or analyzed.

I agree with this finding. The Technical Document specifically addresses that no mitigation is necessary as no adverse effects are reasonably expected by actions resulting from the implementation of the TMDLs. The alternative to action is the continuation of the 2004 document requiring similar measures for lake beneficial use compliance. A sufficient argument is made that the 2019 TMDLs provide a better scientific basis. The SED makes a strong case for innovative compliance strategies given the unique climatic, hydrologic and ecological conditions of both lakes.

27. The proposed amendment meets the "Necessity" standard of the Administrative Procedure Act, Government Code, Section 11352, subdivision (b). Federal regulations require that TMDLs be incorporated into the state's water quality management plan. The Basin Plan is the water quality management plan for the Santa Ana Region along with statewide water quality management plans. Amendments to the Basin Plan are the mechanism through which the Regional Board takes quasi-legislative actions. The adoption of this Basin Plan amendment to revise the 2004 TMDL is necessary to reduce loadings of nutrients to Lake Elsinore and Canyon Lake, and nutrient loading from sediment in the Lakes, and to address water quality impairments that arise therefrom.

Article 9 of the Administrative Procedure Act, Government Code, section 11352, subdivision (b) deals with special procedures pertaining to waste discharge requirements and permits. There is no "Necessity" standard applicable for this section. I believe the finding meant to reference section 11353; in which case I concur that the revision document submitted to the Water Board includes a summary of the necessity for the regulatory provision and that it meets the "necessity" standard as defined in section 11349.

The revision is demonstrated with the availability of substantially more data, evidence, better modeling capabilities, regulatory changes (e.g., CAFO, MS4) and a correction in the inflow volume to Canyon Lake requiring revision of TMDLs. Moreover, a convincing argument is made that replacing a static stressor-response target with a statistical target derived from a reference watershed approach would be more scientifically sound given the spatial and temporal variability in drivers to watershed and water quality responses.

28. Pursuant to Health and Safety Code Public Resources Code section 57004, the Regional Board submitted the relevant technical documents that serve as the basis for the proposed amendment to an external scientific review panel and has considered the panel's comments and recommendations of that panel in drafting the amendment.

I agree that procedures spelled out in HSC 57004 are being followed. At the the time of my review, I cannot comment on whether review comments (such as this) will be considered in drafting the document.

29. The Notice of Filing, the TMDL Report, environmental checklist, and the draft amendment were prepared and distributed to interested individuals and public agencies for review and comment, in accordance with state and federal regulations (23 CCR §3775, 40 CFR 25 and 40 CFR 131). The Regional Board also posted a Notice of Availability and Request for Comment, and all related supporting documents on the Regional Board's Website. The Regional Board considered all comments and prepared written responses to those comments that were submitted by the required deadlines.

I agree with this finding. Referenced documents and actions were discoverable at `https://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/elsinore_tmdl.html` accessed 8/9/2019. The steps in this finding are consistent with EPA 40 CFR 25, and 131(c) as well as 23 CCR 3775.

30. The Regional Board discussed this matter at a duly noticed public workshop conducted on May 3, 2019, after notice was given to all interested persons in accordance with Section 13244 of the California Water Code. Based on the discussion at those workshops, the Board directed staff to prepare the appropriate Basin Plan amendment and related documentation to incorporate the Revised Lake Elsinore and Canyon Lake Nutrient TMDLs. On XXXX XX, 2019, the Regional Board held a Public Hearing to consider the Basin Plan amendment. Notice of the Public Hearing was given to all interested persons and published in accordance with Water Code Section 13244.

The procedure laid out in this finding follows applicable code and regulation, and is correct. I can not comment on whether the public workshop was held, and if a public hearing will be given at a future time.

31. The Basin Plan amendment must be submitted for review and approval by the State Water Board , Office of Administrative Law (OAL) and U.S. Environmental Protection Agency (USEPA). Once approved by the State Water Board, the amendment is submitted to OAL and USEPA. The Basin Plan amendment will become effective upon approval by OAL and USEPA. A Notice of Decision will be filed after the amendment is approved by USEPA.

This procedure is correct.

32. For the purposes of specifying compliance schedules in NPDES permits for effluent limitations necessary to implement these TMDLs, the schedule(s) specified in these TMDLs shall govern, notwithstanding other compliance schedule authorization language in the Basin Plan. The 2004 TMDLs and the related Comprehensive Nutrient Reduction Plan and the Agriculture Nutrient Management Plan previously approved by the Regional Board remain in effect, and are not stayed, until such time as these revised TMDLs are approved by the State Water Resources Control Board, the Office of Administrative Law and the U.S. Environmental Protection Agency.

This is the correct course of action.

Additional remarks:

Pertaining to Conclusion 1

> *The revised Problem Statement provides a scientifically defensible description of the water quality problems in the Lakes related to excessive algae caused by waste discharges.*

The revised problem statement is scientifically defensible. Because of differences primarily 70
in depth and inflows, nutrient cycles vary between Lake Elsinore and Canyon Lake and also within Canyon Lake. Lake Elsinor is decoupled from most of the watershed because of Railroad Canyon Dam and the reservoir function of Canyon Lake delivering flow to Lake Elsinor only periodically in wet years. Lake Elsinor further functions as a terminal lake except for extreme wet years in which some water may flow through the lake. Nutrient sources in Lake Elsinor are predominantly internal while Canyon Lake receives considerable nutrient inputs form throughout the watershed.

Pertaining to Conclusion 2 and 3

> *The establishment of a revised Watershed Reference Condition based on the asymmetric 99-year hydrologic record and no anthropogenic discharges of nutrient wastes, provides a scientifically sound basis for establishing the following Numeric Targets for the Lakes and establishing a scientifically justifiable method for establishing the* 71
> *TMDLs, WLAs, and LAs, as well as the reductions in the waste discharges of Total Nitrogen and Phosphorous from the watershed runoff to the Lakes.*

The proposed TMDLs revision pursues the estimation of allowable nutrient inputs to assure beneficial uses via a reference watershed approach. Allowable loads are calculated based on estimates of watershed nutrient inputs pre-development, and model estimates of resulting water quality metrics based on these inputs. While the previous TMDLs were based on water quality data and distributed TMDL to the watershed, this approach uses the projected "natural" water quality to distribute TMDLs. The reference watershed approach in particular when coupled with CDF representation of loads explicitly recognizes spatial and temporal variability in watershed hydrologic conditions, lake hydrology and ecology as well as implicitly recognizing spatial and temporal variability in nutrient inputs coupled with wet years and extreme events. This approach is commendable.

An argument could be made that changes in the watershed (lake surface reduction, reservoir construction, etc.) negate a reference watershed approach, but I recognize that given the lack of 72
comparable lake systems and large variability in lake responses to climatic trends, a watershed approach is a defensible conservative method.

A convincing argument is made that (1) the runoff flow volume to Lake Elsinor (pg 306, TMDL) was overstate in the 2004 TMDL, and (2) the use of CDF's rather than static targets 73
reduce the allowable nutrient loads in the revision. At the same time, water quality targets in the lakes are less stringent at times (dry years) recognizing that the reference condition would also result in impaired uses under these conditions.

Overall, numeric targets for nitrogen and phosphorous are scientifically justified and appear to be protective of beneficial uses in the lakes. WLAs and LAs are reasonable, have a sound 74
scientific basis, and target the actual algal bloom/eutrophication issue.

Big Picture Questions

1. In reading the staff technical reports and proposed implementation language, are there any additional scientific issues that are part of the scientific basis of the proposed rule not described above? 75

Both lakes have benefited from a range of actions and practices put in place in part because of the 2004 TMDL and are expected to be continued or expanded. The compliance monitoring requirements are reasonable and practical. Striking are two approaches: (1) As part of the 2004 TMDL, Lake Elsinor receives treated wastewater discharge to dilute salts, compensate for evaporative water losses and maintain a relatively stable water level which aids in lowering the water temperature and thereby increases dissolved oxygen in the water column and in particular at the lake sediment surface compared to the reference state. (2) Aluminum sulfate applications to Canyon Lake over several years are aimed at flocculating orthophosphate and prevent diagenesis of phosphorous.

Pertaining to (1). The supplemental water to Lake Elsinor supplies nutrients in the same order of magnitude than the external loading to Canyon Lake. The report argues that benefits of partially compensating evaporation outweigh the substantial additional nutrient inputs. Because Lake Elsinor is practiacaly a terminal lake this additional loading will increase nutrients and TDS in the lake system over time. Given that internal loading is the main contributor to algal 76
blooms, and that a reduction of internal loading is targeted with the amended TMDLs it would be beneficial to include possible actions and estimates for nutrient reduction to address this particular additional source. One possible approach not discussed in the document could be to develop a specific procedure for lake flushing in Lake Elsinor for wet years with excess available water.

Pertaining to (2). I am less confident to provide this comment as this is not my area of expertise. However, I think the benefits of aluminum sulfate applications are somewhat overstated in the report. Aluminum sulfate will form aluminum hydroxide when applied to water and act primarily as a cap for available phosphorous in the lake sediment preventing it 77
from being bioavailable in the water column. While aluminum hydroxide has a high affinity for orthophosphate, it is not the only ion or particulate being attracted. There are several studies that have demonstrated that the cap effect is definite and that aluminum sulfate application are a temporary solution at best.

2. Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?

Taken as a whole, the scientific report is expertly prepared and clearly reflects a lot of hard work by a large number of people. The proposed amendments to the TMDLs explicitly recognize variability in space and time, shifting mechanisms between wet and dry years for sources and 78
lake responses including differences in P and N limitations between sites and climatic regimes, and it recognizes that the watershed has changed considerably. The estimated WLAs and LAs are sound and estimated based on current methods and practices.

Evaluation of a TMDL Technical Report for Lake Elsinore and Canyon Lake, California

TMDL Technical Report: Revision to the Lake Elsinore and Canyon Lake Nutrient TMDL

Draft Dated December 1, 2018

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September 5, 2019

This review contains an evaluation of the December 1, 2018 TMDL report for Lake Elsinore and Canyon Lake based on four components of the TMDL document: (1) conclusion 3, (2) conclusion 4, (3) big picture question 1, and (4) big picture question 2. These evaluations are based on the content of the entire TMDL document.

Evaluation of Conclusion 3: Numeric Targets, Attachment A BPA Section 1.C

Pages 4-14, Revised TMDLs Tech Report Section 3

A. *Revised TMDL numeric targets*. The TMDL finding that the water quality of Lake Elsinore and Canyon Lake would be undesirable for recreation even under natural, undisturbed conditions of the watershed is correct. The watershed in its natural state, without anthropogenic augmentation of nutrient flux, both lakes would have water quality that would be undesirable for designated uses (aquatic life, recreation, water supply). 79

B. *Use of cumulative frequency distributions*. Use of cumulative frequency distributions as a tool for judging the status of the lakes either as modeled or as observed is a valid method for determining the status of the lakes in response to remediation measures. The water quality model, although generally similar to water quality modeling as conducted elsewhere, is not a reliable tool for projecting future water quality conditions of primary interest in Lake Elsinore or Canyon Lake. The model apparently relates algal abundance to P concentration without recognition of a P threshold above which algae are not sensitive to changes in P concentration. The causes of interannual and intraannual variation of algal abundance under current conditions and probable future conditions are explained by factors other than nutrient availability. No such factors are presented in connection with the model. 80

Internal loading of phosphorus for the two lakes has been quantified experimentally in a competent way, but is interpreted and incorporated in modeling incorrectly in that it is assumed that bioavailable phosphorus released from sediments is entirely retained by the overlying water column. Phosphorus released from sediments through conversion of ferric to ferrous iron leads to precipitation as the water reaches oxidized portions of the water column. In essence, the release process is to some extent reversed by a corresponding precipitation process for an unknown portion of the release, as shown by observations and experiments elsewhere. Phosphorus release from sediments probably does contribute significantly to the supply of soluble reactive phosphorus in the upper water column, but the linkage between the sediment release and the actual enrichment of surface waters is not known and therefore cannot be modeled. **81**

Bioavailable phosphorus (soluble reactive phosphorus, SRP) is the primary cause of high algal abundance and high biochemical oxygen demand passing from the surface to the bottom of the lake. Even so, bioavailable P does not presently control temporal variation in biomass because SRP is present in great excess of algal needs, i.e., there is no scarcity of bioavailable P for algae presently or under the influence of any proposed mitigation. Algal populations in both lakes presently respond to factors other than phosphorus that are not well documented and therefore not easily predicted. These likely include episodes of mixing or upwelling that cause suppression of chlorophyll at the surface through biomass dilution or shading of algal biomass associated with changes in depth of circulation for water of low transparency. **82**

Chlorophyll is the most important and least reliable prediction for the model. Modeling
chlorophyll correctly is a common problem for eutrophic lakes. Inadequacy of the model to
predict future chlorophyll is evidence of inadequate information for modeling and 83
inadequacy of models in general to predict chlorophyll in lakes. At present, phosphorus is
always present in excess of algal needs, and therefore cannot be the basis for prediction of
temporal variation in algal abundance.

C. *Control of anthropogenic P sources*. Emphasis of the TMDL is on control of anthropogenic
watershed sources of total P. Valid conclusions can be drawn, however, only by emphasis on
bioavailable phosphorus, which corresponds to soluble reactive phosphorus (SRP) rather than
total phosphorus (total P). Intercepion of particulate P adsorbed on silt and clay from 84
disturbed soil or streets in urban areas will not reduce phosphorus concentrations in the
surface waters of the lakes, where algae grow. Control must be based on SRP, not total P.
Sources of SRP do not correlate uniformly with sources of total P.

Two potent and potentially reversible sources of soluble reactive P are supplemental water
for Lake Elsinore and internal P loading for Elsinore and Canyon Lake. Supplemental water
for Elsinore will be allowed, as shown in the revised TMDL document, to reach 320 μg/L
total P, of which about 80% is soluble reactive P. This source, which accounts for about 27% 85
of the total water entering Lake Elsinore, is unacceptably rich in SRP (~260 μg/L). Further
tertiary treatment of this source could reliably reduce its total P content to approximately 25
μg/L, which could reduce its SRP to ~3 μg/L. This reduction would not be an extreme

investment in view of the overall budget for mitigation of water quality in Lake Elsinore. At an SRP concentration of ~3 µg/L, supplemental water would dilute SRP from the other P sources. The necessary additional tertiary P treatment need not be the direct responsibility of the treatment plant operator; it could occur through TMDL channels with the funds that are allocated for P interception in general. 85

A second and equally pressing priority for control of SRP in the lakes is elimination of anoxia in deep water. This goal may or may not be achievable. One technical strategy for offsetting anoxia, which causes release of SRP from sediments, already has been implemented but is inadequate. A different concept is needed. Maintaining nearly uniform vertical density in the water column (destratification) through use of distributed airlift of the water column or mechanical mixing would allow wind driven circulation to take oxygen to the bottom of the lakes, thus potentially eliminating strong release of SRP from sediments. Favorable for inducing mixing of Lake Elsinore is its low mean depth, but unfavorable is the great size of the lake. Destratification of Canyon Lake, which is smaller, could be more feasible. 86

Use of alum to control sediment phosphorus release in Canyon Lake is unfortunate but is motivated by use of the lake as a potable water source. Evidence that this practice produces the desired result is very weak. The evidence in the TMDL document is based on water column phosphorus concentrations immediately before and immediately after alum treatment. More relevant is the time course of measurement for soluble reactive phosphorus 87 in the entire water column and chlorophyll in the upper water column at varying time spans beyond the applications.

Secondary remediation measures as discussed in the TMDL document are not of interest in that they offer no credible sustained effect on water quality variables in either lake. 88

Evaluation of Conclusion 4: Source Assessment, Attachment A Section E

Pages 16, Revised TMDLs Tech Report Section 4

A. *A revised source assessment*. The assertion that nutrient sources will be controlled to an extent that will not differ from the background watershed concentrations is clear but would be irrelevant to the mitigation of water quality problems in the two lakes. Large amounts of soluble reactive phosphorus are presently added to Lake Elsinore with supplemental water, which would undermine reduction of SRP from the watershed. Also, without elimination of anoxia in the lakes, suppression of external watershed SRP sources will not be effective or, in Canyon Lake, would require eternal alum treatments. The focus of remediation must include all major sources of SRP. Furthermore, the SRP content of the watershed runoff in its natural condition could sustain a hypertrophic condition even if other sources were reduced. 89

B. *Nutrient source assessment*. Proposed reduction of anthropogenic P from the watershed is based on total phosphorus rather than soluble reactive phosphorus. This error, combined with incomplete emphasis on two additional strong sources of phosphorus (internal loading, 90 supplemental water) that must be moderated for Lake Elsinore in particular, handicaps the mitigation plan.

Big Picture Question 1: In reading the staff technical reports and proposed implementation language, are there any additional scientific issues that are part of the scientific basis of the proposed rule not described above? If so, please comment with respect to the statute language given above.

The TMDL document properly recognizes the significance of scientific issues that are described in the statutory language relevant to the TMDL. 91

Big Picture Question 2: Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?

The TMDL document, with its supporting data on water quality and water quality modeling, has some significant weaknesses in application of current knowledge related to causes and control of lake eutrophication, methods, and recommended practices. These are described below. 92

Context for the TMDL Technical Report

The purpose of the 2018 TMDL technical report is to describe and evaluate the water quality of a natural lake, Lake Elsinore, and of a reservoir, Canyon Lake, within the San Jacinto River drainage in California, and to describe future remediation for these two lakes.

Lake Elsinore is a moderately large lake (6000 acres) that in its natural state showed irregular episodes of complete desiccation alternating with high water levels; these two extremes were separated by high interannual variation in water volume and water quality. The lake has been altered through an engineered reduction in size (~50%) and augmentation of water supply as a means of stabilizing the lake volume. These modifications have been successful in converting the lake from its natural state to a state that is more favorable, in terms of physical stability, for recreational and aesthetic values of the general public and regional governments near the lake. Water quality is still quite troublesome from the viewpoint of recreation, however. High abundances of suspended algae (phytoplankton) that show seasonal bursts of abundance (blooms) discolor the lake and support large populations of some algal taxa that are known to produce toxins. A second problem is depletion of oxygen in deep water caused by decomposition processes of bacteria. Episodic mixture of deoxygenated water in the lower water column with water in the upper water column leads to fish mortality caused either by insufficient dissolved oxygen or by inorganic toxins produced under anoxic conditions at the sediment surface. Anoxia is exacerbated by high productivity of phytoplankton, which serves as a strong source of decomposable organic matter reaching the sediment surface. High abundance of phytoplankton and deep water anoxia leading to fish morality are natural features of Lake Elsinore. The purpose of the TMDL is to describe how the water quality of the lake can be modified as needed to serve designated uses.

Canyon Lake, in contrast to Lake Elsinore, is an impoundment; it is relatively small (500 acres). The lake shows high peak abundances of phytoplankton. Canyon Lake also shows strong oxygen depletion leading to anoxia near the sediment surface. Episodic fish mortality may occur but is less likely and much less severe than in Lake Elsinore. Canyon Lake, unlike Lake Elsinore, is a source of potable water. Improvement of Canyon Lake water quality is an objective of the TMDL.

Overview of TMDL Strategies

In addressing its two central goals, suppression of algal abundance and elimination of mass fish mortality associated with low dissolved oxygen, the TMDL document is based on strategies and principles that have much in common with control of these two problems at thousands of locations within the United States and internationally. Suppression of nutrient concentrations, aeration or vertical mixing of water near the sediment-water interface, collection of water quality data, and use of predictive models are common goals and procedures for assessment and remediation of water quality problems such as those of Lake Elsinore and Canyon Lake. For any given lake, however, the difficulty of a TMDL or any other remediation process lies in application of commonly accepted practices to a unique set of circumstances in a way that can reasonably lead to improvement of lake water quality. The TMDL process for Lake Elsinore and Canyon Lake is comprehensive, well funded, and professionally designed, but shows some weaknesses in application of accepted practices for controlling algal abundance and fish mortality associated with dissolved oxygen. The following comments are intended to identify and explain these weaknesses and thereby show how some corrections could strengthen the TMDL process. The following comments address first Lake Elsinore and subsequently Canyon Lake. 93

Lake Elsinore

Implementation of Nutrient Control for Suppression of Algal Biomass

A valid method for suppression of algal biomass in lakes is reduction of the supply of bioavailable forms of nutrients that are most likely to control algal abundance. It is widely agreed that the two elements controlling algal biomass in inland waters are phosphorus and nitrogen. It 94 is also generally agreed that, while algal growth in a lake can be limited either by deficiency of phosphorus or deficiency of nitrogen, control of algal populations is most effectively achieved by control of phosphorus, given that phosphorus is more easily regulated than nitrogen, and that failure to control phosphorus may lead to acceleration of phytoplankton dominance by bloom-forming cyanobacteria that can fix nitrogen (create ammonia from nitrogen gas). Lakes that are nitrogen limited initially can be converted to P limitation by suppression of P to a point at which scarcity of P overtakes scarcity of N. Therefore, the TMDL is correctly oriented on control of phosphorus for suppression of algal abundance. The key requirement of algal control by phosphorus limitation in a lake is to reduce the supply of bioavailable phosphorus to an extent that will begin to suppress algal growth through phosphorus limitation. When the suppression threshold is achieved, further reduction of bioavailable phosphorus will reduce mean and peak biomass of algae, measured as chlorophyll. 94

Analysis and interpretation of phosphorus in connection with algal growth typically is based on concentrations of three fractions: soluble reactive phosphorus (SRP), dissolved organic phosphorus (DOP), and particulate phosphorus (PP). SRP is directly available to phytoplankton, whereas DOP is only partially available, and particulate P is not directly available for uptake. Analysis of phosphorus in Lake Elsinore is presented as total P and soluble reactive P (SRP, “phosphate P”). The difference between the total and SRP consists of particulate P plus dissolved organic P, separation of which would be desirable but probably not necessary as DOP typically is a small fraction of total P and is only partially available to phytoplankton. For Lake Elsinore, it is appropriate to think of particulate P as unavailable P and SRP as bioavailable P. 95

High algal abundances that correspond to a eutrophic (or hypertrophic, which is an extreme version of eutrophy) condition in lakes reflects a supply of bioavailable phosphorus in 96

excess of ~20 μg/L. Eutrophic conditions sustained by a bioavailable P in supply water that exceeds 20 μg/L by small amounts (e.g., 25 μg/L) may be consistent with satisfactory recreational use of lakes and absence of extreme conditions for aquatic life. Water quality conditions over this lower range of eutrophic fertility include undesirable but discontinuous algal blooms (bursts of abundance), as well as accelerated oxygen loss from water in contact with sediments. Approaching or exceeding 30 μg/L of bioavailable phosphorus in supply water, eutrophication of lakes causes serious impairment of recreation in that it produces persistent 96
green algal color during the growing season, frequent blooms, strong dominance of undesirable types of algae (nuisance algae), surface scums that are not consistent with recreation, and very strong deep water oxygen depletion that impairs aquatic life. This degree of enrichment with bioavailable P also may also produce unacceptable amounts of algal toxins in an unpredictable manner.

Given a threshold of recreational suitability near 20-25 μg/L bioavailable P in supply water for a lake, the requirement for control of phytoplankton in Lake Elsinore can be focused on a target of 20-25 μg/L for bioavailable P supply. The TMDL document reflects this goal (page E4), which presents two problems. First, for Lake Elsinore, upper water column P concentrations are far above 25 μg/L, and water entering from the watershed directly or via Canyon Lake has 97
bioavailable P far above 25 μg/L. Second, the lake shows an internal P supply (internal loading) of phosphorus from lake sediments, which means that the P supply has not only an external but also an internal component. The TMDL program is oriented on these two categories of P sources.

Soluble reactive P (SRP, which is bioavailable P, also referred to as phosphate) is present 98
in all inland waters but varies greatly in concentration. If there were no internal sources of SRP,

the volume weighted concentrations of the external sources for Lake Elsinore would produce total P in the upper water column nearly equal to the volume weighted average bioavailable P in supply water. Bioavailable P in lake supply water is converted partly in the lake to algal biomass, which is a form of particulate P. 98

SRP in the upper water column of Lake Elsinore is a source of information on phytoplankton nutritional status in the lake. Phytoplankton are adapted for very high efficiency in uptake of SRP; they can reduce SRP concentrations to ~1-3 μg/L (0.001-0.003 mg/L) when SRP is scarce. Therefore, concentrations of SRP in the upper water column above ~5 μg/L indicate that the phytoplankton community is not experiencing suppression of growth by P scarcity, i.e., that algal populations are P saturated. If SRP is below 5 μg/L, the algae are suppressed or are approaching a status of suppression that will occur when they exhaust their internal reserves of P. The TMDL work on Lake Elsinore does not include this type of nutritional assessment of phytoplankton status, even though SRP was analyzed. The data on Elsinore suggest that SRP in the growth zone is always above 20 μg/L, which would mean that phytoplankton are never limited by P under current circumstances. Suppression of P supply has no effect on algae until bioavailable P is nearly absent from the upper water column (≤3 μg/L). If SRP can be suppressed, assessment of P in the lake should be based on SRP data with detection limits of ~2 μg/L for vertically integrated samples in the mixed layer (as determined by temperature profile) rather than the entire water column (top to bottom). Mixing the top and bottom water prevents nutritional interpretation of SRP data because the bottom water is enriched in SRP from sediments and is not subject to removal of SRP by phytoplankton. 99

Particulate P must be evaluated quite differently for flowing waters than it is for lakes. In lakes, particulate P includes a large proportion of P within phytoplankton cells; it is not available 100

for uptake because it has already been assimilated by algae. In contrast, particulate P in streams and rivers typically includes a high proportion of total P that is adsorbed onto the surface of fine particles (silt, clay). The mineral adsorption process for P is strong and renders the adsorbed phosphorus unavailable to phytoplankton. As adsorbed phosphorus on mineral particles enters a lake, it passes to the bottom of the water column and is integrated into sediments. Therefore, it does not contribute directly to the bioavailable phosphorus (SRP) of the water column in the 100
lake. Phosphorus often enters the lower water column of fertile lakes from anoxic sediments during lake stratification, but phosphorus that is liberated in this way primarily comes from the decomposition of organic matter that was deposited in the lake through growth and death of phytoplankton. Therefore, adsorbed (mineral) phosphorus for practical purposes is irrelevant to the concentration of available phosphorus (SRP) in the upper water column, where algae grow.

Because adsorbed (mineral) particulate phosphorus does not stimulate phytoplankton growth, particulate phosphorus should not be included in modeling or prediction of phytoplankton abundance for a lake. Lake Elsinore receives much of its total phosphorus from the San Joaquin River through Canyon Lake and from direct watershed drainage, but should not 101
be assumed to respond to the particulate component of phosphorus in the supply water. In using total P for modeling and evaluation, TMDL analysts have combined available and unavailable P, which is incorrect.

Accounting for Phosphorus in Supplemental Water

An unusual source of phosphorus for Lake Elsinore is supplemental water, which consists of tertiary treated municipal effluent. 102
The TMDL authors show a great deal of respect for this water source, as they should, given that it is the only means by which the volume of the lake, as

reconfigured with a reduced area, can be stabilized. There appears to be a strong tendency, however, to view this phosphorus source as not subject to regulation because of its importance as a water source. This attitude, if continued, will undermine the possibility of establishing reduced abundance of bioavailable P in Lake Elsinore. The TMDL target for concentrations of total phosphorus in supplemental water has been 0.5 mg/L (more properly, 500 μg/L), but in the future may be lower (~320 μg/L), which reflects recent total P in the supplemental water (Table 5-1). 102

At 320 μg/L, the supplemental water would still be a potent eutrophication agent for Lake Elsinore. Supplemental water will, according to the TMDL document, accounts for ~27% of the water supply for the lake, and could in the future increase in volume. The SRP portion of total P in the supplemental water has been ~80% (Table 5-1); for 320 μg/L total P, the water would yield 260 μg/L SRP, which is far above any reasonable target concentration for available P in the upper water column (~25 μg/L). Therefore, the 320 μg/L target should be reduced if the goal is to suppress algal abundance. The TMDL proposes reduction (Table 7-1), but without specificity. The supplemental source offers a means of reducing the mean SRP in Lake Elsinore source water. For example, 10-year averages of total phosphorus from tertiary wastewater treatment plants at four different locations of the western US in communities that have modest funding for wastewater treatment are as follows: 20, 31, 29, 13 μg/L. Also, very little of the total P from these facilities is SRP (~3 μg/L). The provider of supplemental water for Elsinore may not be able to justify the cost of the necessary additional tertiary treatment, but the Lake Elsinore phosphorus control effort can justify the value of additional treatment for the large supplemental water source as a means of actually diluting SRP in Elsinore; the TMDL should pursue this opportunity if control of bioavailable P supply is intended to control algal growth. 103

Internal P Loading from Sediments

Lake Elsinore shows complete depletion (anoxia) of deep water oxygen in the warm
season, when the bottom waters can be physically separated from the overlying mixed layer
because of density differences caused by a vertical thermal gradient. Anoxia is accompanied by
suppression of redox potential in the sediments. The severity of redox potential suppression is
shown by release of phosphorus (well documented) and apparently the release of sulfide in some 104
instances. Sulfide is not produced in significant amounts during anoxia in most lakes; it is most
likely to be released during deep water anoxia in lakes that have a rich sulfate supply that
accompanies salinity, as is the case for Lake Elsinore. Sulfide is toxic to nonmicrobial aquatic
life, as is anoxia.

The release of phosphorus from the sediments is correctly diagnosed in the TMDL as
caused by conversion of ferric to ferrous iron at redox potentials that are expected in response to
prolonged anoxia. This mechanism is common in fertile lakes. In fact it is not confined to
eutrophic lakes; it can occur even in lakes that have moderate trophic status. A key factor
affecting occurrence and severity of bottom water anoxia is the volume of the hypolimnion,
which determines the amount of hypolimnetic oxygen that is available when the water at the
sediment surface produces an oxygen demand during stratification, at which time oxygen
depletion cannot be offset by vertical mixing extending from top to bottom of a lake. Lake 105
Elsinore has high oxygen depletion rates because the lake has a modest hypolimnetic volume and
is hypertrophic, which insures a rich supply of decaying algal biomass and fecal matter from
grazers descending to the sediment surface. The sediments of Lake Elsinore have been studied
extensively through both experiments and monitoring. The rates of P release have been well
quantified.

Phosphorus leaves the sediment surface when it is released from ferric iron, which holds phosphate, because low redox potential causes the ferric iron to be converted to ferrous iron, which is soluble. Phosphorus attached to ferric iron that becomes ferrous iron thus is released as soluble SRP. Both phosphorus and ferrous iron then enter the water column from the sediment. This is not the end of the story for phosphorus because transport of soluble reactive phosphorus upward toward oxidized water some distance above the sediments causes reversal of the chemical processes that led to separation of ferric iron and phosphate. Ferrous iron, after contacting oxygen above the sediment, is converted back to ferric iron, which in turn can form a precipitate with soluble reactive phosphorus. Ferric phosphate formed in this way returns to the sediment as a flocculant material consisting of iron, phosphorus, and hydroxide complexes. Therefore, it is common for much of the phosphorus released from sediments to return to the sediments. This phenomenon varies from one lake to another, but it is certainly erroneous to characterize the release of phosphorus from the sediment as an intact source of bioavailable phosphorus at the surface of the water column. Therefore, contrary to the assumption given in the TMDL document, internal loading of P is a mystery source, given that its magnitude is unknown as related to soluble reactive phosphorus at the surface of the water column. Internal loading may be a significant source of bioavailable P in the upper water column, but it is being incorrectly characterized as a sediment source that reaches the surface without loss. 106

Reduction or Elimination of Anoxia at the Sediment-Water Interface

The TMDL document cites past installation of submerged tubes for moving water at the sediment-water interface in a manner intended to achieve reduction of oxygen loss from the sediment surface. I was unable to determine the manner in which the system functions. 107

Evidently, however, extreme loss of oxygen persists in deep water. If transfer of soluble reactive phosphorus from the sediment to the upper water column is significant, which is likely, fractional 107
reduction of the area of anoxia on the bottom likely will not be consistent with control of SRP sufficient to suppress algal growth.

Reduction of the severity of oxygen depletion has an additional rationale, aside from control of eutrophication, in that mixing of anoxic water from the bottom with surface waters under conditions that cause the water column to bring anoxic water to the surface in quantity (during fall mixing or intermittent temporary summer mixing of the water column) is of
importance because such mixing can cause fish mortality. Fish mortality in lakes that are not 108
extremely shallow almost never eliminates fish populations, but the associated nuisance caused by decomposition of dead fish and the alarming nature of the mortality to the public justifies efforts to eliminate it in Lake Elsinore.

Control of algal abundance in Lake Elsinore, if successful, would not be a complete solution for deep water anoxia. Much undigested organic matter is present in the sediments and would continue to cause anoxia in the deepest waters indefinitely for the future, even at a lower trophic status for the lake. Therefore, anoxia on the lake bottom must be eliminated by engineering practice. Elimination of anoxia may be impossible in Elsinore because of the
immense volume of oxygen that is need to offset the rapid loss of oxygen to the richly organic 109
sediments in this large lake. Table 7-1 proposes aeration in the future. Probably oxygen demand is too great to be offset by aeration alone, given the size of the lake. Destabilization of warm season layering (often accomplished by large scale airlift of bottom water) might be a more effective and efficient in that it enables natural wind driven gas exchange of the full water

column. This problem deserves further study, but could prove impractical because the lake is quite large.

Benefits of Carp Removal

Removal of carp from the lake is justified in the TMDL document in in that carp mobilize sediment phosphorus and also impair the sport fishery, presumably by negative effects on other fish. Both of these motivations are questionable in practical terms. It is very unlikely that carp are responsible for a significant amount of bioavailable phosphorus enrichment of surface water in Lake Elsinore. The sediments in shallow water are oxic and contain little SRP beyond what is 110
in the water already. Further disturbance by carp is unlikely to be incrementally significant in releasing SRP. Studies probably are based on total P, which is not relevant in that it likely is dominated by particulate mineral P. Also, removal of carp seems unlikely to have significant effect on the abundance of game fish in this large lake. Thousands of warmwater lakes over the United States have large carp populations, yet show significant populations of game fish. If this component of the TMDL is to be continued, it needs to be much more rigorously justified. Documentation of the value of the carp elimination in the TMDL is not satisfactory at present.

Sample Collection and Analysis

As explained in the TMDL document, sample collection was initially quite ambitious and has passed through several stages of moderation. For a few years, sample collection was 111
suspended as a means of saving money. The least a justifiable way of saving money in the TMDL process for Lake Elsinore is to stop collecting data. As various practices are evaluated for effectiveness in changing Lake Elsinore, the only reliable index of change is empirical, i.e., the

observed condition of the lake. The proposed sampling program for the future, as given in the TMDL document, shows a modified and simplified sample collection program. The new plan is justifiable as to location of stations and reduction of the number of stations. Sampling frequency, however, has been reduced to an unacceptable degree, in my opinion. For documentation of trophic conditions and water quality associated with trophic condition, a lake should be sampled approximately 15 times per year, with emphasis on the growing season, i.e., the season when phytoplankton show highest abundance and strong temporal variation in abundance. Phytoplankton can be sampled less frequently in the period of deep mixing, but some samples should be collected in cool weather for the purpose of providing contrast with stratified conditions. Bimonthly sampling of lakes is not sufficient to support interpretation except when the lake is quite stable, i.e., in the cool season for this warm monomictic lake. 111

Watershed (river) sampling should provide information on both storm flows (as recognized in the TMDL) and base flows. Rivers sampled in association with eutrophication should be sampled approximately 15-18 times per year, and paired with quantitative flow data. In the case of Lake Elsinore, appropriate appreciation of storm conditions is reflected in the TMDL document, but sampling frequency needs to cover all magnitudes of storm flow, the constituents of which should be volume weighted. 112

Analytical Coverage for Water Quality

The analytical coverage for Lake Elsinore is relatively narrow, but this narrow focus is justifiable on grounds of the very specific purpose for this study, i.e., identification of eutrophication characteristics and water quality conditions associated with oxygen depletion in deep water. Especially for the lake, it is essential that the study include analysis of soluble 113 reactive phosphorus with detection limits that are appropriate for interpretation of the purpose at hand, i.e., 2-3 µg/L if the observed concentrations fall below the current detection limit of 20 µg/L (they may not). Some autoanalyzers, operated with appropriate care, are capable of this type of resolution. Chemically oriented technicians who understand the importance of water contamination in the lab or field environment are necessary to avoid occurrence of misleading values for soluble reactive phosphorus at low concentrations. Soluble reactive phosphorus is the main basis for interpreting the role of the watershed in determining trophic status in the lake. If SRP is consistently above 20 µg/L, however, high resolution is not needed. 113

Nitrate, which is directly available to phytoplankton, is included in the list of analytes, but is not discussed in the TMDL document. The detection limit for nitrate is too high; it should be ~5 µg/L. Total nitrogen, in contrast to nitrate and ammonia, is often mostly inert, in that it includes organically bound nitrogen that is not bioavailable; emphasis on total N is not useful. Nitrite, although usually scarce, should be analyzed separately in that it can accumulate in the hypolimnion and thus be a cause of mass mortality of fish (chocolate gill mortality) at times of vertical mixing. 114

The ammonia concentrations that appear in all of the waters sampled for this study are surprisingly high. For example, in looking for reference purposes at water draining from a watershed similar to that of the San Joaquin River under conditions where point sources are not dominant, I see a mean ammonia concentrations of ~5 µg/L. For surface waters of the lake receiving this water, I see ammonia concentrations of ~6 µg/L. Persistently low concentrations of ammonia are expected in oxygenated inland waters because of the processes of microbial nitrification and uptake of ammonia by algae. The reason for the high concentrations of ammonia reported in the TMDL needs to be investigated. It is possible that the analytical method, which is 115 referenced and corresponds to an EPA approved automated method, is not giving the correct information or the samples are becoming contaminated in some way. The detection limit is far too high (100 μg/L). High concentrations of ammonia are expected in the deep waters of a lake that has low oxygen concentrations (for the lake mentioned above, median 47 μg/L), but concentrations typically are low in lake surface waters and river waters, except those that are exposed to strong point sources of ammonia, which may or may not apply to the San Jacinto River above Canyon Lake and Lake Elsinore (text is not clear on this point). 115

The toxicity of ammonia should be evaluated by the current USEPA criteria and not by the historical criteria, which were based on unionized ammonia only. Results of these two types of evaluation will be slightly different; the difference could be important in the evaluation of ammonia for toxicity. 116

Measurement of chlorophyll is exceedingly important for the TMDL. Sampling near the surface (0-2 m) and over the entire water column is conducted as part of this of the TMDL studies. I would prefer to see a vertical profile on all dates. Algal biomass is not always distributed evenly in the mixed layer because of the tendency of cyanobacterial bloom species to move toward the surface in calm weather in response to vacuoles that form inside the cells. A profile shows this phenomenon, whereas integrated samples do not. Samples taken only near the surface may give data that do not correspond to an average for the entire mixed layer. 117

I am not in agreement with the authors of the TMDL that satellite images are a reasonable substitute for field sampling as a basis for estimating chlorophyll. Satellite images are more suitable for ocean waters, which are not contaminated by the multiple optically active substances that are found in lake water. Also, surfacing of buoyant blooms may distort estimates of chlorophyll per unit volume based on imaging. It is possible to use satellite imagery successfully 118 for very clear, oligotrophic lakes that approach ocean conditions, but I would reject data that are based on satellite data for the purposes of this TMDL. I suggest a stronger conventional sampling program for chlorophyll. 118

I saw only one mention of phytoplankton species composition in the TMDL document. It is brief and qualitative. Phytoplankton composition is an important component of evaluation for the TMDL. Cell counts are expensive but they do not need to be done in great quantity. Perhaps one upper water column sample per month at the deep water station for Lake Elsinore would be adequate. 119

Recording sondes are used for collection of some TMDL data; these are left in the lake continuously. This is a much more difficult way of collecting data than might seem to be the case. Sondes can drift out of calibration or, for some substances, suffer from biofilm impairment. Accurate continuous recording of water quality conditions is more complicated and more subject to error than time-specific sampling. Flawed continuous data are a tremendous nuisance to interpret and undermine confidence in the data on water quality. 120

Presentation of water quality data for the TMDL is based in most cases on samples taken from the entire water column. The vertical gradient of nutrients and biomass in lakes is strong during stratification; the integration gives a misleading impression of lake water quality; it quantifies neither the mixed layer where phytoplankton grow nor the bottom where bacteria control the environment; it is a mixture of these two distinct environments. 121

Lake Hydrodynamics

Lake Elsinore is monomictic; seasonal mixing occurs in winter and the lake is stratified in summer. The lake has low relative depth, and therefore may show upwelling, partial mixing or 122 deep mixing on an irregular basis during the warm season. These events affect phytoplankton distribution and nutrient availability. This dimension of study, which is quite basic for lake trophic analysis, is missing from the TMDL. 122

Modeling

Modeling is a standard way of organizing and presenting data in ways that are made relatively simple when conducted by computer processing. The frequency distribution curves in the TMDL document, for example, show variance expressed as percentiles of compliance with hypothetical limits on chlorophyll. The Lake Elsinore modeling is useful in summarizing past variability in lake volume, water retention time, and other physical variables.

The modeling of Lake Elsinore as applied to the key water quality problems, which are abundance of algae and anoxia in deep waters, is not useful. As mentioned in the report, the model has difficulty even in mimicking the historical record for chlorophyll. Prediction of future conditions with hypothetical changes in specific variables, including phosphorus supply, is not credible. This flaw is not caused by technical inadequacy of the modeler or the model. The critical predictions are beyond the state of the art for a lake such as Elsinore. Rigorous use of empirical data and the known P requirements of algae will produce the most useful understanding of the response of the lake to control practices. 123

The model includes the concept of a reference condition. The reference condition is a P source that matches the Canyon Lake/Lake Elsinore watershed runoff from undisturbed lands. Emphasis is total P, which is erroneous. Also, bioavailable P in Elsinore is strongly affected by supplemental water and both lakes are affected by internal loading, which may be moderated in Canyon Lake by alum treatments. Threshold conditions for SRP supply should be established as 124 targets, and should include all sources. The key condition for Lake Elsinore is reduction in chlorophyll a that brings the lake into a qualitatively different state than it now shows. Establishment of this state will require SRP reduction in the volume weighted mixture of all sources (including supplemental water) to ~25 μg/L and elimination of anoxia over sediments, probably by airlift destratification. Peak chlorophyll then will be approximately equal to SRP in the lake surface water, if averaged over the mixed layer (as determined by a thermal profile). 124

Supplementary Control Measures

The TMDL document contains a list of supplementary control measures that may be under serious consideration. There is no strong argument or persuasive evidence of validity for any of these supplementary control measures. Macrophytes will not grow in Elsinore because of changes in shoreline position. Meaningful competition of macrophytes with phytoplankton is a phenomenon of small, shallow lakes; it will not occur in Lake Elsinore. Zooplankton grazers do not control average or peak algal abundance in eutrophic lakes; their abundance in such lakes is irrelevant to chlorophyll concentrations. Algal harvesting and algal poisoning are ineffective in controlling phytoplankton in large lakes. Phytoplankton have a doubling rate of approximately one day under favorable conditions. Attempting to offset this growth rate by mechanical or chemical means in a large lake is not feasible. 125

Importance of Focus on Specific Questions

It is important that the TMDL process be focused on the control processes that make the lake undesirable from the viewpoint of human recreation or aesthetic appeal. There should be an elimination process for distracting ideas that cannot be validated even in concept. There is no 126 harm in considering a wide variety of ideas, but the field of discussion and action should be narrowed so that attention and money can be focused on practices that are most likely to have a meaningful effect on the problems at hand.

The TMDL maintains a broad focus because the participants in the TMDL process have brought many thoughts to bear on the problem in these thoughts have carried forward through previous stages of TMDL development and implementation to the present time. The TMDL process should become increasingly clear and sharply focused on specific possibilities as it matures through multiple renewals. The plan for lake improvement will be well served by a narrower focus, a skeptical approach to novel proposed solutions, and rigorous testing of ideas rather than acceptance and continuous discussion of ideas that are irrelevant or ineffective. 126

Is P Suppression of Algae Possible in Lake Elsinore?

It is not clear from the TMDL document that implementation of the TMDL procedures as defined in the document have any chance whatsoever of changing the water quality status of Lake Elsinore. While modeling as well as some of the analysis and interpretation is based on concentrations of total P rather than concentrations of bioavailable P, there is enough information on soluble reactive phosphorus to support some tentative conclusions about the overall feasibility of the TMDL goals. 127

Suppressing phytoplankton abundance in Lake Elsinore requires suppression concentrations of soluble reactive phosphorus in supply water that reach and then extend below the threshold of scarcity that caps growth in phytoplankton abundance. This goal requires control of three sources of soluble reactive phosphorus: watershed runoff, supplemental water, and internal supply of phosphorus to surface water from sediments. Table 5-10 in the TMDL 128

document gives composite SRP concentrations for storm flow runoff in the San Jacinto River
above the two lakes as 280 μg/L. Given that storm flows are the major source of water for the
two reservoirs, the watershed SRP supply to the two lakes would be near 280 μg/L under current
conditions. Even if this source were reduced by 50% through watershed mitigation, the SRP 128
entering the two lakes would be far above concentrations that would limit the growth of
phytoplankton at an appropriate abundance (chlorophyll ~ 25 μg/L at approximately 25 μg/L
SRP).

Supplemental water reaching Lake Elsinore has an SRP concentration of 260 μg/L and a
mean total P of 320 μg/L. This source, if left intact, will prevent the strong suppression of SRP in
Lake Elsinore that is necessary to bring the lake to the threshold for suppression of algal
biomass. The supplemental water is of potential value, however, in that it can be brought to an 129
SRP concentration that is negligible (<5 μg/L) through a higher degree of tertiary treatment and
thereby dilute other sources. Dilution from this source still would not be strong enough,
however, to overcome the high concentration of SRP in the watershed supply water.

A third major source for SRP in Lake Elsinore is internal loading. Release of SRP from
anoxic sediments to the water just above the sediment is known, but the rate of transport to
surface waters where phytoplankton grow is unknown. It is reasonable to assume that this is a 130
significant source that could be eliminated or minimized by destratification of the lake, but the
practicality of destratification is unknown.

In their current form, the main sources of phosphorus for Lake Elsinore are very far out
of line with the mitigation plan that is based on suppression of algal biomass by reduction of
bioavailable phosphorus in the upper water column. If the data at hand are reliable both in terms 131
of analytical results and interpretation, and if mitigation is applied mainly to the watershed

source, seems inevitable that Lake Elsinore will be hypertrophic even with a successful TMDL program as identified in the TMDL report. Therefore, the motivation for the TMDL process is not clear. Examination of the empirical data is necessary. Reliance on the model is not advisable because the model evidently is based on a presumed relationship between phosphorus load and chlorophyll. There is no causal relationship of phosphorus and variation in algal biomass at present or in the past because the amount of available bioavailable phosphorus in Lake Elsinore is constantly far in excess of the amount that would allow suppression of phytoplankton biomass. It is necessary that the concept of a threshold for P limitation be the basis for projecting the effects of phosphorus sequestration on the growth of algae in Lake Elsinore. Given the present information and interpretation, the most credible conclusion is that the mitigation program, if completed as proposed, will not produce significant changes in Lake Elsinore. **131**

Canyon Lake

Many of the comments above concerning Lake Elsinore apply in some degree to Canyon Lake as well and will not be repeated here. The focus here is on topics that apply differently to Canyon Lake than to Lake Elsinore.

Depletion of Oxygen in Deep Water

Depletion of oxygen leading to anoxia occurs in Canyon Lake. There appears to be no proposal in the TMDL document for remediation of anoxia in the lake. The lake is considerably smaller than Lake Elsinore, and has a more focused deep area and a more expansive shallow area than Lake Elsinore. It is possible that the lake could be destratified in warm weather by methods suggested above for Lake Elsinore. A benefit of destratification would be constant mixing of the **132**

entire water column, which could offset the occurrence of anoxia. Under these circumstances, internal phosphorus loading might be minimized. Given the long term expense of alum application, and the accumulative of aluminum in the sediments over decades from this type of 132
treatment, it maybe advisable for the TMDL group to call for a study of feasibility for elimination of deep water anoxia in Canyon Lake.

Phosphorus Concentrations

Concentrations of bioavailable P in Canyon Lake supply water are within the hypertrophic range but can be suppressed by addition of alum to the water column. A fully satisfactory record for the effect of alum is not available in the TMDL document, however. According to the TMDL report, concentrations of phosphorus in the water column are high prior 133
to addition of alum and low afterward. This information is incomplete in that concentrations of bioavailable phosphorus in the lake need to be determined over an entire time course of a year, and not centered around the time of application. Perhaps that information is available, but I did not find it.

Sources of bioavailable phosphorus include the watershed and internal loading. Watershed phosphorus is analyzed in terms of total P coming from the watershed to the lake through the San Jacinto River and from Salt Creek. Watershed sources are broken down by type as they were for the analysis of Lake Elsinore. As indicated for Lake Elsinore, the use of total P 134
as an indicator of phosphorus loading is directly relevant to growth potential for phytoplankton is erroneous. The volume weighted average for soluble reactive phosphorus is the basis for determining the importance of watershed sources.

External Peer Review of Draft Basin Plan Amendment to Incorporate Revised Total Maximum Daily Loads (TMDLs) for Nutrients in Lake Elsinore, Canyon Lake, and the San Jacinto River Watershed, Riverside County, CA

by

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Review Submitted

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Review of Lake Elsinore TMDL Technical Report

The focus of this review is Conclusions 6 (Implementation Plan) and 7 (Economic Analysis) from Attachment 2 of the Draft Basin Plan Amendment-Revised Total Maximum Daily Loads for Nutrients in Lake Elsinore and Canyon Lake, San Jacinto River Watershed. My review is largely based on information provided in the TMDL Technical Report (Dec., 2018) concerning Implementation of Water Control Activities (Section 7) and Economic Considerations (Section 11). Information provided about TMDL Implementation in Section J of Attachment A is also reviewed. I am able to address these topics with confidence, based on 37 years of expertise and experience conducting research on water quality BMPs for TMDL based nutrient reductions.

Section 7: Implementation Plan

Implementation activities for the original and revised TMDL are designed to reduce Chl-a, increase DO and decrease total ammonia. Activities include 1) decreasing external loadings and 2) managing the internal nutrient loading, hydrology, DO levels and algae. Strategies differ for Canyon Lake and Lake Elsinore, with a greater focus in Canyon Lake on alum applications and a greater focus in Lake Elsinore on hydrologic controls that maintain recreational goals.

Climate change poses a threat to implementation activities through increased ET of lake, increased water temperature (that affects lake biology and chemistry), and increased likelihood of drought and flood. **135**

Table 7-1 of the Technical Report summarizes studies and plans undertaken since the 1990's (Phase I activities) to improve water quality in Canyon Lake and Lake Elsinore. A wide range of implementation activities resulted from these studies, including BMPs for permitted MS4's (street sweeping and catch basin cleaning) and agricultural CAFOs (manure hauling, dairy waste management, nutrient management plans). Reductions in nutrient loading (and runoff from ag fields) resulting from these activities were not accounted for in a simple model used as the basis for revised TMDLs. **136**

Watershed monitoring before and after 2011 showed mixed results for TP concentrations, and reductions of from 9-24% for TN concentrations depending on the location of monitoring station. A more definitive analysis should be conducted to estimate changes in TP and TN loads (see Fig. 4-19) or trends (e.g. Kendall Mann tau test). Results suggest an increased emphasis on managing nutrient loss from forested lands, the largest landuse in the watershed. **137**

Additions of alum to Canyon Lake have proven effective at reducing internal loading of phosphorus (Fig. 7-2 and Table 7-7). In Lake Elsinore, past implementation activities included building a levee, addition of supplemental water, aeration and fisheries management. Water quality and recreational benefits occur when the levee combined with supplemental (reclaimed) water maintains Lake Elsinore water levels at above 1,240 ft, primarily by lowering TDS. Aeration and mixing of Lake Elsinore has taken place since 2007, leading to increased DO levels on the lake bottom, decreased release of internal P via reduction of iron in lake bottom sediment, and increased emissions of nitrogen gas (and removal of ammonia) through cycles of oxidation (nitrification) and reduction (denitrification) in lake bottom water. Fisheries management involved removal of carp from 2003-2008. This action reduced carp populations by two-thirds, and resulted in large reductions in release of TP and TN from lake bottom sediments by bioturbation. The exact magnitude of reductions is not clear, because baseline bioturbation rates were **138** not explicitly mentioned. Are lakewide bioturbation rates currently 2 and 5 $mg/m^2/day$ for TP and TN, or are these the baseline rates? Carp populations in Lake Elsinore remain low (< 6/ac).

Modeling of Lake Elsinore water quality involves three scenarios, namely; watershed reference condition baseline (scenario 1), current development without water quality controls (scenario 2), and current development with water quality controls (scenario 3). Fig 7-7 indicates that scenario 3 reduces chlorophyll a concentrations dramatically compared with scenario 2, and reduces chlorophyll a concentrations better than scenario 1 at concentrations exceeding 150 ug/L. Modeling suggests that internal loading of TP and TN will be reduced by 33 and 22%, respectively, for scenario 3 relative to internal loadings for scenario 2. **139**

Potential Phase 2 implementation activities, summarized in Table 7-10, are primarily focused on reducing internal loading of P and N from Lake Elsinore and/or Canyon Lake. While Table 7-10 specifies the general nature of water quality benefits associated with each of the potential Phase 2 implementation activities, a more specific estimate of reductions in TP and TN (e.g. Low, Medium, High) should be added. These estimates would need to be refined during Phase 2 to prioritize each activity (along with considerations for cost and stakeholder preferences). **140**

The potential activities in Table 7-10 are intended to supplement Phase 1 implementation activities that are based upon lake level control at 1,240 ft in Lake Elsinore, and alum additions in Canyon Lake, combined with nutrient management activities in the watershed upstream of Canyon Lake. The first step in Phase 2 will involve selecting which of the supplemental activities to implement and the schedule for implementing them over the next 15-20 years. Phase 2 implementation is contingent on approval of the revised TMDL by local, regional, state and federal entities. **141**

Upon approval of the revised TMDL, four primary milestones are envisioned (Tables 7-11 of Technical Report and 6-9s of Attachment A). These include engaging and coordinating with stakeholders, revising existing permits, revising watershed based nutrient management plans for municipalities and agriculture, and implementing existing as well as supplemental activities to reduce external and internal nutrient loadings to Lake Elsinore and Canyon Lake. Water quality monitoring will be continued to assess the effectiveness of these activities at controlling nutrient loadings and the extent to which progress is being made on attainment of the revised TMDLs. Additional research studies are anticipated to support implementation activities, including identification of additional reference sites for water quality monitoring, verify assumptions in developing the revised TMDLs (effectiveness of implemented control activities, refinement of lake models), obtain a better understanding of lake nutrient dynamics, or study the impact of wildfires on nutrient export to surface water bodies. Research will also be needed to specifically model the effectiveness of potential supplementary implementation activities listed in Table 7-10. Finally, progress in attaining the revised TMDL will be evaluated annually and cumulatively every 5 years, and adaptive management techniques will be used to modify the implementation plan as needed. **142**

Section 7.4.2 and Table 7-12 of the Technical Report (and Table 6-9t of Attachment A) are not entirely consistent with information provided in Tables 7-10 and 7-11 of the Technical Report (and Table 6-9s of Attachment A), as neither the text in Section 7.4.2 nor Table 7-12 (or 6-9t) refer in detail to implementation of potential supplementary activities. Implementation activities in Table 7-12 (and Table 6-9t) are essentially ongoing activities from Phase 1, including Canyon Lake alum additions, Lake Elsinore aeration/mixing and fisheries management, and maintenance of Lake Elsinore water levels **143** through addition of reclaimed wastewater. Section 7.4.2.3 of the Technical Report comes closest to describing how potential implementation activities in Table 7-10 could be incorporated into Phase 2 through revision of watershed nutrient management plans. However, there is no recognition that the activities in Table 7-10 are primarily focused on reducing internal lake nutrient loadings and not export of nutrients from the upstream urban, agricultural or forested watersheds. Export of upstream nutrients is best addressed through watershed nutrient management plans, as is perhaps the topic of Mystic Lake drawdown. It would seem more appropriate to discuss implementation of activities in Table 7-10 that relate to internal lake loadings in Section 7.4.2.4, which is heavily focused on control activities in Lake Elsinore or Canyon Lake per se. 144

Stakeholder coordination via the Lake Elsinore Canyon Lake Task Force is briefly mentioned in Section 7.4.2.1 and again at the top of Table 7-12 (and Table 6-9t). Their role is largely limited to implementing the research and analysis needed to revise the Lake Elsinore/Canyon Lake TMDLs, and to implement studies and monitoring efforts to make progress in complying with the revised TMDL. It is recommended that a broader stakeholder engagement process be organized to actually decide on the strategy and timeline for selecting and deploying supplementary implementation activities in Table 7-10. This process is briefly mentioned in Section 7.4.2.4, without specific details who the entities responsible for TMDL compliance are, nor how these entities and associated stakeholders will decide on the strategy or timeline for selecting and deploying supplementary implementation activities. 145

From a technical point of view, revisions to existing NPDES and wastewater permits (Section 7.4.2.2), revision of existing watershed implementation plans (Section 7.4.2.3), and implementation of existing water quality controls (Section 7.4.2.4) are all reasonable. 146

Finding and Assumption for TMDL Implementation

According to Attachment 2: "The Implementation and TMDL Compliance Monitoring requirements of the proposed revised TMDLs provide a reasonable, practicable, and feasible plan for ensuring that waste discharges of nutrients will be controlled to return these waste discharges, and return the lakes, to the revised Watershed Reference Condition (WRC), using a combination of the continuation of all existing TMDL compliance control measures and additional nutrient reduction and control measures to meet the revised TMDLs." 147

In large part, this reviewer agrees with the above finding and assumption from Attachment 2. Phase 1 water quality control activities alone have been shown by lake modeling results (based on water quality monitoring data) to meet or exceed nutrient reductions and water quality objectives needed to attain watershed reference conditions. Adding or substituting potential supplementary water control activities associated with Phase 2 to existing activities implemented under Phase 1 should also allow these objectives to be achieved.

Section 11: Economic Considerations

According to California statutes, an economic analysis is required when a Basin Plan is revised. This analysis must include two components, namely; 1) the estimated costs and sources of funding for implementing an agricultural water quality control program, and 2) assurance that means of compliance with the revised TMDL are reasonable and economically feasible to implement. Economic costs are associated both with the ongoing Phase 1 implementation activities as well as with potential supplemental implementation activities associated with Phase 2.

Costs of existing Phase 1 projects are estimated based on recent expenditures (Table 11-1). The largest cost of $1.4 million/yr is associated with release of reclaimed wastewater by EVMWD to stabilize Lake Elsinore water levels. It is not clear whether or not this cost includes operation and maintenance costs of associated with the need to maintain and upgrade infrastructure. This cost is shared by the City of Lake Elsinore and EVMWD, and apparently is based partly on fees for water and sewer service levied on residential, commercial and landscape irrigation customers. **148**

As a technical note, EVMWD actually did relax discharges to Lake Elsinore during the floods in January of 2017. **149**

MS4 stormwater BMP control measures are estimated to cost $0.4 million annually (Table 11-1). These do not include (and are dwarfed by) costs borne by urban developers for stormwater capture and infiltration on new construction projects. Costs to urban developers would have to be paid, regardless of the TMDL requirements. No estimates are provided for the anticipated extent of urban growth expected during the years 2020-2045, but it is likely to be substantial. As a result, costs to urban developers for stormwater capture and infiltration are also likely to be substantial in future years. **150**

Lake Elsinore/Canyon Lake Task Force agreements and grants fund another $1.2 million/yr in costs to implement Phase 1 activities (Table 11-1) such as water quality monitoring, program administration, lake aeration, addition of alum, and carp removal. It is not clear whether or not the costs for lake aeration and mixing take into account the need for replacement and/or upgrade of existing infrastructure. Since carp removal has only been practiced one time, it is not clear how the annual cost for carp removal was estimated. **151**

Implementation of Agricultural BMPs during Phase 1 are estimated to cost approximately $10 million. Given that there are less than 60,000 ac of agricultural land in the Lake Elsinore/Canyon Lake Basin, this equates to $166/ac in costs, which seems high. Costs associated with nutrient management or conservation tillage practices on the 46,000 ac of rainfed or irrigated cropland in the Basin would typically be $40/ac or less. Costs associated with installation of dairy waste management systems would typically be exponentially higher, but there are only 816 ac of dairy in the Basin. It would be advisable to provide more detail concerning how the costs for implementing BMPs on agricultural land were estimated. Are there mechanisms in place to track cost share dollars paid to agricultural producers by EQIP along with state or local incentive programs? What is the source of funding for the estimated $10 million expended by agricultural producers? What are the estimated annual costs and sources of funding for continued implementation of BMPs on agricultural land during Phase 2 (e.g. 2025-2040)? **152**

Costs of ongoing Phase 1 water control activities and potential supplemental control activities are summarized in Fig. 11-1. This Figure omits cost estimates for urban watershed BMPs that are described in Section 11.1.2.12. No quantitative analysis of the effectiveness at reducing nutrient loadings is undertaken for any of these control activities. However, for each supplemental control activity a qualitative description of potential water quality benefits is provided. It would be useful, in addition, to add another sentence or two for each supplemental control activity indicating a categorical classification (low, medium or high) for effectiveness of the activity at achieving water quality benefits relative to other potential supplemental control activities. **153**

Costs of Potential Phase 2 Supplemental Control Activities

Mystic Lake drawdown is proposed at a rate of 4,000 acre ft per year (AFY). This drawdown is anticipated to send relatively high quality water downstream to Canyon Lake, resulting in flushing of nutrients and algae, and increased ability to stabilize water levels in Lake Elsinore. In my opinion, the water quality benefits would be greatest if drawdowns were timed to periods long enough after intense runoff events at Mystic Lake to allow time for settling of sediment and nutrients. However, water quality benefits of flushing may be offset if water from the Mystic Lake drawdown has high concentrations of phosphorus or nitrogen. Water quality monitoring is needed to determine N and P concentrations in Mystic Lake. The volume of water sent to Canyon Lake during drawdown of Mystic Lake rivals the volume of reclaimed water added to Lake Elsinore, so costs of sending reclaimed water to Lake Elsinore may be offset to some extent by the Mystic Lake drawdown. Costs of drawing down Mystic Lake, including infrastructure, capital costs and operation and maintenance are relatively low at $1.6 million/yr. **154**

Addition of alum to Canyon Lake inflows is proposed during high runoff periods. This alum would bind bioavailable phosphorus entering Canyon Lake before it can diffuse through the water column. This supplemental practice would reduce the need to apply alum treatments to Canyon Lake to bind phosphorus and reduce internal loading of phosphorus from bottom sediments. Costs for alum additions to Canyon Lake inflows during storm events seem relatively low compared to the potentially large water quality benefits (Table 11-3) of this potential practice. **155**

Incremental increases in the volume of reclaimed water (by 2 MGD or 3.5 MGD) added to Lake Elsinore are being proposed in drought years as a supplemental activity. The annual incremental costs are relatively small ($1.5-2.1 million), and would only occur periodically. Incremental increases in reclaimed water additions to Lake Elsinore could have adverse impacts on water quality, because the water contains low concentrations of phosphorus and nitrogen. / The primary purpose of adding reclaimed water is to stabilize lake water levels above 1,240 ft, with primary benefits for recreational uses. In addition, stabilization of lake water levels may potentially reduce wave induced suspension of sediments, facilitate the establishment of shoreline aquatic vegetation and reduce concentrations of total dissolved solids. However, no solid assessment of the potential benefits of these impacts on water quality was provided. **156**

Hypolimnetic oxygenation is proposed as a supplemental activity to alum additions in Canyon Lake. This is anticipated to reduce internal loading of phosphorus and increase conversion rates of ammonium to nitrate from sediments in the main body of Canyon Lake. There would be no water quality benefits from hypolimnetic oxygenation in the East Bay of Canyon Lake. Costs to construct, operate and maintain the infrastructure for hypolimnetic oxygenation are estimated at about $ 4 million, which seems reasonable. **157**

Dredging of roughly 200,000 cubic yards of bottom sediment from roughly 50 acres in East Bay of Canyon Lake has been proposed by the Canyon Lake Property Owners Association (POA). Their primary motivation is improved access by boats to homeowner docks. A dredging project organized and paid by the POA between 2002 and 2008 removed 20,000 cubic yards before being halted by a court order that reclassified the project as a public works project requiring payment of prevailing wages and doubling the costs of dredging. **158**

Costs of dredging bottom sediment from the East Bay of Canyon Lake have been estimated at a high cost of $14 million based on wages that would be paid as a public works project, and based on the worst case scenario for disposal of lake sludge in a landfill. POA has proposed saving money by disposing of dredged sediment on the bottom of the western portion of East Bay, on land east in the floodplain of Salt Creek, or on land owned by POA. It is not clear who would end up paying for the costs of dredging East Bay of Canyon Lake, given the strong role played by POA in proposing this project. **159**

Dredging of East Bay would remove sediment that contributes to internal loading of phosphorus and nitrogen. However, in the long-term, internal loading would resume from sediments remaining on the lake bottom. Water quality benefits of the dredging project appear to be temporary and limited in nature. The project also does not address the primary source of the problem, which is delivery of sediment in runoff to East Bay of Canyon Lake. Primary benefits of dredging would accrue to homeowners through improved access by boats to private docks, and increased capacity to store flood water. **160**

Indirect Potable Use involves pumping advanced treated reclaimed water to the northern end of Canyon Lake. This water would slowly flow through the lake, before being withdrawn at the lower end of Canyon Lake for drinking water treatment. The primary purpose and benefit of the project is to provide a local source of potable drinking water. An alternative method for providing local drinking water is to inject the reclaimed water into aquifers, where it would later be recovered and treated to produce a local source of drinking water. **161**

No water quality benefits to Canyon Lake would occur with the groundwater recharge, recovery and treatment alternative. Water quality benefits to Canyon Lake would only occur with the reservoir augmentation option. These water quality benefits involve dilution of lake phosphorus and nitrogen concentrations. However, since the magnitude of reservoir augmentation (volume added) was not clearly specified (is Phase 1 volume 3,360 AFY at RWRF?), it is not clear that dilution would be a significant benefit in Canyon Lake. In addition, reservoir augmentation in wet periods would increase delivery of nutrients downstream to Lake Elsinore, worsening water quality there. **162**

Costs associated with water quality benefits of indirect potable use equate to the difference in costs for reservoir augmentation versus costs for groundwater recharge, recovery and treatment (Table 11-7). Baseline capital costs considered as a stand alone cost are very high for either option. However, the incremental benefits of reservoir augmentation relative to groundwater recharge are much lower, at approximately $10 million. Since the primary purpose of indirect potable use is to provide a local source of drinking water, it is not clear who would bear the incremental costs associated with the reservoir augmentation alternative. **163**

Lakeshore vegetation establishment is proposed on up to 100 acres (about 20-30 miles) of Lake Elsinore shoreline and littoral zone. Submerged aquatic vegetation could be challenging to establish and maintain as a result of limited penetration by sunlight in turbid waters, salinity or fluctuating water levels. Water quality benefits could include reduced wave induced shoreline erosion, uptake of phosphorus and nitrogen, improved oxygenation in the near shore region, and improved habitat for fish and benthic organisms. Benefits depend on the success rate of vegetation establishment, and likely would not be large relative to the revised TMDL goals. Costs of establishing lakeshore vegetation are reasonable at roughly $2.9 million. This assumes replanting is not necessary. **164**

Artificial recirculation of oxygen depleted nutrient rich water from the hypolimnion in deep water of Canyon Lake through a three mile pipeline to shallow water at the inlet of East Bay in Canyon Lake, where it would gradually flow back to the main lake. Removal of low oxygen water from the main lake would reduce internal loading of phosphorus and nitrogen. Recirculating water would be reaerated, and would flush nutrients out of East Bay, reducing the severity of algal blooms. Water quality at the water treatment plant in Canyon Lake would be improved. 165

Costs of artificial recirculation in Canyon Lake are relatively high at $11.1 million, and may not be warranted if water quality benefits are small. Costs are primarily due to infrastructure and capital costs, operations and maintenance are relatively small. It also is not clear what proportion of the costs will be borne by local homeowners whose streets are torn up and rebuilt to install the pipeline.

Ultrasonic control of cyanobacteria algae is proposed in East Bay of Canyon Lake. The entire East Bay area could be treated using 12 ultrasonic units powered by three floating solar panel arrays at a cost of $0.3 million. Sonication would reduce the cyanobacteria population as well as the health risks of associated toxins. There would be no direct impacts of ultrasonic treatments on nutrient levels, nor would algae levels in the main portion of Canyon Lake be impacted. 166

Algaecide control of cyanobacteria algae in Canyon Lake and Lake Elsinore is proposed using PAK 27, which releases hydrogen peroxide. Cyanobacteria killed using this technique would settle to the lake bottom, potentially producing elevated toxin levels after repeated use of the algaecide. Since lake nutrient levels are not affected by this control activity, algae blooms could reappear following treatment. 167

Costs of algaecide control were estimated at $7 million based on a single annual application to the entire surface area of Canyon Lake and Lake Elsinore to a depth of four feet. Costs may be underestimated, as It is unclear whether or not a single application would be sufficient for control of cyanobacteria.

Harvesting algae from a barge is proposed in Lake Elsinore, and perhaps the main portion of Canyon Lake. Harvested algae could potentially be sold for biofuel, compost, or nutritional supplements if no toxins are present. Costs do not include potential revenue from sale of harvested algae, nor are the potential costs of disposing toxic algal residue considered. There is an overestimate in cost calculations of $1.2 million, as Lake Elsinore is 20 times smaller than Klamath Lake, not 20% of the area. Water quality benefits of harvesting algae are anticipated to include reductions in chlorophyll-a, removal of N and P taken up in algal biomass, and reduced release of toxins into lake. 168

Urban watershed BMPs are proposed to capture and infiltrate runoff from large storms with a return period of 5 years. A strategy is described that involves regional detention and infiltration basins that store 6 ft of water, bioretention structures that store 1.5 ft of water and pervious pavement. The approach to considering urban watershed BMPs seems rather lacking in detail, narrow in scope and short term in vision. Detail is lacking on how much of the 90,000 acres of existing urbanized land could be retrofitted, and how much homeowners would be engaged through education and incentive programs. The cost estimate seems based on treating runoff from only a 500 acre urban drainage area. The section is narrow in scope, as it does not consider conversion of land to xeriscaping, use of rainbarrels, stormwater collection system infiltration systems, controls on application of N and P to 169 lawns, or sweeping of leaf and lawn litter. Proposed activities are focused only on short term and not on policies to guide future urban development that would place a greater emphasis on reducing cumulative impacts of stormwater runoff on Canyon Lake and Lake Elsinore.

Cost estimates for urban watershed BMPs are based on an economic analysis by the Santa Ana Water Board on methods to control bacterial water quality objectives during dry weather. Neither low impact development BMPs nor controls on N and P use or sweeping of lawn and leaf litter are comparable with methods to control bacterial water quality. A statement to the effect that costs for installing permeable pavement are unreasonable leads to a question about whether costs for installing bioretention structures are also unreasonable? The economic analysis for urban watershed BMPs is lacking in detail, is narrow in scope, and short term in vision, and so does not lend confidence to the results presented. **170**

Section 11.12 has the objective of discussing the potential natural resource and economic benefits of implementing water quality controls in Phase 1 and 2 of the TMDL and revised TMDL. Many of these bullets are written in a generic fashion that does not allow for the extent of natural resource or economic benefits to be assessed (even in a relative sense such as low, medium or high). For example, how much will lakeshore vegetation improve fish populations? How much will use of Lake Elsinore and Canyon Lake for boating, fishing and swimming increase as a result of implementing water quality controls? The downward trend in purchase of fishing licenses is not a benefit. What aspects of aesthetic benefits and ecosystem health will improve? How much is lake clarity and hence property values expected to improve? What cost savings will result from improved water treatability? How will improvements in the health and water quality of Canyon Lake affect the health of species in and around the lake? What are the economic benefits (externalities) associated with all of the above? Are any efforts planned to better link water quality objectives associated with the revised TMDL to any of the above natural resource or economic benefits through modeling or quantitative analysis? **171**

Section 11.13 on potential funding sources for implementation of agricultural water quality control measures contains adequate detail. It would be useful to provide a similar level of detail for all other water quality control measures discussed in Section 11 of the report. **172**

Finding and Assumption for Economic Analysis

According to Attachment 2: "The supporting documentation and evidence for the revised TMDLs includes an Economic Analysis of the proposed revised TMDLs that evaluates the potential costs of compliance with the proposed revised TMDLs. As well as the potential costs of compliance to agriculture, and identifies potential sources of funding to help the agricultural community subject to the Revised TMDLs to comply. The Economic Analysis provides a sound and supportable evaluation of the potential costs of compliance, as required." **173**

To a moderate degree, this reviewer agrees with the above finding and assumption from Attachment 2. Costs of implementing Phase 1 water control activities are based on historical data associated with their ongoing implementation in Lake Elsinore, Canyon Lake and their upstream watersheds. Costs of implementing potential Phase 2 supplemental water quality control activities are largely based on sound assumptions and economic analysis. **174**

To some extent, this reviewer disagrees with the cost estimates for implementing potential supplemental water control activities in Phase 2. For example, costs of dredging seem overestimated, since the local Property Owner Association (POA) has identified private land for sludge disposal. Costs of **175** harvesting algae from a barge are also overestimated due to a mistake in accounting for the difference in area of Lake Elsinore relative to Klamath Lake. Costs of implementing urban watershed BMPs seem somewhat questionable based less on the cost analysis per se, and due more to the lack of detail regarding area of implementation, narrowness in scope of selected BMPs, and lack of a long term vision for alternative mechanisms (policies, incentives, etc) to achieve nutrient reductions from urban watersheds. 176

Three other weaknesses of the Economic Analysis also warrant mention. First, there is little discussion about the reasonableness or feasibility of costs for implementing potential supplemental water quality control activities during Phase 2 (with the exception of dredging and installing permeable pavement). Part of this stems from a lack of effort to identify the cost/lb of nutrient reduced, in other words the absence of an assessment on economic effectiveness of achieving nutrient reductions for any individual water quality control activity. Much more emphasis is needed on this assessment of economic effectiveness during Phase 2. Another part stems from a failure to identify potential funding sources for potential supplemental in-lake water control activities. 177

Second, the Technical Report does not always identify who bears the costs of implementing potential supplemental water quality control activities in comparison to whom benefits the most from their implementation. For example (one among many possible examples), dredging would primarily benefit Canyon Lake homeowners along East Bay by providing them with better boat access to their docks. Water quality benefits of dredging are minor. Would the costs of dredging be borne primarily by these homeowners or more generally by stakeholders in the Canyon Lake watershed? 178

Third, the economic assessment does not employ full cost accounting techniques to assess costs or benefits associated with externalities such as recreation, fish populations, property values, etc. To a large degree, there is a great need to quantitatively link water quality outcomes provided through lake modeling with outcomes important to stakeholders, such as recreation, fish populations, and property values. 179

PEER REVIEW OF DRAFT BASIN PLAN AMENDMENT TO INCORPORATE REVISED TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR NUTRIENTS IN LAKE ELSINORE, CANYON LAKE, AND THE SAN JACINTO RIVER WATERSHED, RIVERSIDE COUNTY, CA

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University of Washington
Seattle, Washington
August 16, 2019

The following includes a review of certain conclusions, assumptions, and findings derived from information in the following two documents:

1. **Attachment A to Tentative Resolution RB8-2019-0041, a Basin Plan Amendment for revised TMDLs for Nutrients in Lake Elsinore and Canyon Lake, in the San Jacinto River Watershed, Riverside County, CA (Attachment A BPA), Pages 1-47 to be reviewed**
2. **DRAFT FOR PUBLIC REVIEW AND PEER REVIEW TMDL Technical Report: Revision to the Lake Elsinore and Canyon Lake Nutrient TMDLs, including the Substitute Environmental Document (SED/CEQA Section 11) (TMDLs Revisions Technical Report)**

My review focuses primarily on the following elements from Attachment 2 in the correspondence from Jayne Joy, Executive Officer, Santa Ana Regional Water Quality Control Board, Riverside, CA to Gerald Bowes, Ph.D., Manager, Cal/EPA Scientific Peer Review Program, Office of Research, Planning and Performance, State Water Resources Control Board, Riverside, CA dated July 19, 2019:

1.**Problem Statement Section 1.A Pages 1-3, Attachment A Basin Plan Amendment (BPA) and Revised TMDLS Tech Report Sections 1 and 2.**

2. Watershed Reference Conditions ((Used as the basis for the Numeric Targets, TMDLs, WLAs, LAs and required nutrient load reductions in the Resolution and Attachment A). Findings No 18-21 of the Resolution and Revised TMDLs Tech Report Sections 2 and 3)

3. Numeric Targets, Attachment A BPA Section 1.C Pages 4-14, Revised TMDLs Tech Report Section 3 Findings and Assumptions a)-d).

5. TMDLs, WLAs, LAs and nutrient reductions and Margin of Safety, Attachment A Sections F and G Pages 17-26, Revised TMDLs Tech Report Section 6.

9. References. Resolution and Attachment A, Revised TMDLs Tech Report Section 12

The Big Picture

Education, Experience and Expertise

The education, experience and expertise that I have applied to this review include a Bachelor of Science in Mechanical Engineering and a Master of Science in Geology and Geophysics from the Massachusetts Institute of Technology and a Master of Science in Mechanical Engineering and a Doctor of Philosophy in Water Resources from the University of Washington. In my 36-year career as an Environmental Scientist for the US Environmental Protection Agency (EPA) and its predecessor, the Federal Water Pollution Control Agency (FWPCA), I developed and applied mathematical models for surface water and groundwater to simulate the impacts of point and non-point sources on water temperature, dissolved oxygen, coliform bacteria, nutrients, phytoplankton, suspended solids, and heavy metals in streams, rivers, lakes, reservoirs and estuarine/ocean systems. In this capacity, I was designated a National Expert in Water Quality Modeling for the US EPA. As such, I participated in the review and development of several Total Maximum Daily Load determinations, as well as analyses of National Pollution Discharge Elimination Systems (NPDES) permits, National Environmental Policy Act (NEPA) reviews and risk analysis studies. In addition to my work as an Environmental Scientist for the US EPA, I taught a graduate course in Water Quality Modeling in the University of Washington's Department of Civil and Environmental Engineering.

After retiring from the US EPA, I received an appointment as an Affiliate Professor in the University of Washington's Department of Civil and Environmental Engineering. In this position, I continue to develop and publish papers in peer-reviewed journals on the impacts of climate change on water quality at scales ranging from urban to global.

Review

General Comment: In the precise mathematical definition of Cumulative Distribution Function (CDF), the probability is a function of the random variable and, therefore, plotted as the ordinate rather than the abscissa. The probability of all events occurring is, of course, 1.0 and, generally, displayed as such. 180

Executive Summary

Executive Summary-Page Es-4: The term, 'Linkage Analysis' is used here and in several other places before being defined on Page 3-13. **181**

1.Problem Statement Section 1.A Pages 1-3, Attachment A Basin Plan Amendment (BPA) and Revised TMDLS Tech Report Sections 1 and 2.

Tech Report-Page 1-1: '*The TMDLs specified numeric targets for DO, chlorophyll-a, ammonia, Total Phosphorus (TP)—*'. The carbon: chlorophyll *a* ratio, where carbon is a measure of phytoplankton biomass is not a constant (e.g., Yacobi and Zohary, 2010) **182**

Tech Report-Page 1-2: -*Aluminum sulfate ("alum") binds with phosphorus thereby preventing excess algae growth in the lake. As of February 2018, 1,520 metric tons of alum have been applied*' The precipitate is a solid waste (e.g., FACT SHEET FOR NPDES PERMIT WA-002447-3 City of Spokane - Riverside Park Water Reclamation Facility (POTW) and Spokane County (Pretreatment Program)). Is there consideration of the impact of this on the lake ecosystem, as in Table 10-1? **183**

Tech Report-Page 1-2: '--estimate nutrient loads to both lakes (LESJWA 2010)'. This reference is not in the archived list of references. **184**

Tech Report-Page 1-2: Anderson (2012a) does not include any discussion of model development for Canyon Lake. Rather, it evaluates the effectiveness of certain chemicals for sequestering the macronutrients, nitrogen and phosphorus. It is not clear from the report regarding the way in which they are included in the water quality model.
The report by Anderson (2016abcdef) describes the model development for Lake Elsinore, only. More discussion of model development is in Section 5 of the Tech Report. However, it would seem more logical to build the case for model development prior to discussing the results. **185**

Tech Report-Page 2-33: "*Currently, monitoring and analysis of nutrients and chlorophyll-a occurs monthly during the summer months of July, August, and September, and bi-monthly between September and July*" compared to "*Beginning in July 2016, the monitoring frequency of Lake Elsinore was increased to bi-weekly during the summer months of July, August, and September*:" Clarify which monitoring frequencies are in effect. The latter is best for capturing the frequency and magnitude of plankton blooms. **186**

Tech Report-Page 2-35&36: The discussion of Total Phosphorus (TP) is confusing. Prior to January 1993, orthophosphate concentrations in Lake Elsinore were below detection limits. The report suggests that the overflow from Canyon Lake in 1993 resulted in increased TP in Lake Elsinore. The observed data for TP are only shown for the period, 2002-2016, however. For these observations, TP is initially near the TMDL limit, but varies greatly from ~0.8 mg/l to <0.1 mg/l. Was it due to additional influx from Canyon Lake or rather to some internal processes in Lake Elsinore? **187**

Tech Report-Page 2-47: "-- *finding that may be expected for a shallow eutrophic lake*." Reference? **188**

Tech Report-Page 2-56: '*As in Lake Elsinore, a majority of the phosphorus in the water column in Canyon Lake exists in soluble reactive form (Ortho-P).'* The discussion then changes immediately to a discussion of TP: '*Spikes in TP of greater than 1.0 mg/L were recorded in August 2007, and several dates between October2010 and June 2011.*' and does not mention Ortho-P again. Since the report claims that Ortho-P is the major component of TP and is the component available for phytoplankton growth, it should be given more attention and clarification. **189**

Tech Report-Page 2-58: Methods are available for performing statistical analyses on nondetects (Table 2-15) **190**

Tech Report-Page 2-75: What is 'mobile-P' and what is its significance? **191**

Tech Report-Page 2-77: '*Anderson (2012d) estimated the half-life (t1/2) of nutrients delivered to the lake bottoms of Canyon Lake (t1/2 of 6.7 years for organic-P and 16.7 years for TN) and Lake Elsinore (t1/2 of 60.4 years for organic-P --*' What's the significance of this? Is it in the model? Does organic P equal Total P for eroded soils? **192**

Peer Review Conclusions

Agreed that the revised Problem Statement provides a scientifically defensible description of the water quality problems in the Lakes related to excessive algae caused by waste discharges after appropriate responses to review comments. **193**

2. Watershed Reference Conditions ((Used as the basis for the Numeric Targets, TMDLs, WLAs, LAs and required nutrient load reductions in the Resolution and Attachment A). Findings No 18-21 of the Resolution and Revised TMDLs Tech Report Sections 2 and 3)

Peer Review Conclusions

After addressing the concerns expressed in the peer review, agreed that the establishment of a revised Watershed Reference Condition based on the asymmetric 99-year hydrologic record and no anthropogenic discharges of nutrient wastes, provides a scientifically sound basis for establishing the following Numeric Targets for the Lakes and establishing a scientifically justifiable method for establishing the TMDLs, WLAs, and LAs, as well as the reductions in the waste discharges. **194**

3. **Numeric Targets, Attachment A BPA Section 1.C Pages 4-14, Revised TMDLs Tech Report Section 3:**

Tech Report-Page 3-2: ‘*numeric nutrient endpoint (NNE)’* It would be better if this were in the main text rather than in a footnote. 195

Tech Report-Page 3-4: ‘*The revised TMDL includes a numeric target for chlorophyll-a, which is a measure of a pigment found within algae, and a commonly used measure of algae concentration in surface waters*.’ If this is, in fact a commonly used measure of algae concentration (biomass?), there needs to be a reference. See comment above regarding C:Chl. 196

Tech Report-Page 3-5: ‘*Chlorophyll-a, a pigment found within algae, is a commonly used measure of algae concentration in surface waters*’ There should be a reference here, as above. 197

Tech Report-Page 3-10: “*A CDF is a plot of a statistical distribution for a set of data*” See General Comment above 198

Tech Report-Page 3-10: “*However, over time, future water quality data converted to a CDF should align with the CDF of historical water quality, if no significant changes are made in the watershed or to the lakes that impact water quality in the lakes’* This is a leap of faith. Furthermore, it may only be true in the (unlikely) event the second clause in the sentence is true. A better rationale would seem to be to invoke other examples such as the one from Chesapeake Bay (EPA 2003) rather than making claims regarding the immutability of the CDF’s. 199

Tech Report-Page 3-11: ‘*~~logical~~ premise’* 200

Tech Report-Page 3-11: The issue raised in footnote 3 is addressed in Sections 3.2.2.1, 3.2.2.2 and 3.2.2.3. The footnote is not necessary. 201

Tech Report-Page 3-14: ‘*It is not possible to calculate the toxicity of ammonia for all volume elements at a daily time-step, using the lake water quality models developed in the linkage analysis. Moreover, it would be infeasible for future monitoring to assess whether ammonia toxicity is at levels that would naturally occur at a comparable spatial scale’* Why is this the case? The model used for the reference condition, CAEDYM (Hipsey et al., 2005) simulates water temperature and pH. Algebraic relationships for unionized ammonia are well known (https://rdrr.io/cran/AmmoniaConcentration/man/ammonia.html). Or use the algorithm in Table 5-9n of Attachment A. 202

Tech Report-Page 3-18: In terms of readability, it would seem that the discussion of the models used in developing the reference condition (Section 5) would precede the discussion of the way in which they are applied. 203

Tech Report-Page 3-18: A reference is needed for the model ELCOM. (Hodges, 2000?) 204

Tech Report-Page 3-19:The reference condition for Canyon Lake is based on a computationally intensive application of a 3-D model. Review of this approach is in Section 5, Linkage Analysis, Sections 5.2 and 5.3. 205

Tech Report-Page 3-21,3-22: There is something troubling about these 'CDF's'. In the case of chlorophyll *a* and Total Ammonia-N, how can there not be a probability that all values of both of these state variables be equal to 1.0? The fact that in the reference condition the lake has no water should not be relevant. If there is no water, there are no phytoplankton. As for DO, it is somewhat surprising that over a 100-year period, the volume of water is either equal to or greater than 5.0 mg/l or 0.0 mg/l. Seems odd and needs an explanation. 206

Tech Report-Page 5-4: '*Lakes and reservoirs tend to be more complex systems than a 0-D model can represent.*' There should be a reference here, or at least at discussion of the time and space scales for which the 0-D is valid compared to 1-D, 2-D or 3-D. 207

Tech Report-Page 5.4: '*Geometric complexity of Canyon Lake, combined with its vertical stratification, requires a 3-D model such as ELCOM to capture key processes of physical transport and vertical nutrient fluxes.*' What is ELCOM? A justification for using a complex 3-D model like ELCOM requires considerably more discussion than this. The horizontal aspect ratio of Canyon lake (Width/Length), shown in Figure 2-33, suggests that a 2-D model that accommodates branches (CEQUAL-W2, for example) would be entirely appropriate, Such a model would be much less demanding computationally than the 3-D model chosen here. Furthermore, there is no reference to measurements of currents or water quality constituents that support the conclusion that a 3-D model would provide better results than a 2-D model. 208

Tech Report-Page 5-7: '*CAEDYM includes full eutrophication kinetics and can adequately represent water column water quality dynamics in both lakes. Water quality in Lake Elsinore and Canyon Lake was simulated using CAEDYM v.3.*' The reference to CAEDYM (Hipsey et al., 2006(5?)) is to Version 2.2. Assuming Version 2.2 and Version 3.? are essentially the same, there should be considerably more discussion of which of the many compartments (Figure 1.1, Hipsey et al., (2006)) are applicable or are being simulated for the Lake Elsinore/Canyon Lake TMDL. 209

Tech Report-Page 5-16: Define 'relative percent error (%RE)'. 210

Tech Report-Page 5-16: 5.3.5 Water Quality Model Summary Statistics. Assessing model acceptability should be based on more than simply relative percent error (%RE). See Moriasi et al., 2007 for a discussion and various metrics. 211

Tech Report-Page 5-18: '*intensive computational demand of the ELCOM 3-D hydrodynamic model restricted the simulation to a 5-year time period for calibration*' 212

Using a simpler model here, as described previously would make possible a longer period of record for creating the reference condition. 212

Tech Report-page 5-21: '*For internal water quality processes, default water quality parameters were used in CAEDYM (Hipsey et al. 2006) except for key parameters for bioavailable nutrient (SRP and NH4) fluxes and SOD, as follows'* The behavior of the many compartments in Figure 1.1 of Hipsey et al. (2006) is controlled by the parameter estimates. While it is not necessarily the case that the estimates are unique to a specific ecosystem, there should be an in-depth discussion of why these parameters can be used in the models for Lake Elsinore and Canyon Lake. The flow of carbon to phytoplankton, as characterized by its surrogate, chlorophyll *a*, will be affected by the flow of carbon to the other compartments of zooplankton, fish and macroalgae. These features may not be ones that are part of either of the aquatic ecosystems included in the TMDL. As a result, carbon flow simulated by the model may be quite different than that which occurs in either Lake Elsinore or Canyon Lake. It's difficult to say whether or not aggregating the results at a fairly high level, which is the case for this report, reduces the uncertainty associated with using parameterization that is not representative of the system. However, it does suggest that a much less complex model with fewer compartments might provide as satisfactory a result. Increasing model complexity does not necessarily decrease model uncertainty. 213

Tech Report-Page 5-23: '*As with DYRESM, the ELCOM and CAEDYM models require a very large number of parameters; default values were used for almost all thermodynamic and chemical/biological/ecological values'* . How is this different from the parameter estimates mentioned above? Similar comments to those above apply. 214

Tech Report-Page 5-24: '*Model parameters were varied to improve goodness-of-fit between observed and predicted values*.' Which parameters? How does this relate to the previous discussion regarding parameter estimation? This is a highly underdetermined inverse problem for which the actual version of the model being used has thousands of parameters and for which observations are limited. 215

Tech Report-Page 5-30: Table 5-5 should include other metrics for evaluating model acceptance as in Moriasi et al. (2007) 216

Peer Review Conclusions

3.a) Agreed that the revised TMDLs sets revised Numeric Targets, based on a scientifically justifiable assumption that excessive algae growth in the lakes is that which would occur under a watershed reference condition without the inputs of any nutrient waste discharges by man, and that nutrient waste discharges to the Lakes will be controlled to be no more than the reference watershed nutrient runoff after addressing peer review comments. 217

3.b) The likelihood that the Numeric Targets for the Lakes will provide for the return of the Lakes to the modeled WRC is increased by the use of Cumulative Distribution 218

Frequencies (CDFs) for the Numeric Targets for the Lakes, but not certain. 218

3.c) Tentative agreement that the model used provides a scientifically defensible method for approximating the response of the Lakes to watershed discharges of nutrient wastes and the internal flux of nutrients from the sediment in the Lakes. This would depend on the responses to review comments above and in Section 5, below. 219

3.d) See 3.b) above.

5. TMDLs, WLAs, LAs and nutrient reductions and Margin of Safety, Attachment A Sections F and G Pages 17-26, Revised TMDLs Tech Report Section 6.

Peer Review Conclusions

Agreed that the revised TMDLs for nutrients in the lakes, using the Numeric Targets, Source Analysis, and Linkage Analysis, provide scientifically defensible revised TMDLs for nutrients in Lake Elsinore and Canyon Lake after addressing the peer review comments. 220

9. References. Resolution and Attachment A, Revised TMDLs Tech Report Section 12

The references below should be added to the list of references, as should the URL's in the text above and those mentioned in the text, above, where references are missing or incorrect. 221

Additional Comments

Tech Report-Page 7-24 and Figure 7-6: '*Some corroboration of these offsets has been found in the DYRESM-CAEDYM model*' How can there be corroboration with 1-D model when this is very likely to be, based on Figure 7-6, a 2-D phenomenon. 222

Tech Report-Figure 7.7: This 'CDF' suffers from the problem discussed above for pages 3-21 and 3-22. That is, the probability that all the values of chlorophyll *a* can never be 1.0 in the reference condition. As a result, the reference condition and the modeled scenarios cannot be compared. 223

Tech Report-Figure 7.8: Why does the scenario with the controls in place perform more poorly than the one without controls? 224

Tech Report-Page 7-35: '*Given the longevity of climatic cycles and the potential impacts from climate change*' See Blickenstaff et al., (2013). 225

Tech Report-Sections 8.2.3 and 8.2.4: Monthly and bi-monthly monitoring may not adequately capture peak values of constituents, particularly those of phytoplankton. Based on the discussion on Page 2-47, (*seasonal succession dominated by diatoms in the* 226 *winter and cyanobacteria during summer months (Appendix A, Figure A-6)* bi-monthly monitoring in Lake Elsinore in the winter may not be adequate. 226

Tech Report- 9.1 Approach 1 - Numeric Target and 9.2 Approach 2 - Reference Condition Model: Does compliance accommodate uncertainty in model estimates of the reference condition? See EPA (2003) for a detailed analysis of the way it was characterized in the Chesapeake Bay TMDL. 227

What is the rationale for using the previous 10-year period for testing compliance? Should the reference condition be updated by replacing older years with more recent ones? 228

The Big Picture

1. In reading the staff technical reports and proposed implementation language, are there any additional scientific issues that are part of the scientific basis of the proposed rule not described above? If so, please comment with respect to the statute language given above.

A major scientific issue, addressed only marginally in Sections 7.1.4 and 7.4.1.2, is that of climate change. It seems likely that the reference curves, for which basin hydrology plays an important role, will evolve as the climate changes. Furthermore, water temperatures, which control many processes in lakes and rivers such as saturation levels of DO and CO_2 and growth rates of aquatic organisms, are likely to increase. Numerous studies (e.g., Blickenstaff et al., 2013) and databases (e.g., Livneh et al., (2013) and Abatzoglou (2013)) are available to simulate conditions under projected levels of climate change. 229

2. Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?

There are elements of the scientific knowledge, methods and practices upon which the rule is based that can be improved. The most vulnerable element is that of the development and interpretation of the reference condition. Selection and application of the models used to develop the curves are likely to be the subject of considerable scrutiny. As a result, both the methods and applications of the methods should be stated clearly and accurately. Taken as a whole, however, and addressing issues raised in the review process will result in a rule that is based on sound scientific knowledge, methods, and practices. 230

References

Abatzoglou, J.T. (2013), Development of gridded surface meteorological data for ecological applications and modelling, International Journal of Climatology 33 (1), 121-131.

Blickenstaff, K., S. Gangopadhyay, I. Ferguson, and L. T. Pruitt (2013). Technical Memorandum No. 86-68210-2013-02, U.S.Bureau of Reclamation, Water and Environmental Resources Division (86-68200) Water Resources Planning and Operations Support Group (86-68210) Technical Services Center, Denver, Colorado Climate Change Analysis for the Santa Ana River Watershed Santa Ana Watershed Basin Study, California Lower Colorado Region.

Hodges, B.R. (2000) Numerical Techniques in CWR-ELCOM
(code release v.1),Centre for Water Research, The University of Western Australia
Nedlands, Western Australia, AUSTRALIA 6907
CWR manuscript WP 1422 BH

Livneh B., E.A. Rosenberg, C. Lin, B. Nijssen, V. Mishra, K.M. Andreadis, E.P. Maurer, and D.P. Lettenmaier (2013) A Long-Term Hydrologically Based Dataset of Land Surface Fluxes and States for the Conterminous United States: Update and Extensions, Journal of Climate, 26, 9384–9392.

Moriasi, D.N., J. G. Arnold, M. W. Van Liew, R. L. Bingner, R. D. Harmel, T. L. Veith (2007), Model evaluation guidelines for systematic quantification of accuracy in watershed simulations, *Trans. of the ASABE*, 50(3): 885−900.

Yacobi, Y.Z. & Zohary, T. (2010). Carbon:chlorophyll *a* ratio, assimilation numbers and turnover times of Lake Kinneret phytoplankton,*Hydrobiologia* 639: 185. https://doi.org/10.1007/s10750-009-0023-3