Technical Memorandum

Task 2: Evaluation of Long-Term Reduction of Phosphorus Loads from Internal Recycling as a Result of Hypolimnetic Oxygenation in Canyon Lake

Objective

The objective of this task was to evaluate the long-term reduction in internal nutrient recycling from bottom sediments and water quality that would result from installation and operation of a hypolimnetic oxygenation system at Canyon Lake.

Approach

The DYRESM-CAEDYM model was used to predict water quality over a 10-yr time horizon. The period January 2002 – December 2011 was selected since a number of studies have been conducted at the lake and watershed over this time period, meteorological and flow data are available, and a wide range in precipitation regimes were present, including drought (2002, 2007-2009) and near-record rainfall (2005). The previous parameterization of the model (Anderson, 2007; Anderson, 2008) was used as the starting point for this modeling effort. The availability of monitoring data and related field studies allow for robust verification and use of the model over this extended period of time. Three (3) different scenarios were evaluated: (i) a reference scenario that reflected conditions present in the lake and watershed; (ii) a scenario in which no internal recycling of nutrients occurred, and thus predicted water quality subject only to external loading to the lake (this would thus represent the *theoretical best* water quality attainable through in-lake treatment); and (iii) hypolimnetic oxygenation of the lake following PACE design 10b.

Meteorology

The meteorological conditions for 2002-2011 as measured at the CIMIS station at UCR (CIMIS #44) were used in all simulations. Daily average values for shortwave solar radiation, air temperature, and rainfall were used as part of the input data used to drive the thermodynamic-hydrodynamic model (DYRESM) (Fig. 1). Daily average shortwave radiation flux (J_{sw}) exhibited a well-defined seasonal trend, with daily winter values generally 100-150 W m^{-2} and summer maximum values of about 350 W m^{-2} (Fig. 1a). Day-to-day variations were nonetheless apparent and result from absorption and scattering of the incoming solar radiation by the atmosphere, especially cloud cover. On particularly cloudy winter days, the shortwave solar radiation averaged over the 24-h period often dropped below 50 W m^{-2} (Fig. 1a) and resulted in net cooling of the water surface and/or low equilibrium temperatures in the lake.

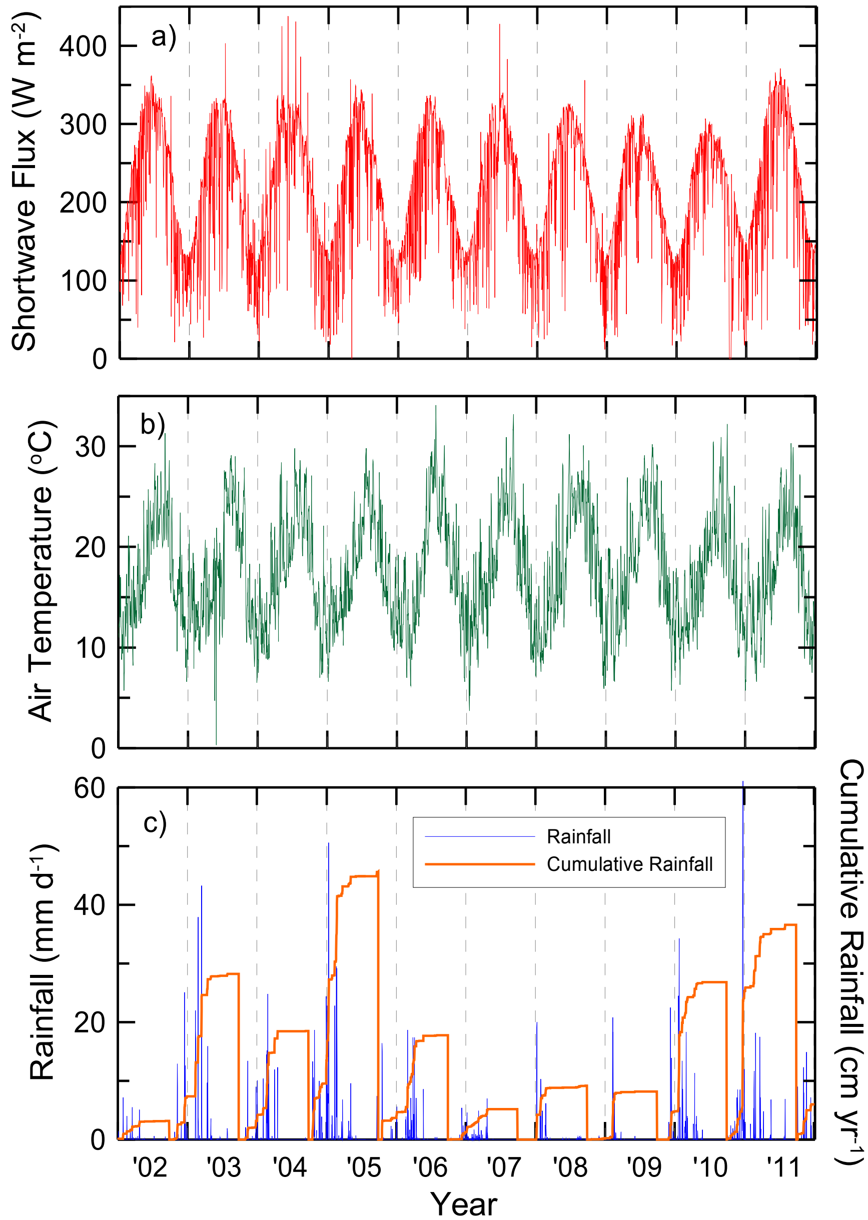

Fig. 1. Key meteorological data used to drive hydrodynamic-thermodynamic DYRESM model.

Daily average air temperatures exhibited strong seasonal trends as well (Fig. 1b). Daily values were typically around 10-12 ºC in the winter and 25-30 ºC in the summer. The atmosphere contributes longwave (>3000 nm wavelength) heat flux (J_l) to the lake (calculated from temperature and cloud cover) that, combined with shortwave heat flux, constitute the principal heat inputs to the lake (eq 1):

$$J_{net} = J_{sw} + J_l - (J_{br} + J_e + J_c) \qquad (1)$$

where J_{net} is the net heat flux, J_{br} is back radiation, J_e is evaporative heat flux and J_c is convective heat flux. Several processes thus also result in *release* of heat from the lake. For example, back-radiation from the water surface (J_{br}) that is related to the surface water temperature, following the Stefan-Boltzmann law, exports a significant amount of heat, as does evaporative heat flux (J_e). Evaporative heat flux is especially important in this region, where very warm dry conditions, often combined with strong winds, can export a substantial amount of heat (2.3 kJ g^{-1} water evaporated). DYRESM also requires information about windspeed and humidity in the air (not shown).

While these meteorological parameters define the net heat flux to the lake and the mixing that results from wind shear on the water surface, rainfall is part of the water balance calculation:

$$\frac{dV}{dt} = \sum_i Q_i + PAs - (EAs + W + Q_{out}) \qquad (2)$$

where V is lake volume, t is time, Q_i is the daily flow rate of inflow I, P is the precipitation rate, As is the lake surface area, E is evaporation rate, W is the withdrawal from the lake by EVMWD, and Q_{out} is overflow to Lake Elsinore.

Rainfall varied markedly over the 10-yr period, with daily events ranging from <0.1 mm d^{-1} to >50 mm d^{-1} (blue lines, Fig. 1c). Rainfall was most abundant in the winter, with very strong differences in the total annual (based on water year) rainfall values that ranged from <5 cm (2002) to 45.7 cm (2005) (Fig. 1c). Rainfall directly on the lake surface is generally only a very small contribution to the water budget, although precipitation on the watershed that results in inflow (Q_i) can be very substantial (Fig. 2). Runoff to the lake was taken from USGS gaging stations for the San Jacinto River and Salt Creek near Sun City (USGS #11070365 and #11070465, respectively). The very high amount of rainfall in WY 2005 resulted in runoff events at the beginning of the year with flows in SJR >2500 cfs; in contrast, very little SJR flow was recorded in 2002 and 2006 (Fig. 2a). Generally substantially lower flow rates were present in Salt Creek (Fig. 2b).

Evaporation was determined from temperature (Fig. 1b), humidity (vapor pressure) and wind speed (not shown); it is widely recognized that evaporation removes 1.4-1.5 m of water from the lake surface each year. Detailed records on withdrawals by EVMWD for water treatment and distribution were provided by Julius Ma (EVMWMD). The final component of the water budget is that of overflow (O) that was calculated from water balance and information about lake hypsography and dam crest height. DYRESM dynamically calculated the heating of the water column (eq 1), wind mixing, and water budget (eq 2) over the 10-yr simulation period using a 60 min time step.

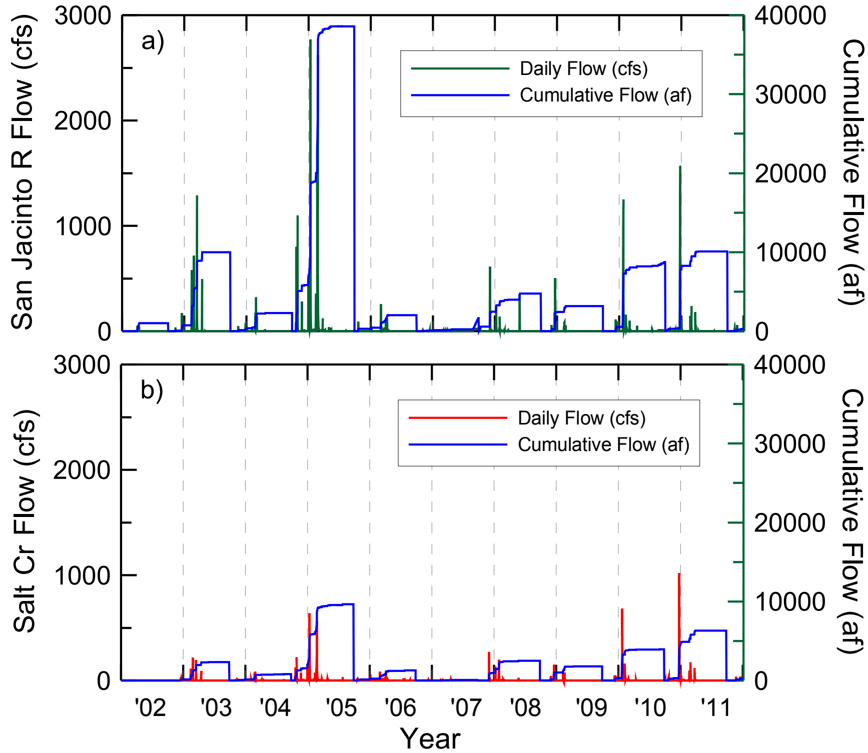

Fig. 2. Daily and cumulative flows to Canyon Lake from a) San Jacinto River and b) Salt Creek.

The model was also used to simulate water quality, including concentrations of nutrients, chlorophyll a, and dissolved oxygen (DO), as well as water transparency and pH and other properties. The model thus solves mass balance equations for each constituent that includes inputs associated with streamflow, recycling within the lake, atmospheric deposition (for N and P), as well as chemical, microbial and biological transformations, and losses via sedimentation and export (from overflow to Lake Elsinore and withdrawal of water by EVMWD).

The input of nutrients from external loading, especially associated with flows into Canyon Lake from San Jacinto River and Salt Creek (Fig. 2), is thus a critical part of the model calculations. Statistical analysis of the measured water quality at the TMDL sampling stations on the San Jacinto River and Salt Creek (2001-2010) yielded mean, geometric mean and median influent concentrations (Table 1). Median values were used as input for the model.

Rates of internal loading of nitrogen and phosphorus to the water column were calculated dynamically in the model based upon DO, temperature, and pH from rates measured in laboratory core-flux studies (Anderson, 2007a). The rates of NH_4-N and SRP release from bottom sediments were thus reduced with increased DO concentrations above the sediments from rates measured under anoxic conditions. Flux rates measured in 2001-2002 were used as the reference flux rates (Anderson, 2002). Sediment oxygen demand was also specified in the model using results from measurements conducted in 2006-2007 (SOD values of about 0.3 g/m^2/d, with modest difference between sites and dates) (Anderson, 2007a).

Table 1. Statistical analysis of watershed sampling data for San Jacinto River and Salt Creek.

Constituent	Source	Mean	Geomean	Median
NH_4-N	Salt Creek	0.39	0.32	0.30
	San Jacinto R	0.45	0.30	0.24
NO_3-N	Salt Creek	0.70	0.63	0.56
	San Jacinto R	0.74	0.59	0.61
TKN	Salt Creek	1.70	1.48	1.45
	San Jacinto R	1.83	1.56	1.60
PO_4-P	Salt Creek	0.44	0.39	0.39
	San Jacinto R	0.45	0.36	0.32
Total P	Salt Creek	0.70	0.58	0.57
	San Jacinto R	1.00	0.80	0.80
TSS	Salt Creek	153	105	88
	San Jacinto R	316	207	220

Results

External Loading

Modeling of the 10-yr period of time from 2002-2011 required daily meteorological data as well as information about inflow. It was thus helpful to first consider the hydrologic loading to the reservoir over this time interval. The individual rainfall events in Fig. 2 were summed within each water year (October 1 – September 30) and clearly show the bulk of the precipitation and runoff occurs near the end of the calendar year/beginning of the following year (x-axis shown as calendar year, so dashed lines correspond to beginning/end of each calendar.) One notes dramatically different total inflows to Canyon Lake (Fig. 3). Water year 2007 generated almost no runoff to the lake (1783 af), while the near-record rainfall in WY 2005 produced almost 50,000 af delivered to Canyon Lake from the San Jacinto River and Salt Creek (Fig. 3).

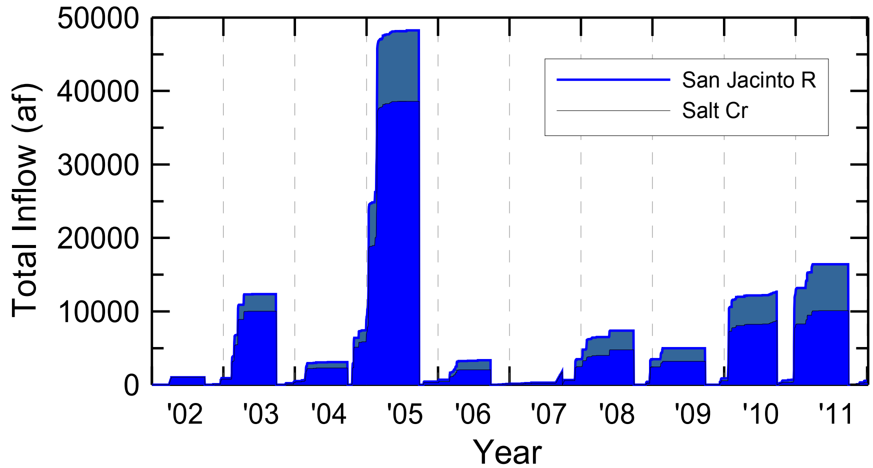

Fig. 3. Cumulative annual inflows to Canyon Lake by water year.

These very large flows also delivered more than 120,000 kg of N and 45,000 kg of P to the lake (Fig. 4). External loading in other years were generally much lower but still significant and associated with winter runoff events (Fig. 4; Table 3).

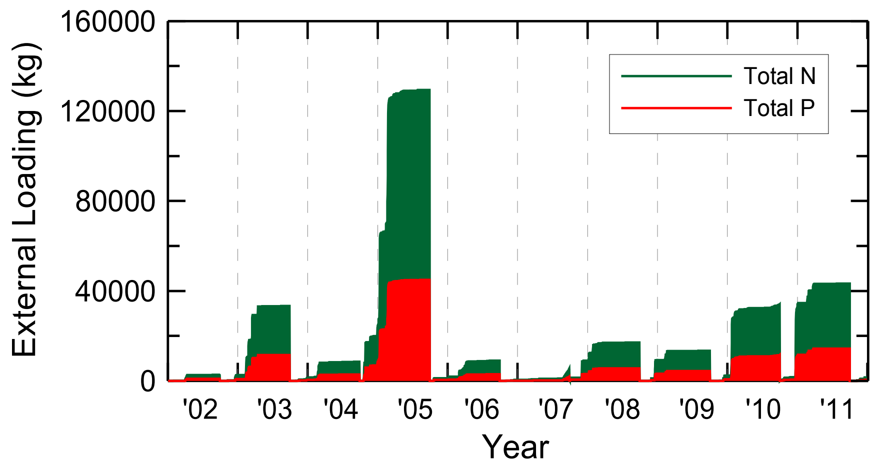

Fig. 4. Cumulative total external loading of N and P to Canyon Lake by water year.

This large volume of flow in 2005 displaced the entire volume of Canyon Lake about 5x, delivered a tremendous amount of nutrients, and effectively reset the water quality and biogeochemistry of the lake. For example, core-flux measurements made in 2006-07 yielded SRP and NH_4-N release rates that were about 60% larger than those found in 2001-02 (Anderson et al., 2007) (Table 2) that resulted from the associated very large external loading of nutrients in 2005 (Fig 4).

Table 2. Average nutrient internal recycling rates in Canyon Lake (Anderson 2002; Anderson et al., 2007).		
Year	**SRP Flux ($mg\ m^{-2}\ d^{-1}$)**	**NH_4-N Flux ($mg\ m^{-2}\ d^{-1}$)**
2001-02	9.4	25.8
2006-07	15.7	44.1

This external loading can be expressed on an areal basis for comparison with internal loading rates; expressed in this way, the gross external loading of nutrients to Canyon Lake, while quite low during intervals of limited runoff (e.g., 2002, 2007), is often comparable to that due to internal loading (Table 3).

Table 3. Gross external loading of N and P to Canyon Lake.				
Water Year	**Total N Load (kg)**	**Total P Load (kg)**	**Total N Load ($mg\ m^{-2}\ d^{-1}$)**	**Total P Load ($mg\ m^{-2}\ d^{-1}$)**
2002	2,635	965	4.7	1.7
2003	33,277	11,520	58.8	20.4
2004	8,470	2,835	15.0	5.0
2005	129,402	44,887	228.8	79.4
2006	9,002	2,933	15.9	5.2
2007	5,367	1,857	9.5	3.3
2008	17,028	5,616	30.1	9.9
2009	13,339	4,409	23.6	7.8
2010	33,982	11,462	60.1	20.3
2011	43,280	14,366	76.5	25.4

A portion of those externally loaded nutrients (as well as internally loaded nutrients) will be exported from the lake during flows sufficient to over-top the dam and to a lesser extent, with withdrawals by EVMWD, however. Outflows to downstream San Jacinto River and Lake Elsinore predictably varied with runoff conditions, with almost all runoff to the lake in 2005 spilling to Lake Elsinore (Fig. 5). Significant outflows from the lake were also seen in 2003, 2010 and 2011, while no flows were predicted (nor observed) in 2002 and 2007.

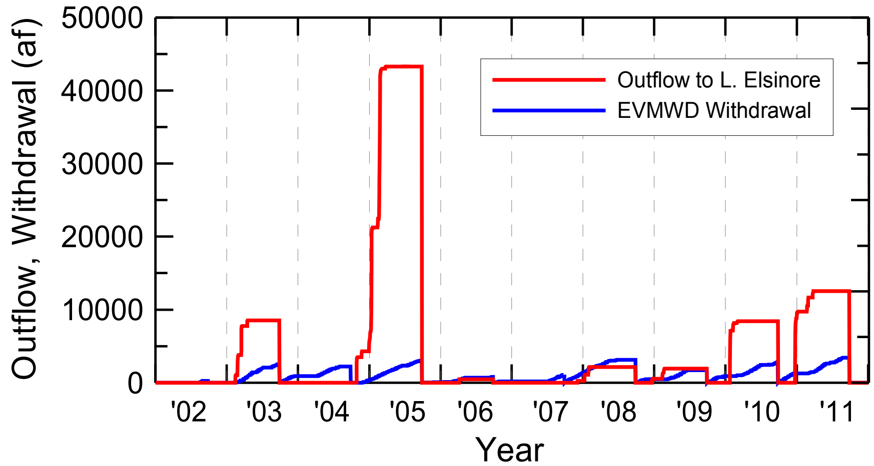

Fig. 5. Cumulative water removal from Canyon Lake via overflow from dam and EVMWD withdrawal by water year.

The water spilled over the dam (and the relatively small volumes withdrawn by EVMWD) removed nutrients from the lake. The gross external loads of total N and total P can be compared with those exported via outflow and withdrawal (Fig. 6). As one can see, years with outflow (Fig. 5) did export total N and P from the lake, up to about 10,000 kg of total P and 20,000 kg of total N in 2005, but only a modest proportion of the gross external load was exported (Fig. 6). Canyon Lake, as modeled in this reference scenario (no hypolimnetic oxygenation system or other in-lake management strategies implemented), thus has finite capacity to retain runoff and storm flows, but is generally quite effective at retaining nutrients.

The annual retention of N and P in Canyon Lake is summarized in Table 4. Phosphorus was generally retained more effectively than N, with an average net retention of P of 84.9%, compared with 68.2% for N. Expressed as % transported (15.1% and 31.8% for P and N respectively), we see that Canyon Lake is on average twice as effective at retaining P than N. Nonetheless, the % nutrients retained did vary from year to year that appeared to be a complex function of amount of water retained and, more importantly, the duration and timing of the inflows. Storms that quickly flushed through the lake would provide little residence time of water and thus result in limited opportunity for settling of particulate forms of nutrients, uptake, and biological transformation reactions. Conversely, flows and nutrient inputs from a series of storms over much of the winter would provide time for reaction and potentially greater in-basin removal.

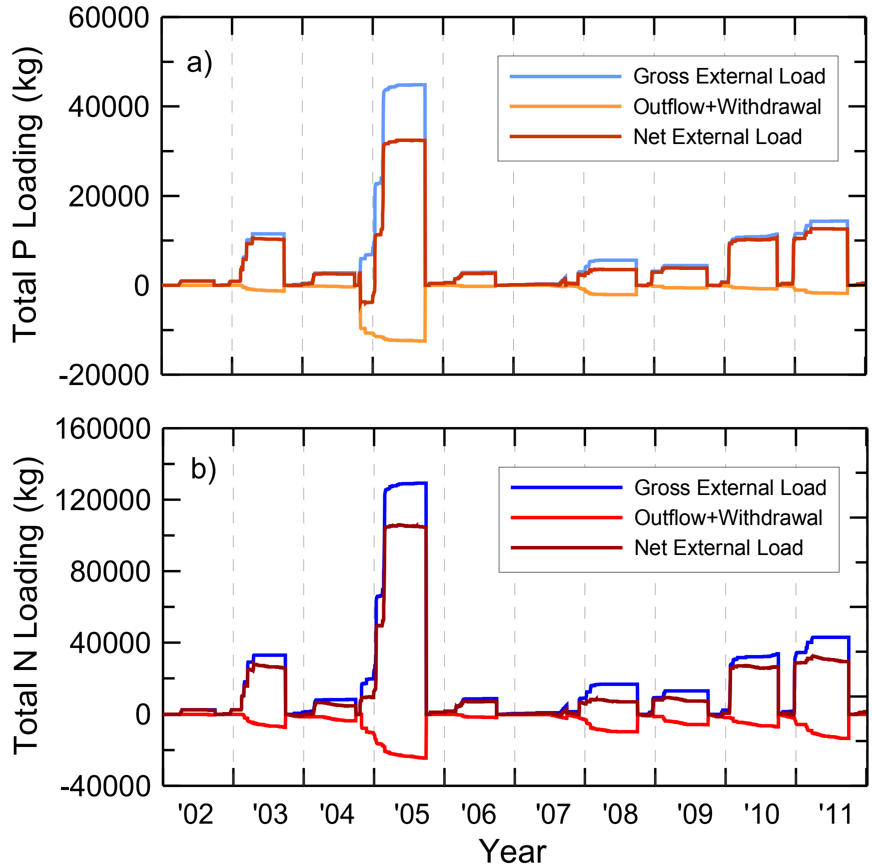

Fig. 6. Cumulative nutrient budgets for Canyon Lake by water year: a) total P and b) total N.

Table 4. Retention of inflow and externally loaded nutrients in Canyon Lake by water year.

Water Year	Water Volume Retained (af)	Total P Retained (kg)	Total N Retained (kg)
2002	814 (78.3%)	944 (97.1%)	2,162 (86.0%)
2003	1,225 (9.9%)	10,222 (88.7%)	25,730 (77.8%)
2004	871 (28.0%)	2,489 (87.8%)	4,667 (56.4%)
2005	1,998 (4.1%)	32,398 (72.2%)	104,679 (81.0%)
2006	2,807 (62.4%)	2,664 (90.8%)	7,033 (79.9%)
2007	706 (39.6%)	1,526 (82.2%)	2,932 (56.7%)
2008	4,237 (57.6)	3,501 (62.3%)	7,007 (41.6%)
2009	1,290 (25.9%)	3,806 (86.3%)	7,200 (54.8%)
2010	4,278 (33.7%)	10,620 (92.6%)	26,647 (78.9%)
2011	466 (2.8%)	12,571 (88.5%)	29,535 (68.6%)

Correcting for nutrients exported from the basin, we see that external loading expressed as a flux rate (Table 5) remains comparable to or exceeds the annual average internal recycling rate (Table 2) in 4 out of 10 year.

Table 5. Net external loading of N and P to Canyon Lake.

Water Year	Net Total N Load (kg)	Net Total P Load (kg)	Total N (mg m^{-2} d^{-1})	Total P (mg m^{-2} d^{-1})
2002	2,266	937	4.0	1.7
2003	25,890	10,218	45.7	18.1
2004	4,777	2,489	8.5	4.4
2005	104,816	32,408	185.3	57.3
2006	7,193	2,663	12.7	4.7
2007	3,043	1,526	5.4	2.7
2008	7,084	3,499	12.5	6.2
2009	7,310	3,805	12.9	6.7
2010	26,812	10,614	47.4	18.8
2011	29,690	12,714	52.5	22.5

Simulation #1: Reference Condition

DYRESM-CAEDYM was used to simulate water quality in Canyon Lake subject to the above meteorological and runoff conditions under the natural conditions in the lake (i.e., with no hypolimnetic oxygenation or other in-lake restoration efforts). As we have seen in previous simulations, the model predicted strongly stratified conditions in Canyon Lake through much of the year, with epilimnion temperatures exceeding 25 ºC and with much cooler temperatures in the hypolimnion, generally 10-12 ºC (Fig. 7a). The multi-year record simulated here demonstrated that there is some year-to-year variation in the hypolimnion temperature related to specific meteorological conditions present when stratification sets up in the early spring (Fig. 7a).

The model predicted high DO concentrations in the epilimnion in the summer and through much of the water column during the winter mixing condition, although the extent of mixing of DO varied from year-to-year, with weaker predicted mixing in early winter 2005 and 2011 and complete mixing in early winter 2007 (Fig. 7b).

Total N and total P concentrations also exhibited strong seasonal and vertical differences. Rapid development of anoxia in the hypolimnion promoted reductive dissolution of $Fe(OH)_3$-H_2PO_4 sorbed phases as well as mineralization of organic-N and organic-P phases resulting in internal loading of NH_4-N and PO_4-P to the water overlying the bottoms sediments (Fig. 7c,d). Total N (principally as NH_4-N) reached concentrations of 4-5 mg/L above the bottom sediments in the fall, while concentrations in the epilimnion were more typically 1-1.4 mg/L (Fig. 7c).

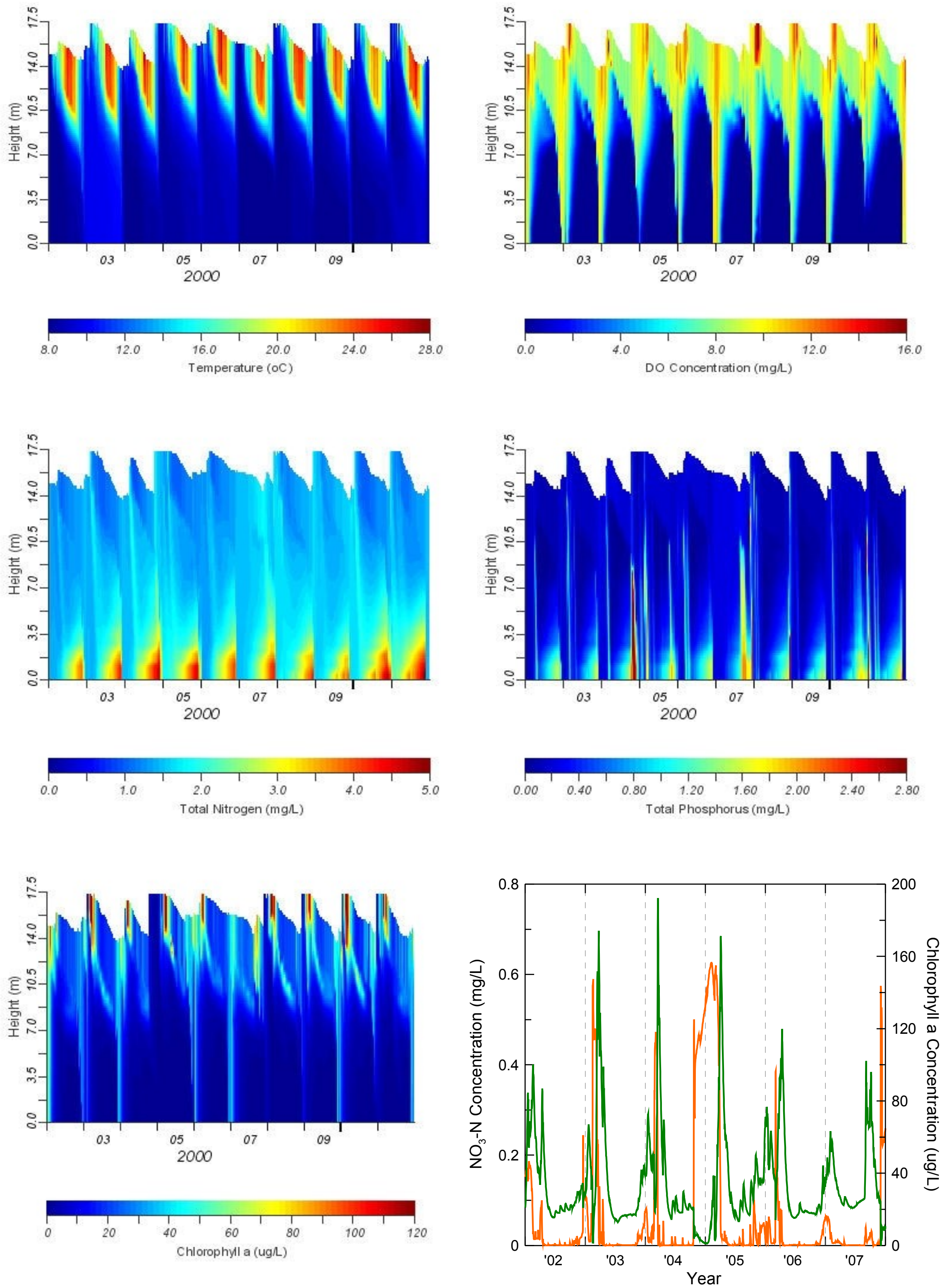

Fig. 7. Predicted water column conditions and water quality in Canyon Lake under reference scenario: a) temperature, b) DO, c) total N, d) total P, e) chlorophyll a, f) NO3+chlroophyll a.

Similar trends were seen for total P (principally as PO_4-P), with concentrations near 2 mg/L above the bottom sediments in the fall prior to mixing, although higher concentrations were seen in 2005 following the very large input of particulate inorganic P (Fig. 7d). Total P concentrations were generally much lower in the epilimnion (0.2-0.4 mg/L). Finally, chlorophyll a concentrations exhibited particularly strong seasonal and vertical differences. Very high concentrations were present in the epilimnion in the winter-spring, often exceeding 100 μg/L, while concentrations were predictably much lower deeper in the lake owing to light limitations (Fig. 7e). Mixing did distribute some phytoplankton with depth however. Simulations indicate that it is the availability NO_3-N that promotes or limits algal production in the lake, consistent with previous algal nutrient bioassays (Fig. 7f).

<u>Simulation #2: No Internal Loading</u>

The theoretical limit for in-lake restoration efforts aimed at reducing internal recycling would be complete elimination of all internal loading through, e.g., alum application combined with zeolite to remove all PO_4-P and NH_4-N release from bottom sediments. While complete suppression of internal recycling is not possible in reality, it is nonetheless useful to explore water quality in Canyon Lake due only to external loading. As we have seen, a substantial external load of nutrients is delivered to the lake with some frequency (e.g., Fig. 4). For this simulation, then, internal loading of both N and P was set to 0, while all other conditions were held unchanged from the reference simulation described above.

As expected, internal loading did not have a noticeable effect upon temperature or thermal structure in Canyon Lake (Fig. 8a) since this is regulated chiefly by meteorological conditions (Fig. 1). Moreover, the absence of internal loading had little effect on DO concentrations; significant photosynthetic production of DO was still observed in the upper part of the water column, and anoxia was present for much of the year in the hypolimnion (Fig. 8b). More dramatic effects were witnessed for N and P (Fig. 8c,d). Total N did not accumulate above the bottom sediments although concentrations in the upper water column were only modestly reduced (Fig. 8c). In a similar way, total P concentrations generally remained uniformly low throughout the water column, although the externally loaded P that included some particulate forms were evident and reached high concentrations for a period of time during large runoff events (especially winter 2004-2005, late fall 2007, and winter 2010-11) (Fig. 8d). The elevated concentrations deeper in the water column resulted from an “underflow” condition wherein the inflowing water was colder and more dense that the lake, and thereby plunged deeper in the water column. Chlorophyll a concentrations (Fig. 8e) appeared to be modestly reduced, but were not dramatically altered relative to the reference case (Fig. 7e)

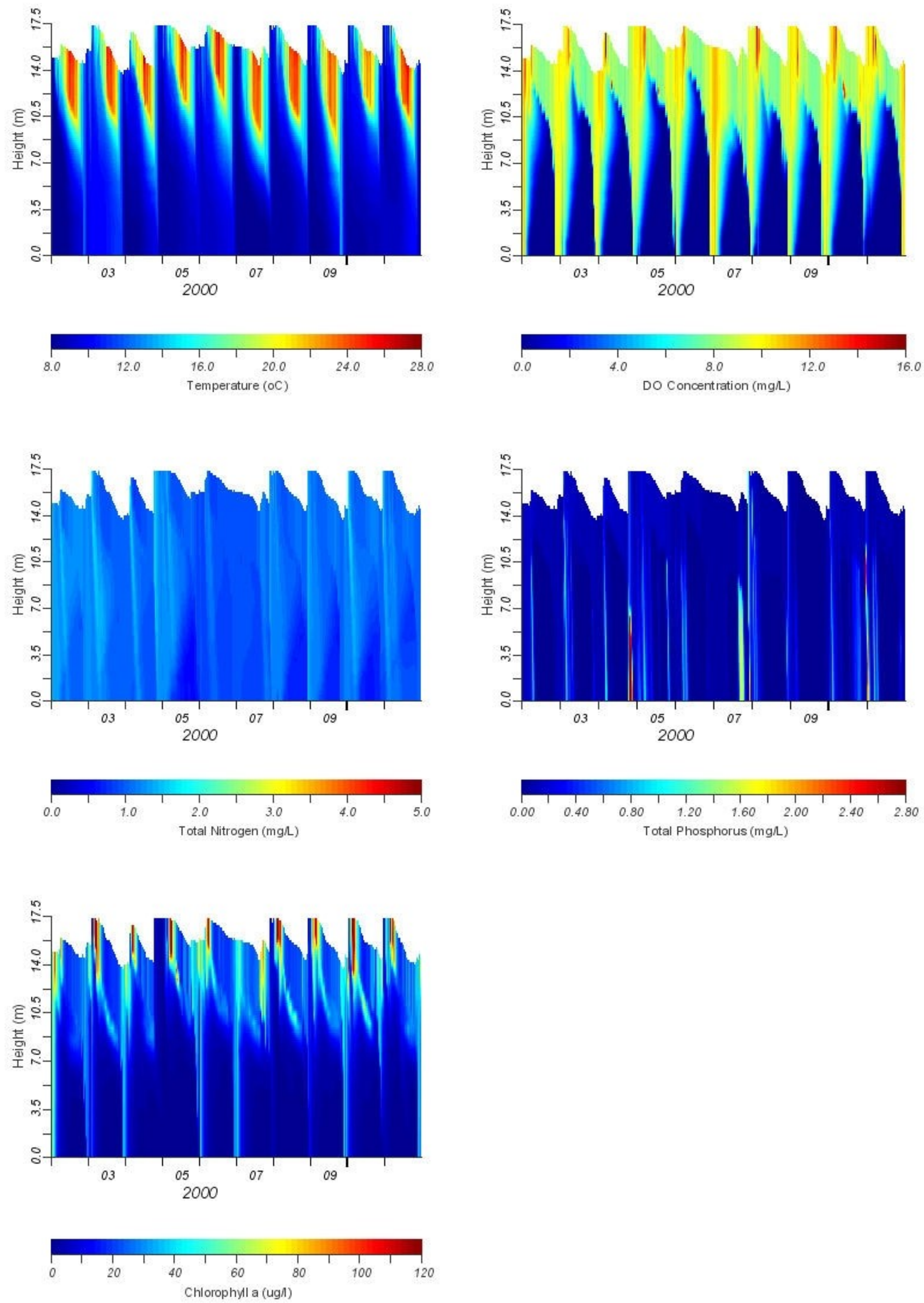

Fig. 8. Predicted water column conditions and water quality in Canyon Lake under no internal loading scenario: a) temperature, b) DO, c) total N, d) total P and e) chlorophyll a.

The effect of no internal loading can be seen more clearly when compared with concentrations at specific depths (Figs. 9-11). We thus see that with internal loading, the concentrations of total N (Fig. 9) and total P (Fig. 10) increased through the spring and summer, and then generally decreased (especially noticeable for the bottom depths (panel b on Figs. 9-10). An increase in concentrations in the surface waters in both scenarios was often seen in the winter as a result of external loading. Lower concentrations were consistently present in the simulation with no internal loading, reflecting the reduction in total loading to the water column. Very similar behavior was seen for both total N (Fig. 9) and total P (Fig. 10).

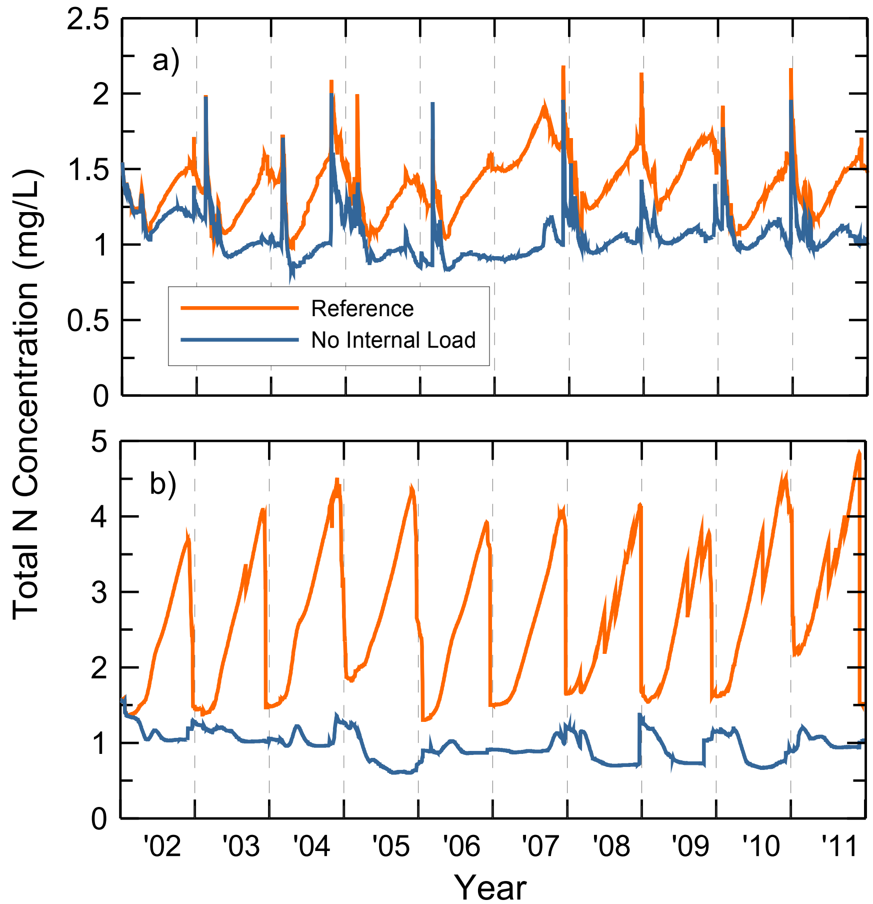

Fig. 9. Predicted total N concentrations comparing the reference scenario with the no-internal loading scenario: a) 1 m below surface and b) 1 m above bottom sediments.

The absence of internal loading did result in somewhat lower chlorophyll concentrations in the epilimnion, although peak concentrations following external loading (especially of NO_3-N) were broadly similar (Fig. 11). Thus, even with no internal loading, chlorophyll a concentrations were predicted to remain relatively high (Fig. 11).

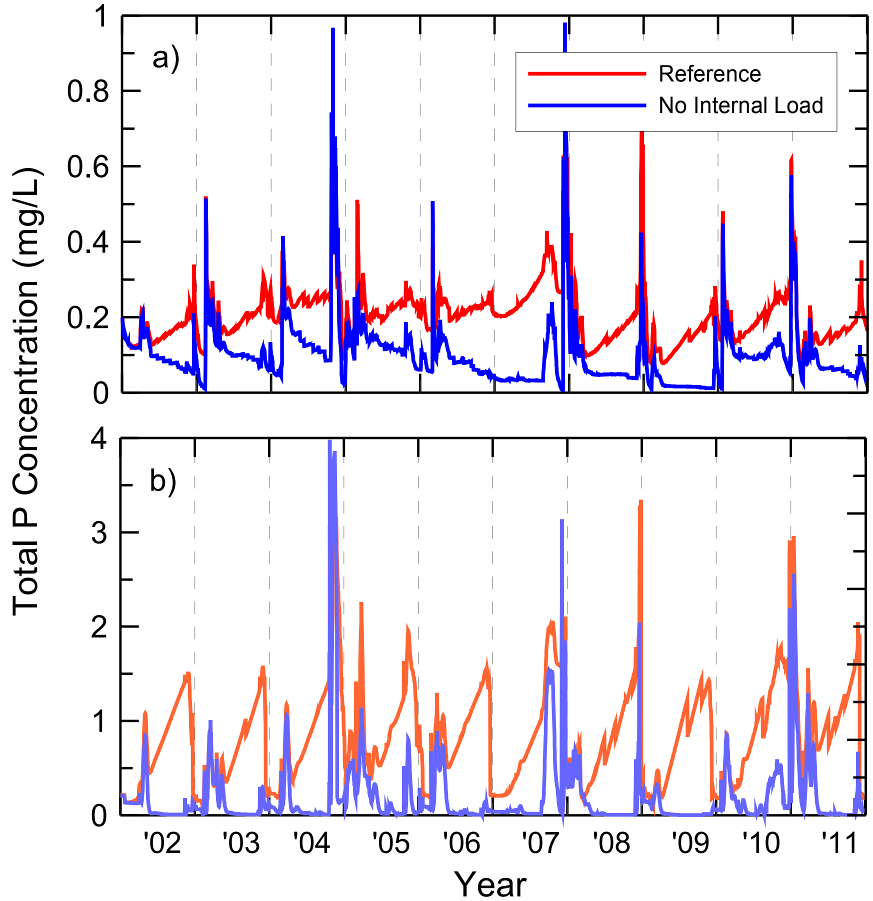

Fig. 10. Predicted total P concentrations comparing the reference scenario with the no-internal loading scenario: a) 1 m below surface and b) 1 m above bottom sediments.

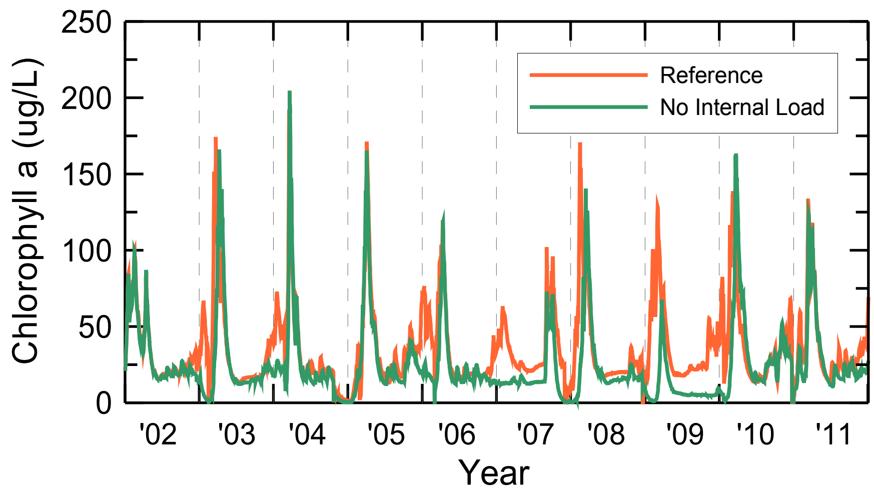

Fig. 11. Predicted chlorophyll a concentrations comparing the reference scenario with the no-internal loading scenario (1 m below surface).

<u>Simulation #3: Hypolimnetic Oxygenation</u>

The previous simulation is thought to represent a theoretical best-case outcome from in-lake restoration through, *e.g.*, use of alum in combination with zeolite sufficient to suppress all release of PO_4-P and NH_4-N. The purpose of this scenario is to evaluate the efficacy of a hypolimnetic oxygenation system for reducing internal loading of nutrients and improving overall water quality in Canyon Lake. Since the previous no internal loading simulation did not explicitly alter DO conditions (beyond those that would be achieved from changes in nutrient availability and productivity), changes in biogeochemical conditions and further transformations could potentially occur as a result of installation and operation of an oxygenation system.

As seen from other simulations (e.g., Anderson, 2007), hypolimnetic oxygenation has negligible effect on the thermal stratification in the lake (Fig. 12a). Conversely, it had a profound effect on the distribution of DO within the water column (Fig. 12b). Oxygen was delivered to the bottom of the lake at a rate of 1,700 lbs O_2 d^{-1} following PACE alternative #10b to offset sediment and water oxygen demands. This oxygen delivery was able to maintain strongly oxic conditions above the sediments, but due to limited vertical exchange, was not fully mixed within the hypolimnion. The model transported oxygen away from the bottom sediments principally by diffusion, and so did not fully capture the features of the hypolimnetic oxygenation system proposed by PACE in which care was taken to mix the DO throughout the hypolimnion (Fig. 12b). Nonetheless, DO concentrations remained above 2 mg L^{-1} even below the thermocline and would thus not meaningfully alter PO_4-P, Fe or related biogochemistry of the lake compared with a uniformly mixed DO condition in the hypolimnion.

Oxygenation did a very good job of suppressing accumulation of N and P above the bottom sediments (Fig. 12c,d), achieving conditions broadly similar to the no internal loading scenario (Fig. 8c,d). One does note slightly higher total N concentrations in the water column however. Total P levels here also show the delivery of nutrients with external loads in late fall-winter of large runoff years (Fig. 12d). Chlorophyll a concentrations also appear at this scale to be broadly similar to those found with no internal loading (Fig. 12e).

A more careful look at predicted concentrations at 1 m below the water surface and 1 m above the bottom sediments better shows the similarities and differences. Total N concentrations in the epilimnion (1 m below water surface) were found to be intermediate between those predicted for the reference scenario and that with no internal loading (Fig. 13a). The average total N concentration over the entire 10-yr simulation period was 1.26 mg L^{-1}, a value that was 10% lower than the reference value (1.40 mg L^{-1}), but 20% higher than the mean value for the no internal loading scenario (1.05 mg L^{-1}) (Table 6). The HOS system more dramatically lowered total N concentrations above the bottom sediments however (1.48 mg L^{-1} vs. 2.65 mg L^{-1} for the reference case), but still greater than the no internal loading scenario (Table 6).

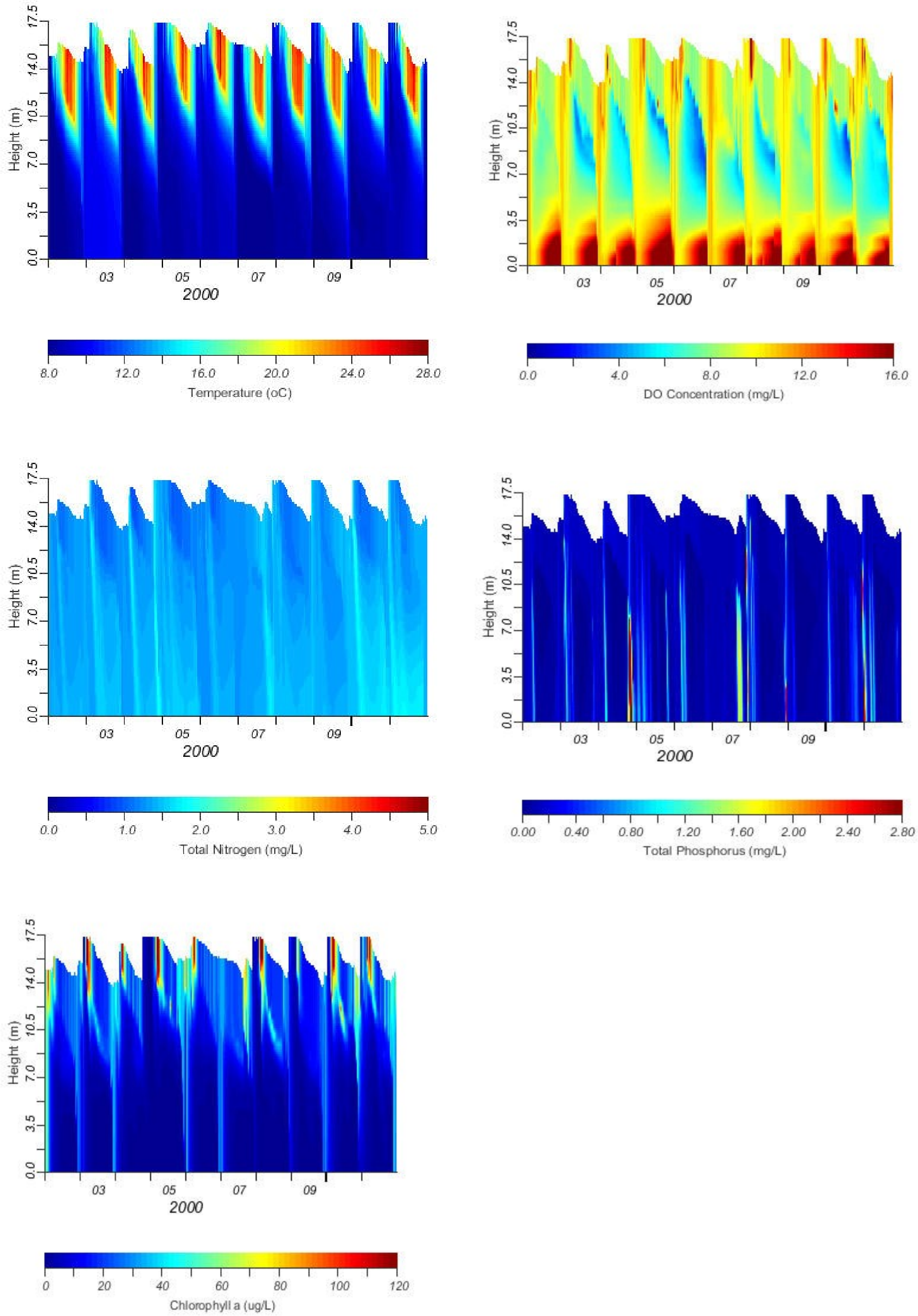

Fig. 12. Predicted water column conditions and water quality in Canyon Lake with hypolimnetic oxygenation: a) temperature, b) DO, c) total N, d) total P and e) chlorophyll a.

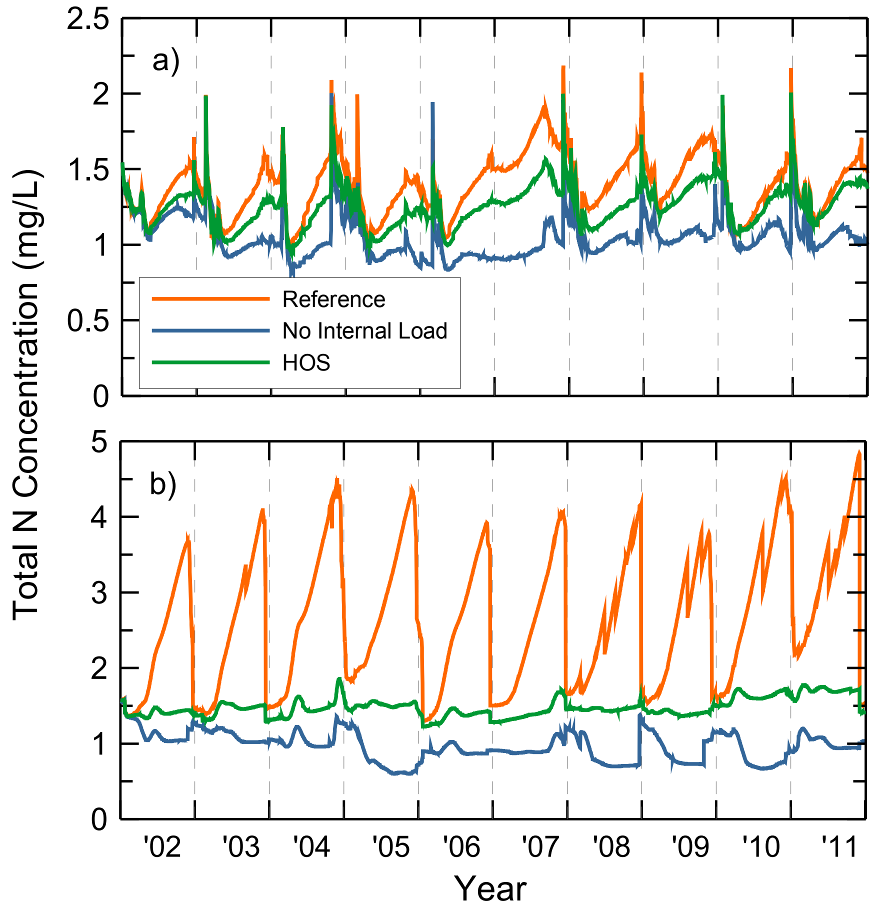

Fig.13. Predicted total N concentrations comparing the 3 scenarios: a) 1 m below surface and b) 1 m above bottom sediments.

The hypolimnetic oxygenation system was predicted to have a greater effect on total P (Fig. 14), achieving levels substantially lower 10-yr mean values than the reference scenario and only modestly larger than the no internal loading scenario (Table 6). The effect of HOS on chlorophyll was limited however (Fig. 15, Table 6). The N-limitation in the lake constrained the improvements in chlorophyll levels that were achieved with HOS despite substantial reductions in total and available P concentrations.

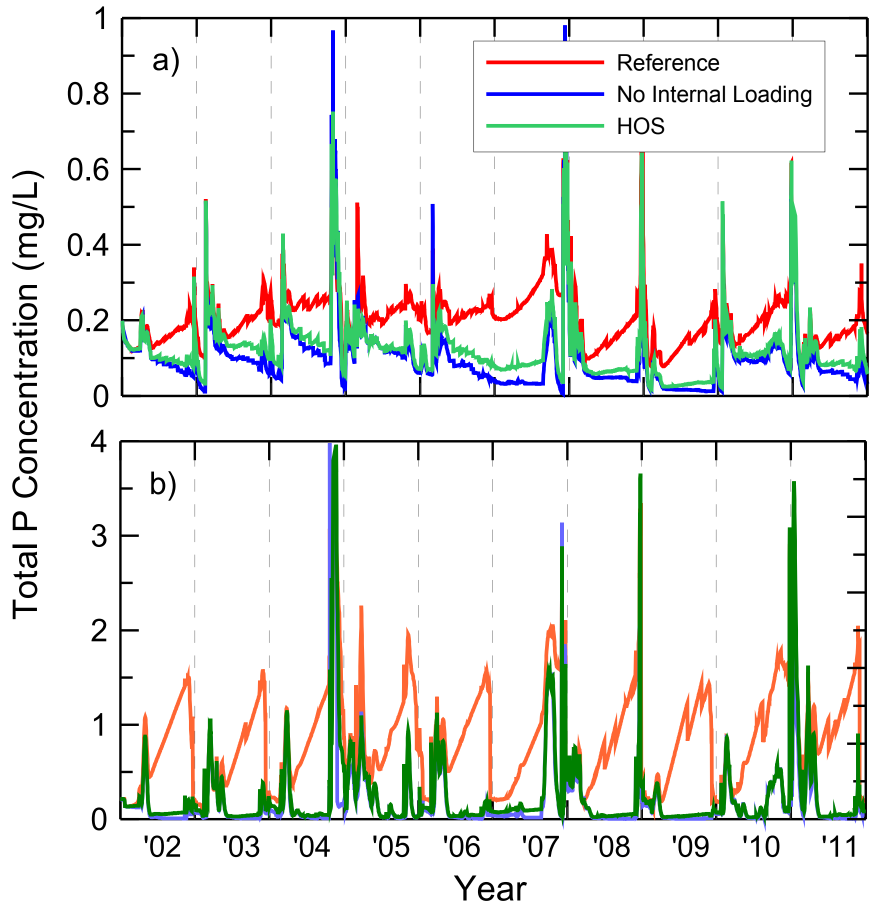

Fig. 14. Predicted total P concentrations comparing the 3 scenarios: a) 1 m below surface and b) 1 m above bottom sediments.

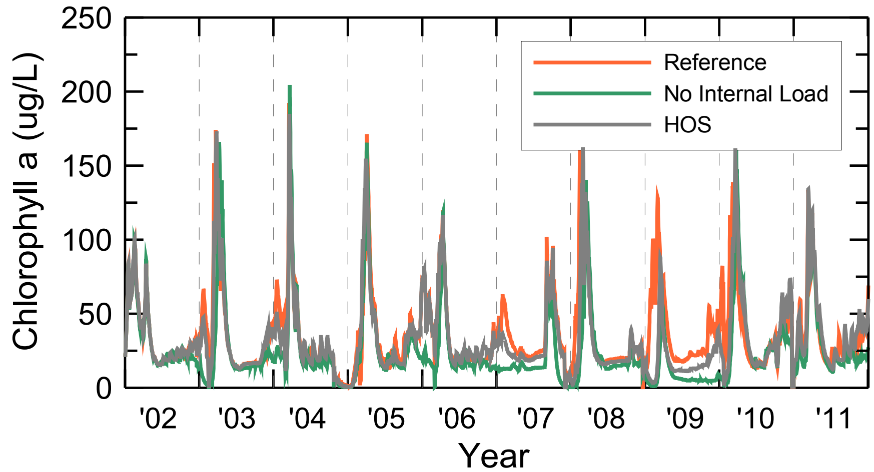

Fig. 15. Predicted chlorophyll a concentrations comparing the reference scenario with the no-internal loading scenario (1 m below surface).

Table 6. Predicted 10-yr average concentrations of total N, total P and chlorophyll a under the reference, no internal loading and HOS scenarios.

Constituent	Depth	Reference Scenario	No Internal Load Scenario	HOS Scenario
Total N	1 m Surface	1.40 ± 0.20	1.05 ± 0.14	1.26 ± 0.14
	1 m Bottom	2.65 ± 0.90	0.97 ± 0.19	1.48 ± 0.12
Total P	1 m Surface	0.21 ± 0.08	0.10 ± 0.09	0.12 ± 0.08
	1 m Bottom	0.85 ± 0.53	0.20 ± 0.46	0.25 ± 0.50
Chlorophyll a	1 m Surface	36.1 ± 27.6	25.5 ± 26.5	33.1 ± 27.0

Conclusions

Results of this study that involved simulation of water quality for the period 2002-2011 demonstrated a number of key findings:

(i) External loading events deliver nutrients to Canyon Lake at rates that can approach or exceed internal loading rates (this occurred 4 out of 10 years in this past 10-yr period of time).

(ii) Canyon Lake is very effective at retaining P and effective at retaining N delivered with runoff, achieving an average of about 84.9% retention of P and 68.2% retention of N based upon these simulations.

(iii) The preferential retention of P relative to N (by about a factor of 2x based upon transported mass) is thought to play a role in the typical P-limitation in Lake Elsinore.

(iv) Elimination of all internal loading to the water column, as would be the theoretical limit from, e.g., application of alum, in combination of zeolite, was found to achieve average reductions of total N in the epilimnion of 25%, total P of 52%, and chlorophyll a of 29% relative to the reference scenario.

(v) Installation and operation of a hypolimnetic oxygenation system achieved a 10% reduction in the average total N concentration, a 43% reduction in total P, and an 8% reduction in chlorophyll a relative to the reference scenario.

(vi) The close connection of Canyon Lake to the San Jacinto River watershed, with regular delivery of often very large external nutrient loads, presents challenges for typical in-lake restoration efforts to fully meet all water quality objectives.

(vii) It appears that control of internal loading will not be sufficient to meet all water quality objectives; in the absence of dramatic reductions in external loading of nutrients, aggressive stripping of nutrients (especially NO_3^-) out of the inflow or water column will also be required.

References

Anderson, M.A., 2001. *Internal Loading and Nutrient Cycling in Lake Elsinore.* Final Report to the Santa Ana Regional Water Quality Control Board. 52 pp.

Anderson, M.A. and H. Oza. 2003. *Internal Loading and Nutrient Cycling in Canyon Lake.* Final Report to the Santa Ana Regional Water Quality Control Board. 69 pp.

Anderson, M.A., C. Paez and S. Men. 2007. *Sediment Nutrient Flux and Oxygen Demand Study for Canyon Lake with Assessment of In-Lake Alternatives.* Final Report to the San Jacinto River Watershed Council. 24 pp.

Anderson, M.A. 2007. *Predicted Effects of In-Lake Treatment on Water Quality in Canyon Lake.* Final Report to the San Jacinto River Watershed Council. 31 pp.+ Appendix.

Anderson, M.A. 2008. *Predicted Effects of External Load Reductions and In-Lake Treatment on Water Quality in Canyon Lake – A Supplemental Simulation Study.* Final Report to LESJWA. 21 pp.

DRAFT 4/10/12

AGREEMENT TO FORM
THE LAKE ELSINORE AND CANYON LAKE TMDL TASK FORCE

This Agreement to form the Lake Elsinore and Canyon Lake TMDL Task Force (hereinafter "AGREEMENT") is made and effective this 18th __th day of May________, 2006 2012 by and among the following entities, which are hereinafter sometimes collectively referred to as "TASK FORCE AGENCIES" or individually as "TASK FORCE AGENCY":

- United States Forest Service (San Bernardino and Cleveland National Forest Management Zones)
- US Air Force (March Air Reserve Base)
- March Air Reserve Base Joint Powers Authority
- California Department of Transportation
- California Department of Fish and Game
- County of Riverside
- City of Beaumont
- City of Canyon Lake
- City of Hemet
- City of Lake Elsinore
- City of Moreno Valley
- City of Murrieta
- City of Perris
- City of Riverside
- City of San Jacinto
- City of Menifee
- City of Wildomar
- Elsinore Valley Municipal Water District
- Eastern Municipal Water District
- Western Riverside County Agriculture Coalition (on behalf of the participating Agricultural Operators in the San Jacinto River Basin)
- Western Riverside County Agriculture Coalition (on behalf of the participating Dairy Operators in the San Jacinto River Basin)
- Riverside County Flood Control and Water Conservation District

I. RECITALS

A. Whereas, in 1998, the Santa Ana Regional Water Quality Control Board (hereinafter "Regional Board") designated Lake Elsinore and Canyon Lake in the Lake Elsinore and San Jacinto Watersheds (Collectively the "Watersheds") as "impaired water bodies" pursuant to Section 303(d) of the federal Clean Water Act because of high levels of algae in both lakes and low dissolved oxygen in Lake Elsinore, attributed to excess phosphorus and nitrogen (Nutrients). As a result of said Section 303 designation, the Clean Water Act and California's Non-point Source Pollution Control Plan requires that total maximum daily loads (hereinafter "TMDLs") be established by the Regional Board for these waterbodies; and

B. Whereas, in response to the Section 303(d) designation, the Regional Board adopted a Resolution R8-2004-0037 on December 20, 2004 amending the Water Quality Control Plan for the Santa Ana River Basin (BASIN PLAN AMENDMENT) to incorporate nutrient TMDLs for Canyon Lake and Lake Elsinore. The Basin Plan Amendment specifies, among other things, an Implementation Plan, which holds specified stake holders (TASK FORCE AGENCIES) individually and/or jointly liable for complying with the TMDLs by means of specific tasks to be completed by specified dates under penalty of law. These tasks include development and implementation of a watershed-wide nutrient water quality monitoring program, development of an in-lake nutrient monitoring program for Canyon Lake and Lake Elsinore, development of a plan and schedule for in-lake sediment nutrient reduction for Lake Elsinore, development of a plan and schedule for evaluating in-lake sediment nutrient strategies for Canyon Lake, updating watershed and in-lake nutrient TMDL water quality models, developing a pollutant trading plan, and reviewing and revising the TMDL to reflect updated data and science; and

C. Whereas, the purpose of this AGREEMENT is to form a task force (hereinafter "TASK FORCE") to implement certain tasks identified in the TMDL Implementation Plan and to pursue TMDL related tasks agreed upon by TASK FORCE AGENCIES; and

D. Whereas, the TASK FORCE AGENCIES agree that the purpose of this TASK FORCE is to (1) review and develop recommendations to update the TMDL BASIN PLAN AMENDMENT based on the best available scientific information, and (2) implement TMDL Implementation Plan Tasks identified below and jointly assigned to TASK FORCE AGENCIES, and (3) propose appropriate revisions to the TMDL BASIN PLAN AMENDMENT to the Santa Ana RWQCB by June 30, 2010, and (4) allow watershed stakeholders to participate in efforts to meet appropriate water quality standards so that Canyon Lake and/or Lake Elsinore can be de-listed from the Clean Water Act 303(d) list of impaired water bodies; and

E. Whereas, hundreds of individual agricultural and dairy operators are subject to the Canyon Lake and Lake Elsinore TMDLs and its component TMDL Implementation Plan; and

F. Whereas, the Western Riverside County Agricultural Coalition(WRCAC) is a non-profit organization representing the interests of participating agricultural and dairy operators within the San Jacinto Watershed; and

G. Whereas, WRCAC's membership is open to any and all agricultural and dairy operators within the San Jacinto watershed; and

H. Whereas, March Air Reserve Base (MARB) is an installation of the United States Air Force~~, and the San Bernardino and Cleveland National Forest are~~is on federal lands~~ under the administration and management o f the Forest Service~~. ~~Both are~~areas an ~~agencies~~ agency of the federal government, ~~and are~~it is therefore subject to limitations in ~~their~~ its ability to comply with every provision stated herein to the same extent that other non-federal TASK FORCE AGENCIES are able to comply. These limitations are based upon, but not limited to, those identified in the federal Clean Water Act, the federal Antideficiency Act, the principle of sovereign immunity and the holdings of the Supreme Court of the United States, and other binding federal court decisions, as they interpret those sources of federal law. The limitations so mentioned include, but are not limited to, the availability of federal funding to pay for participation in this program, and the ability of MARB ~~and Forest Service~~ to participate directly in sampling, research or data gathering activities which are not located on or near MARB ~~or National Forest System~~ lands or a point source of water discharge arising on MARB ~~or National Forest System~~ lands, or other activities not specifically authorized by the Federal Clean Water Act section 313. To the extent that the limitations described herein prevent MARB ~~or Forest Service~~ from fully participating in any aspect of this program, they reserve the right, in their sole discretion, to participate in the program as a matter of comity. By entering into this agreement, MARB ~~and Forest Service do~~does not authorize any of the TASK FORCE AGENCIES to exercise regulatory authority over them. MARB ~~and Forest Service~~ agrees that State and federal regulatory agencies that are or may become members of this TASK FORCE have regulatory authority over MARB ~~and Forest Service~~ only to the extent permitted by State or Federal Law; and

I. Whereas, the TASK FORCE AGENCIES acknowledge and agree that the effectiveness of the TASK FORCE may be improved by the inclusion of other agencies as additional TASK FORCE AGENCIES to the TASK FORCE; and

J. Whereas, the Riverside County Flood Control and Water Conservation District (RCFC&WCD) serves as the Principal Permittee for the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Permit (MS4) for the Santa Ana Region of Riverside County; and

K. Whereas, the County of Riverside and Cities of Beaumont, Canyon Lake, Hemet, Lake Elsinore, Moreno Valley, Murrieta, Perris, Riverside, San Jacinto, Menifee, Wildomar are MS4 CO-PERMITTEES for the NPDES MS4 Permit for the Santa Ana Region of Riverside County; and

L. Whereas, the MS4 PRINCIPAL PERMITTEE and MS4 CO-PERMITTEES collectively represent the MS4 PERMITTEES within the San Jacinto Watershed; and

M. Whereas, the NPDES MS4 Permit for the Santa Ana Region of Riverside County is regulated by the Regional Board -and subject to the requirements of the nutrient TMDLs for Canyon Lake and Lake Elsinore; and

N. Whereas RCFC&WCD has agreed to provide services on behalf of itself as an NPDES MS4 PERMITTEE and on behalf of the MS4 CO-PERMITTEES for the purposes of this AGREEMENT; and

O. Whereas RCFC&WCD has prepared and reviewed the MS4 CO-PERMITTEES cost share allocation with MS4 CO-PERMITTEE staff at the NPDES MS4 Permit Technical Advisory Committee Meetings and with the affected City Managers and County Executive Office, or designated representatives thereof during the NPDES MS4 Permit Management Steering Committee Meeting of February 16, 2006; and

P. Whereas, the TMDL assigned nutrient waste load allocations for Supplemental Water addition to Lake Elsinore to stabilize the Lake's elevation; and

Q. Whereas, the nutrient waste load allocation for Supplemental Water, which includes Island Well water, EVMWD treatment plant effluent, and other sources of non-stormwater, may reduce the TMDL waste load allocation and TMDL load allocation of other point and non-point sources because in-lake nutrient capacity was not adjusted to account for increased lake levels associated with the addition of Supplemental Water; and

R. Whereas, the assumptions regarding load allocations for Supplemental Water may not be consistent with the actual operation of Supplemental Water sources; and

S. Whereas, the City of Lake Elsinore and EVMWD previously entered into an agreement to equally share the cost of Supplemental Water addition to the Lake under the "Lake Elsinore Comprehensive Water Management Agreement", and

T. Whereas,- for the purposes of this Agreement, the City of Lake Elsinore shall be acknowledged and recognized as a separate and equal contributor with EVMWD for the cost and voting rights accorded under this Agreement attributed to EVMWD for Supplemental Water addition; and

U. Whereas, the TASK FORCE AGENCIES have considered many alternative cost sharing methodologies based on TMDL assigned load allocation, load reduction, and permutations thereof; and

V. Whereas, certain TASK FORCE AGENCIES were strong proponents of cost sharing based on load allocation and other TASK FORCE AGENCIES were strong proponents of cost sharing based on load reduction; and

W. Whereas, these TASK FORCE AGENCIES have been unable to agree upon a methodology for distributing costs based on either an allocation or a load reduction methodology; and

X. Whereas, the TASK FORCE AGENCIES have reviewed and agreed upon an interim negotiated cost allocation methodology acceptable to all TASK FORCE AGENCIES for the purposes of initiating the TASK FORCE, based on consideration of TMDL assigned load allocations, load reductions, and permutations thereof; and

Y. Whereas, the TASK FORCE AGENCIES agree that certain nutrient dischargers have been either inappropriately named or not named as responsible parties for various tasks in the BASIN PLAN AMENDMENT; and

Z. Whereas, the TASK FORCE AGENCIES agree that agricultural and dairy lands are converting to urban and open space lands; and

AA. Whereas, the TASK FORCE AGENCIES agree that an amendment to the TMDL to address, at minimum, the proper naming of responsible parties for various tasks in the TMDL Implementation Plan, to correct the load allocation and waste load allocations to properly address the impacts of Supplemental Water on Lake Elsinore, and to revise the load allocation and waste load allocations to address the ongoing conversion of agriculture and dairy lands to urban and/or open space should be addressed as part of a revision to the TMDL Implementation Plan; and

~~BB. Whereas, the TASK FORCE AGENCIES agree that upon amendment of the existing BASIN PLAN AMENDMENT, including the TMDL Implementation Plan, by the Regional Board to address, at a minimum, the issues described in Recital Z, the TASK FORCE AGENCIES shall amend this AGREEMENT to revise the cost allocation methodology for future fiscal years to incorporate a task-specific cost sharing methodology, based on assigned load allocation or waste load allocation of TASK FORCE AGENCIES, or categories of TASK FORCE AGENCIES, responsible for each TMDL Implementation Plan task; and~~

CC. Whereas, MARB agrees to budget for and to participate in the TASK FORCE, provided that sufficient funds are appropriated by the Congress, in FY 06-07 and future years, and on the condition that funding requirements under this AGREEMENT do not violate the Anti-deficiency Act, and provided that the TASK FORCE AGENCIES agree to relocate the proposed monitoring station from Kitching Channel to the Heacock drainage channel, and use any fees provided by MARB, for participation in this program, to establish and monitor this station.

II. COVENANTS

NOW, THEREFORE, in consideration of the foregoing recitals and mutual covenants contained herein, the TASK FORCE AGENCIES agree as follows:

1. Creation of a Task Force. There is hereby created a "Lake Elsinore and Canyon Lake TMDL Task Force" ("TASK FORCE") ~~initially~~ consisting of the TASK FORCE AGENCIES and certain Non-Voting, Non-Funding Members as more specifically provided for in paragraph 2 below.

2. Representation on the Task Force.

   a. Appointment. Concurrently with the execution of this Agreement, each TASK FORCE AGENCY shall, in accordance with such TASK FORCE AGENCY's own governing provisions, appoint one primary representative to the TASK FORCE and one alternate representative to act in the absence of the primary representative ~~-~~(hereinafter collectively referred to as "REPRESENTATIVES" or individually as "REPRESENTATIVE"). The REPRESENTATIVES shall have the authority to act on behalf of its appointing TASK FORCE AGENCY. The REPRESENTATIVES shall serve at the pleasure of the appointing TASK FORCE AGENCY and may be removed at any time, with or without cause by such TASK FORCE AGENCY; provided, however, that the TASK FORCE AGENCIES acknowledge and agree the continuity of representation on the TASK FORCE is important to the overall effectiveness of the TASK FORCE, and the TASK FORCE AGENCIES further agree to ensure such continuity whenever possible.

   b. Additional Agencies. The TASK FORCE AGENCIES acknowledge and agree that the effectiveness of the TASK FORCE may be improved by the inclusion of other agencies as additional TASK FORCE AGENCIES to the TASK FORCE. Such agencies may join the TASK FORCE on such written terms and conditions as are acceptable to all then existing TASK FORCE AGENCIES of the TASK FORCE, including, but not limited to, agreed-upon cash contributions for past, present, and/or future work, of the TASK FORCE. The inclusion of such agencies as additional TASK FORCE AGENCIES to the TASK FORCE shall be effected by a written amendment to this AGREEMENT signed by all then existing TASK FORCE AGENCIES. Such additional TASK FORCE AGENCIES shall each appoint their TASK FORCE primary REPRESENTATIVE and alternate REPRESENTATIVE as provided in Section II.2.a above or in said written amendment. The following agencies will be considered for inclusion as additional TASK FORCE AGENCIES in future amendments to this Agreement within the meaning of this section:

Any other named stakeholder in any future amendments of the BASIN PLAN AMENDMENT.

____.

c. Non-Voting, Non-Funding Members. The Regional Board, Lake Elsinore and San Jacinto Watersheds Authority and the San Jacinto River Watershed council are hereby appointed as Non-Voting, Non-Funding Members of the TASK FORCE. Additional Non-Voting, Non-Funding Members may be appointed by a majority vote of the TASK FORCE representatives. Non-Voting , Non-Funding Members appointed herein, and any appointed in the future are authorized only to make recommendations upon the functioning of this TASK FORCE and the development of this program. Federal, State and local regulatory agencies acting as Non-Voting, Non-Funding Members, now or in the future, retain authority to regulate TASK FORCE MEMBERS only to the extent that they are so authorized under State and Federal law.

d. Dairy and Agricultural Operators. The TASK FORCE AGENCIES acknowledge that the Western Riverside County Agriculture Coalition (WRCAC) shall represent the collective interest of both participating agricultural and dairy operators in the San Jacinto River Watershed in the TASK FORCE at this time. WRCAC shall appoint two primary TASK FORCE REPRESENTATIVES and two alternate REPRESENTATIVES as provided in Section II.2.a. One set of REPRESENTATIVES shall be designated for agricultural operator interests; the other set of REPRESENTATIVES shall be designated for dairy interests for the purposes of this TASK FORCE.

e. Committees. The TASK FORCE may establish subcommittees, consisting of REPRESENTATIVES and Non-Voting, Non-Funding Members who shall be selected by, and serve at the pleasure of, the TASK FORCE.

f. Task Force Administrator. A TASK FORCE administrator (hereinafter "TASK FORCE ADMINISTRATOR") shall be appointed by the TASK FORCE. The TASK FORCE ADMINISTRATOR shall have the following administrative responsibilities:

(1) Organizing and facilitating TASK FORCE meetings;
(2) Secretarial, clerical, and administrative services;
(3) Managing TASK FORCE funds and preparing annual reports of TASK FORCE assets and expenditures;
(4) Retaining TASK FORCE-authorized consultants; and
(5) Seeking funding grants to assist with achieving the work of the TASK FORCE and other goals and objectives approved by TASK FORCE AGENCIES.
(6) Possible administrator of future pollutant trading (water quality trading) agreements.

The TASK FORCE AGENCIES hereby appoint the Lake Elsinore and San Jacinto Watersheds Authority as the initial TASK FORCE ADMINISTRATOR.

g. Meetings of the Task Force.

(i) Frequency and Location. The TASK FORCE shall, by resolution or motion, agree upon the time and place for holding its regular meetings. Special meetings may be called at the request of the TASK FORCE ADMINISTRATOR or by a majority of the TASK FORCE REPRESENTATIVES.

(ii) Task Force Chair. The TASK FORCE REPRESENTATIVES shall select a chair and a vice-chair. The term of the chair and vice-chair shall be one year and shall be rotated among the TASK FORCE REPRESENTATIVES interested in serving as chair.

(iii) Quorum. One half or more of the REPRESENTATIVES of the TASK FORCE shall constitute a Quorum.

(iv) Voting. Actions of the TASK FORCE shall be validly taken only when a Quorum is present and upon the affirmative vote of a MAJORITY of the TASK FORCE REPRESENTATIVES. A MAJORITY of the REPRESENTATIVES shall be determined as follows:

Each TASK FORCE AGENCY shall have one vote assigned for each $1,000 increment of PRO RATA COST SHARE, as described in Paragraph II.5 below, contributed to the TASK FORCE Budget developed for a given fiscal year. A MAJORITY of the REPRESENTATIVES shall consist of greater than 50% of the total votes based on the Budget for the fiscal year during which the action is taken.

(v) All meetings of the TASK FORCE or any of its committees shall be conducted as may be required by any applicable provisions of the Ralph M. Brown Act (California Government Code §§54950 et seq.). The provisions contained in the Ralph M. Brown Act shall prevail in the event of any conflict with provisions contained in this Agreement.

The TASK FORCE may adopt such additional rules and regulations as may be required for the conduct of its affairs so long as such rules and regulations do not conflict with this Agreement.

3. Work of the Task Force. The TASK FORCE shall perform the following tasks in accordance with guidelines established by the Regional Board:

a. To retain consulting services to review scientific and other assumptions contained within the TMDL. Consultant(s) shall provide a report identifying preliminary TMDL opportunities such as site specific objectives, pollutant trading strategies, and integration strategies. The final scope of work shall be approved by the Task Force. The report shall specifically consider assumptions supporting the TMDL. The report should also provide preliminary analysis of the ability to achieve in-lake nutrient reductions and verify that load assignments are appropriate. Upon completion of the report, Consultant(s) shall also review work described herein, and make recommendations to ensure that work is specifically designed to resolve any deficiencies, where appropriate. Consultant(s) shall also coordinate development of BASIN PLAN AMENDMENT language, in coordination with the Regional Board, which can be used to revise the TMDLs as part of the Regional Board's Triennial Reviews at a minimum, or no later than by June 2010.

b. TMDL IMPLEMENTATION PLAN Task 4 - ~~Develop and~~ Implement a Watershed-wide Nutrient Monitoring Program. This program shall obtain data necessary to update the Lake Elsinore and Canyon Lake Nutrient TMDL, and to determine compliance with interim and final nitrogen and phosphorus allocations, and compliance with the nitrogen and phosphorus TMDLs. Monitoring and management of monitoring data to update the Lake Elsinore and Canyon Lake Nutrient TMDL shall commence immediately upon approval of this Agreement. An annual report summarizing the data collected for the year shall be submitted to the Regional Board by August 15 of each year ~~commencing in 2007~~.

c. TMDL IMPLEMENTATION PLAN Task 4 - ~~Develop and~~ Implement a Lake Elsinore and Canyon Lake Nutrient Monitoring Program. This program shall obtain data necessary to update the Lake Elsinore and Canyon Lake Nutrient TMDLs, and to determine compliance with interim and final nitrogen, phosphorus, chlorophyll A and dissolved oxygen numeric targets. In addition, the monitoring program shall determine the relationship between ammonia toxicity and the total nitrogen allocation to ensure that the total nitrogen allocation will prevent ammonia toxicity in Lake Elsinore and Canyon Lake~~. —~~. Lake m~~M~~onitoring and management of lake monitoring data shall be deferred based on agreement with the Regional Board until after the Canyon Lake Hypolimnetic Oxygenation System is constructed and will commence upon completion~~immediately upon approval of this agreement~~. Thereafter, ~~A~~an annual report summarizing the data collected for the year shall be submitted to the Regional Board by August 15 of each year~~ commencing in 2007~~.

d. TMDL IMPLEMENTATION PLAN Tasks 9 and 10 - ~~Develop and~~ Implement a Plan to Reduce Nutrients ~~in~~from ~~Lake Elsinore~~ sediments in Lake Elsinore and Canyon Lake~~and develop a sediment nutrient treatment evaluation plan for Canyon Lake~~. The projects will be based on prepared plans shall evaluate the efficacy of various in-lake treatment technologies to prevent the release of Nutrients from lake sediments as a long-term strategy for control of Nutrients in the sediment. The program may also include a sediment nutrient monitoring program to evaluate the effectiveness of any technologies that may be implemented. Target Date for Completion Date: July 1, 2015 (Interim TMDL targets) July 1, 2020 (Final TMDL targets)~~March 31, 2007~~.

e. TMDL IMPLEMENTATION PLAN Task 11 - ~~Develop and~~ Implement a Plan and Schedule for Updating the Existing Lake Elsinore/San Jacinto River Watershed Nutrient Model and the Canyon Lake and Lake Elsinore In-Lake Models. Develop and implement a plan and schedule to update and execute Watersheds and in-lake models to track the progress of TMDL efforts. In-lake models should be analyzed as soon as sufficient data becomes available. Target Date for Completion: ~~March~~ December 31, ~~2007~~2018.

f. TMDL IMPLEMENTATION PLAN Task 12 - Investigate, Develop and Implement a Pollutant (Water Quality) Trading Plan. Investigate the feasibility of pollutant trading in the Watersheds, and develop a feasibility plan for Regional Board review and approval. Target Date for Completion: ~~September~~ December ~~30~~31, ~~2007~~2012.

g. Investigate Long Term TMDL Implementation Structure, Cost Sharing Formula and Funding Sources. Investigate possible long term administrative structures, cost sharing formulas and funding sources that can be used to obtain compliance with the TMDL requirements. Target Date for Completion: ~~June~~ December ~~30~~31, ~~2010~~2012.

h. Other Tasks. The TASK FORCE may undertake such other plans, programs and studies as authorized by the TASK FORCE pursuant to II.2.g. of this Agreement.

i. Limitations on MARB~~ and Forest Service~~. As described above in Section I.h., MARB is an agency of the federal government and is therefore unable to participate in each and every aspect of Section 3 to the same extent as other TASK FORCE MEMBERS. To the extent that it is unable to participate in any tasks under section 3, it reserves the right, in its sole discretion, to participate to the fullest extent that it is able, as a matter of comity.

4. Budgets. ~~Beginning in FY2007-2008, t~~The total Annual Budget, adjusted to remove in-kind services, grant funding and funding credits associated with this Agreement shall not exceed $800,000, except as authorized by the TASK FORCE via two-thirds approval via votes based on the Budget for the then current fiscal year pursuant to II.2.g. of this Agreement. The TASK FORCE ADMINSTRATOR shall prepare and submit a proposed Budget for each fiscal year of this Agreement to the TASK FORCE AGENCIES by November 30th. The proposed Budget shall include all anticipated costs for the scope(s) of work developed by the TASK FORCE for the next fiscal year. The TASK FORCE Representatives shall approve the Budget by December 31st. Each

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TASK FORCE AGENCY shall pay its PRO-RATA SHARE of the approved fiscal year's TASK FORCE Budget and arrears by August 31st of the following year. The Budget for ~~the eighteen (18) month period starting January 1, 2006 and extending through June 30, 2007~~ the fiscal year 2012-2013 and ~~estimated~~ estimate for fiscal year ~~Budgets through June 30, 2010 are~~2013- 2014 is included as Attachment A to the Agreement. Approval of this Agreement shall constitute approval of the Budget ~~through June 30, 2007~~for fiscal year 2012- 2013. Payment of the fiscal year 2012-2013 Budget ~~through June 30, 2007~~ shall be by August 31, ~~2006~~2012, or within 30 days of the approval of this Agreement by each TASK FORCE AGENCY, whichever is sooner.

The TASK FORCE ADMINISTRATOR shall endeavor to minimize carry-over fund balances to those necessary to complete work of the TASK FORCE and to maintain contingencies limited to those necessary to ensure work of the TASK FORCE is not impeded. Excess not necessary to complete budgeted work of the TASK FORCE or maintain adequate reserves shall be credited back to the TASK FORCE AGENCIES in the Budget consistent with the PRO-RATA SHARE methodology described in Paragraph II.5 below. THE TASK FORCE AGENCIES shall agree to a reasonable reserve balance as part of each year's Budget.

After September 30 of each year, the TASK FORCE ADMINSTRATOR shall provide an accounting of all PRO RATA SHARES collected via cash or in-kind contributions. If PRO RATA SHARES collected are less than Budget, the TASK FORCE shall meet with Regional Board staff to determine appropriate priorities for scheduled TASK FORCE work and revise Budget based on available funds.

5. Pro-Rata Share Calculation. The annual PRO-RATA SHARE shall be calculated in the following manner:

A. TMDL TASK FORCE costs identified within the Task Force Budget under Part A: Task Force Regulatory/Administrative Budget (see Exhibit "X") shall be shared equally by the DISCHARGERS.

A. TMDL TASK FORCE costs identified within the Task Force Budget under Part B: TMDL Implementation Project Budget (see Exhibit "X") shall be shared by the DISCHARGERS, based upon participation in the individual program or project. The PRO-RATA SHARE for each DISCHARGER under Part B shall be per an amount agreed upon and/or in kind services among ~~via written agreement as detailed between~~ the participating parties.

~~The PRO-RATA SHARE for MS4 CO-PERMITTEES, Agricultural Operators and EVMWD shall be based on the BUDGET reduced by the value of available grant funding identified in Section 1 of Attachment A and in-kind services identified in Section 3 of Attachment A (LINE 1k BUDGET). The PRO-RATA SHARE for MS4 CO-PERMITTEES, and Agricultural Operators shall each be 28.5% of the LINE 1k BUDGET. Based on the prior agreement of EVMWD and the CITY OF LAKE ELSINORE involving the sharing of cost for supplemental water into Lake Elsinore, the PRO-RATE SHARE for EVMWD and the CITY OF LAKE ELSINORE shall each be 14.25% of the Line 1k Budget.~~

~~The PRO-RATA SHARE for Dairy shall be 5% of the LINE 1k BUDGET.~~

~~The PRO-RATA SHARE for RCFC&WCD shall be the cash value of the in-kind services described in Section 3 of Attachment A.~~

~~The PRO-RATA SHARE for all other TASK FORCE AGENCIES shall be as a base amount set forth in the Budget.~~

The PRO-RATA SHARE for additional TASK FORCE AGENCIES shall be per in--kind services

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and/or an amount agreed upon via written amendment of this AGREEMENT per Section II.2.b.

If the estimated funds collected under the PRO-RATA SHARE calculations exceed the BUDGET, the contributions of MS4 CO-PERMITTEES, EVMWD, City of Lake Elsinore, Agricultural Operators, Dairy and other TASK FORCE AGENCIES contributing in excess of the base amount shall be raised or reduced proportionately based on the percentage of their PRO-RATA SHARE, until the estimated total PRO-RATA SHARES equals the BUDGET.

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RCFC&WCD shall provide the TASK FORCE ADMINSTRATOR with annual individual MS4 CO-PERMITTEE cost share distribution of the MS4 CO-PERMITTEES PRO-RATA SHARE for ~~budgets following~~each Fiscal Year~~ 2006-07~~. The methodology used by RCFC&WCD to calculate the MS4 CO-PERMITEE cost share distribution may be amended at the NPDES MS4 Management Steering Committee.

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X. Pro rata cost shares assigned to DISCHARGERS who are not PARTIES to this Agreement shall be considered unfunded portions of the BUDGET and are addressed in Section II.4, paragraph 3 of this Agreement.

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6. In-Kind Credits. The PRO-RATA SHARE of a TASK FORCE AGENCY shall be reduced by the value of IN-KIND CREDITS provided toward agreed-upon budgeted tasks by, or on behalf, of the TASK FORCE AGENCY(S). Credits shall be applied to each budget period and adjusted at the end of each budget year based on actual verified costs unless deferred to a future budget year among the TASK FORCE AGENCIES with credits.

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7. Modifications to the TASK FORCE PRO-RATA SHARE methodology. The methodology deriving the TASK FORCE PRO-RATA SHARE as provided in Section II.5 of this Agreement may be modified upon written approval of all then existing TASK FORCE AGENCIES who's PRO-RATA SHARE would be affected.

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8. The TASK FORCE AGENCIES shall cooperate fully with one another to attain the purposes of this Agreement.

9. Nothing in this Agreement, nor the work set forth in this Agreement, nor any activity approved or carried out by the TASK FORCE AGENCIES hereunder, is intended to be nor shall be interpreted as a waiver by TASK FORCE AGENCIES of the "Maximum Extent Practicable" standard set forth in the Clean Water Act (33 U.S.C. Section 1251 *et seq.).*

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10. Each TASK FORCE AGENCY shall indemnify, defend, and hold each of the other TASK FORCE AGENCIES, including their special districts, officials, agents, officers, and employees, harmless from and against any and all liability and expense arising from any act or omission of such TASK FORCE AGENCY, its officials, agents, officers, and employees, in connection with this Agreement, including but not limited to defense costs, legal fees, claims, actions, and causes of action for damages of any nature whatsoever, including but not limited to bodily injury, death, personal injury, or property damage; provided, however, that no TASK FORCE AGENCY shall indemnify another TASK FORCE AGENCY for that TASK FORCE AGENCY's own negligence or willful misconduct.

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MARB~~ and the Forest Service~~, as an ~~agencies~~ agency of the federal government, ~~are~~ is unable to indemnify or hold harmless any other TASK FORCE AGENCY for any liability arising under this agreement. MARB ~~and the Forest Service~~ expressly does not indemnify or hold harmless any other TASK FORCE AGENCY for any injuries or liabilities, to itself, to any third party or to MARB~~, or the Forest Service~~, or its employees under this agreement or any activities carried out under authority of this agreement.

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11. In light of the provisions of Section 895.2 of the Government Code of the State of California imposing certain tort liability jointly upon public entities solely by reason of such entities being parties to an agreement (as defined in Section 895 of said Code), each of the TASK FORCE AGENCIES hereto, pursuant to the authorization contained in Sections 895.4 and 895.6 of said Code, shall assume the full liability imposed upon it or any of its officers, agents, or employees by law for injury caused by any act or omission occurring in the performance of this Agreement to the same extent that such liability would be imposed in the absence of Section 895.2 of said Code. To achieve the above stated purpose, each of the TASK FORCE AGENCIES indemnifies, defends, and holds harmless each other TASK FORCE AGENCY for any liability, cost, or expense that may be imposed upon such other TASK FORCE AGENCY solely by virtue of said Section 895.2. The provisions of Section 2778 of the California Civil Code are made a part hereof as if incorporated herein.

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MARB ~~and the Forest Service~~, as an ~~agencies~~ agency of the federal government, ~~are~~ is unable to indemnify or hold harmless any other TASK FORCE AGENCY for any liability arising under this agreement. MARB ~~and the Forest Service~~ expressly does not indemnify or hold harmless any TASK FORCE AGENCY for any injuries or liabilities, to itself, to any third party or to MARB ~~or Forest Service~~ or their employees under this agreement or any activities carried out under authority of this agreement. Tort liability for federal employees, including employees of MARB ~~and the Forest Service~~, is expressly authorized and limited by the Federal Tort Claims Act, which will control liability of MARB ~~and the Forest Service~~ and their employees under the terms of this agreement.

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12. All obligations of CALTRANS under the terms of this Agreement are subject to the appropriation of the resources by the Legislature and the allocation of resources by the California Transportation Commission. This Agreement has been written before ascertaining the availability of Federal or State legislative appropriation of funds, for the mutual benefit of the TASK FORCE AGENCIES in order to avoid program and fiscal delays that would occur if the Agreement were executed after that determination was made. This Agreement is valid and enforceable as to each of the CALTRANS as if sufficient funds have been made available to CALTRANS by the United States Government or California State Legislature for the purposes set forth in this Agreement. If the United States Government or the California State Legislature does not appropriate sufficient funds for CALTRANS to participate in this Agreement, this Agreement may be amended in writing by the TASK FORCE AGENCIES to reflect any agreed-upon reduction in the percentage of funds contributed by CALTRANS to continue its participation in this Agreement. CALTRANS, however, has the option to withdraw from this Agreement in the event sufficient funds are not appropriated for CALTRANS. Should CALTRANS exercise its option to withdraw from this Agreement, CALTRANS shall remain responsible for its share of liability, if any, incurred while participating in this Agreement.

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13. No TASK FORCE AGENCY shall have a financial obligation to any other TASK FORCE AGENCY under this Agreement, except as expressly provided herein.

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14. Any notices, invoices, reports, correspondence, or other communication concerning this Agreement shall be directed to the TASK FORCE AGENCY REPRESENTATIVE on file with the TASK FORCE ADMINISTRATOR, except that any TASK FORCE AGENCY may change its name or address by giving the other TASK FORCE AGENCIES at least ten days written notice of the new name or address.

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15. The TASK FORCE AGENCIES are, and shall at all times remain as to each other, wholly independent entities. No TASK FORCE AGENCY to this Agreement shall have power to incur

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any debt, obligation, or liability on behalf of any other TASK FORCE AGENCY unless expressly provided to the contrary by this Agreement**.** No employee, agent, or officer of a TASK FORCE AGENCY shall be deemed for any purpose whatsoever to be an agent, employee or officer of another TASK FORCE AGENCY.

16. This Agreement shall be binding upon and shall inure to the benefit of the respective successors, heirs, and assigns of each TASK FORCE AGENCY.

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17. This Agreement shall be governed by, interpreted under and construed and enforced in accordance with the laws of the State of California, except as to ~~the Forest Service and~~ the March Air Reserve Base to whom federal law is applicable.

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18. If any provision of this Agreement shall be determined by any court to be invalid, illegal or unenforceable to any extent, the remainder of this Agreement shall not be affected and this Agreement shall be construed as if the invalid, illegal, or unenforceable provision had never been contained in this Agreement**.**

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19. Each individual TASK FORCE AGENCY has been represented by its own separate counsel in the preparation and negotiation of this Agreement**.** Accordingly, this Agreement shall be construed according to its fair language and any ambiguities shall not be resolved against the drafting TASK FORCE AGENCY.

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20. Each of the persons signing below on behalf of a TASK FORCE AGENCY represents and warrants that he or she is authorized to sign this Agreement on behalf of such TASK FORCE AGENCY.

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21. Duration of Agreement. This Agreement shall terminate June 30, ~~2010~~ 2017(unless extended by mutual agreement of all TASK FORCE AGENCIES), provided that all debts and liabilities of the TASK FORCE are satisfied. Notwithstanding the foregoing, each TASK FORCE AGENCY reserves the right to withdraw from the TASK FORCE at any time, upon sixty (60) days' prior written notice to the TASK FORCE. TASK FORCE contingency, projects and studies underway at the time of withdrawal shall continue to be fully funded by the withdrawing TASK FORCE AGENCY until the end of the fiscal year in which the TASK FORCE AGENCY gave notice to withdraw.

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22. Counterparts. This Agreement may be executed simultaneously or in counterparts, each of which shall be deemed an original and together shall constitute one and the same instrument.

23. Amendment. This Agreement may not be amended except in a writing signed by all the TASK FORCE AGENCIES.

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24. Effective Date. This Agreement shall become effective when it has been executed by all of the TASK FORCE AGENCIES.

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IN WITNESS WHEREOF, the TASK FORCE AGENCIES have executed this AGREEMENT on the date set forth below.

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AGENCY	**AGENCY**
~~**UNITED STATES FOREST SERVICE (SAN BERNARDINO AND CLEVELAND NATIONAL FOREST MANAGEMENT ZONES)**~~	**US AIR FORCE (MARCH AIR RESERVE BASE)**
	BY_______________________________
~~BY_______________________________~~	DATE_______________________________

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~~DATE______________________________~~

MARCH ~~AIR RESERVE BASE~~ JOINT POWERS AUTHORITY	**CALIFORNIA DEPARTMENT OF TRANSPORTATION**
BY________________________________	BY________________________________
DATE______________________________	DATE______________________________
CALIFORNIA DEPARTMENT OF FISH AND GAME	**COUNTY OF RIVERSIDE**
BY________________________________	BY________________________________
DATE______________________________	DATE______________________________
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	**ELSINORE VALLEY MUNICIPAL WATER DISTRICT**
BY________________________________	BY________________________________ Board Chair
DATE______________________________	DATE______________________________
EASTERN MUNICIPAL WATER DISTRICT	**WESTERN RIVERSIDE COUNTY AGRICULTURE COALITION**
BY________________________________ Board Chair	BY________________________________
DATE______________________________	DATE______________________________
LAKE ELSINORE & SAN JACINTO WATERSHEDS ~~PROJECT~~ AUTHORITY	**CITY OF BEAUMONT**
BY________________________________ Board Chair	BY________________________________ Mayor
DATE______________________________	DATE______________________________
CITY OF CANYON LAKE	**CITY OF HEMET**
BY________________________________ Mayor	BY________________________________ Mayor
DATE______________________________	DATE______________________________
CITY OF LAKE ELSINORE	**CITY OF MORENO VALLEY**
BY________________________________ Mayor	BY________________________________ Mayor

DATE______________________________ DATE______________________________

CITY OF MURRIETA **CITY OF PERRIS**

BY_________________________________ BY_________________________________
Mayor Mayor

DATE______________________________ DATE______________________________

CITY OF RIVERSIDE **CITY OF SAN JACINTO**

BY_________________________________ BY_________________________________
Mayor Mayor

DATE______________________________ DATE______________________________

CITY OF WILDOMAR **CITY OF MENIFEE**

BY_________________________________ BY_________________________________
Mayor Mayor

DATE______________________________ DATE______________________________

SANTA ANA REGIONAL WATER QUALITY CONTROL BOARD

BY__________________________________

DATE______________________________

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