



### **FINAL**

### **TECHNICAL MEMORANDUM**

то:	Vic Ramirez, LCRA	DATE:	March 18, 2009 Revised May 11, 2009
FROM:	Emily Chen, Anchor QEA Jim Patek, Parsons Jennifer Benaman, Anchor QEA	RE:	Lake Travis scenario runs - FINAL
CC:	Lisa Hatzenbuehler, LCRA John Wedig, LCRA Randy Palachek, Parsons	JOB#:	PARcrm:161

This memo summarizes the scenarios performed using the watershed and lake water quality models developed for Lake Travis for Phase 2 of the Colorado River Environmental Models (CREMs) project. The goal was to investigate the sensitivity of water quality in the lake to various potential changes in the Lake Travis watershed. Specifically, ten scenarios were evaluated that focused on three variables:

- the increase of point source discharges to the lake at locations with a wastewater treatment facility and current and pending land application permits and at a location close to Max Starcke Dam;
- the increase of urbanization in subbasins undergoing potential development within the Lake Travis watershed, with and without the Highland Lakes Watershed Ordinance (HLWO) in place; and
- the increase of nutrient and organic loadings at the upstream boundary of Lake Travis (i.e., the load coming into Lake Travis over Max Starcke Dam, which represents the load from Lake Marble Falls).

The Lake Travis model is comprised of linked watershed (SWAT) and lake water quality (CE-QUAL-W2) models. Details on the model development, calibration, and model sensitivity can be found in the *Colorado River Environmental Models Phase 2: Lake Travis Final Report* (Anchor QEA and Parsons 2009).

#### SCENARIO DEVELOPMENT

Table 1 presents an overview of the ten scenarios that were applied to the calibrated watershed and lake water quality models in order to investigate the sensitivity of the lake water quality to these watershed changes. As illustrated in Table 1, of the ten scenarios, four (#1, #2, #3, and #4) involve only an increase in point source discharges, two (#5 and #6) are a function solely of

Table 1. Scenario overview.	Poi	nt Source	Discharg	ers <sup>a</sup>	Urbanization			Upstream Loadings	
SCENARIO	No new point source dischargers	10 MGD point source (wet-weather discharge) <sup>b</sup>	10 MGD point sources (constant discharge)	2 MGD point source into upstream part of lake	Current land use (2000 USGS/USEPA)	Increased urbanization (20 yrs into future) HLWO not in-place	Increased urbanization (20 yrs into future) HLWO in-place	Current	Increased loading by 10%
1. All point sources (10 million gallons per day [MGD], incl. wastewater treatment facilities and current/pending land applications)			х		х			х	
2. Point sources (wet-weather discharge) only		х			x			х	
3. Point source (2 MGD) into upstream portion of lake				х	х			х	
4. Point source (2 MGD) into upstream portion of lake & all point sources (10 MGD)			х	х	х			х	
5. Increased urbanization without Highland Lakes Watershed Ordinance (HLWO) in place	х					x		х	
6. Increased urbanization with HLWO in place	х						х	х	
7. Increased upstream loading	х				х				х
8. All point sources & increased urbanization without HLWO in place			х			x		х	
<ol> <li>All point sources, increased urbanization without HLWO in place, &amp; increased upstream loading</li> </ol>			х			x			х
10. All point sources (wet-weather discharge), increased urbanization without HLWO in place, & increased upstream loading		x				x			х

Notes: a. The following will be assumed regarding a discharge: Flow = 1 MGD, BOD = 10 mg/L, TSS = 15 mg/L, DO = 4 mg/L, NH<sub>3</sub>-N = 1 mg/L, NO<sub>2</sub>+NO<sub>3</sub> = 20 mg/L, TP = 1 mg/L (all immediately "available" for algal growth)

b. Wet-weather discharge in operation when modeled flows from Sandy Creek were above 1 cfs.

urbanization, one (#7) entails only an increase in upstream loading, one (#8) involves both an increase in point source discharges and urbanization, and two (#9 and #10) scenario include changes in all three variables. These scenarios considered changes in only one of the three areas described above, as well as cumulative impacts from a combination of different changes occurring "simultaneously" over the watershed.

For all of the scenarios simulated, the impact is measured relative to the calibrated model result, which represents "current" conditions. The hydrologic condition that is simulated for the scenarios in the model is the same period as the calibration (1984 – 2006). This 23-year period represents a range of low, high, and somewhat average precipitation conditions (Figure 1; all figures can be found after the memo text). By running the future scenarios using the same hydrology as the calibration, it is possible to observe relative impacts in the lake to changes on the watershed during both wet and dry periods. A bounding calibration was developed that represents an estimate of uncertainty in the model prediction. The scenarios were also run using this bounding calibration and these results were used in conjunction with the base-calibration future scenario results to show a potential range of chlorophyll-*a* concentrations for a given watershed change.

#### **REPRESENTATION OF THE SCENARIOS WITHIN THE MODEL FRAMEWORK**

#### **Increases in Point Source Discharges**

Of the ten scenarios, seven involve an increase in point source discharges. For such scenarios to be a reality, the current Texas Commission on Environmental Quality (TCEQ) Highland Lakes Point Source Discharge Ban, which precludes the discharge of wastewater treatment plant effluent into Lake Travis except for those facilities in operation before the ban went into effect, would have to be lifted. For the seven future scenarios involving point source discharges, it was assumed that the discharge ban was lifted and that current and pending land application permit holders were allowed to discharge at permitted flows through wastewater treatment facilities into Lake Travis at locations closest to those in their permit applications. Specification of the point sources in the lake water quality model required information on location (spatially and at depth), discharge rate, and effluent concentration.

For scenarios where discharges within ten stream miles of Lake Travis included flows from one wastewater treatment facility and flows from 38 current and pending (as of April 2008) land application permits, the model segments into which the discharges were assigned are shown on Figure 2. Discharges were placed in the lake "at depth" (about a meter above the sediment bed at all locations).

For Scenarios #1, #4, #8, and #9, it was assumed that all point source discharges will total approximately 10 million gallons per day (MGD). The total flow rate, however, of all wastewater treatment dischargers and current and pending land application permits is about 7 MGD. In order to increase the total rate to 10 MGD, an additional 3 MGD of discharge was assigned to permittees located upstream of Turkey Bend to represent possible increases (number of permittees, permitted discharge quantities, etc.) in the future. The 3 MGD was prorated among

these locations using the ratios of the permitted discharge rates. Point source discharges for these scenarios were constant for the duration of the model simulation.

Two of the point source discharge scenarios assume that discharges would only be allowed at times when natural flows into Lake Travis exceed a certain threshold. In order to simulate such wet-weather conditions (Scenarios #2 and #10), the point sources of all wastewater treatment dischargers and current and pending land application permits (including the proration up to 10 MGD) were activated on days during the model simulation when the modeled flow in Sandy Creek was greater than 1 cubic feet per second (cfs). An evaluation of modeled daily flow rates for Sandy Creek from the lake model's water balance showed that 1 cfs was an appropriate threshold; flow exceedance of this threshold occurred about 12% of the time (Figure 3). Therefore, whenever modeled flow rates exceeded 1 cfs in Sandy Creek, point source discharges were "turned on" in the lake water quality model. For the scenarios, no adjustments were made to allow augmented discharges during wet-weather; in other words, only 12% of the total load from point sources enters Lake Travis over the course of the 23-year simulation during wet-weather conditions, compared to the loads discharged in the continuous discharge simulation.

Two of the point source discharge scenarios assumed an additional point source discharge of 2 MGD into the upstream portion of the lake. The discharge rate of 2 MGD is typical of the amount of volume expected from the municipalities in the basin. Scenarios #3 and #4 included a 2 MGD point source into the most upstream model segment at one meter above the sediment bed. Scenario #3 tested the effects of the 2 MGD discharge only and Scenario #4 tested the cumulative impacts of the 2 MGD discharge together with the 10 MGD point source discharges described above.

For all discharge scenarios, the concentrations of pollutants in the effluent were based on current point source discharge limits and professional judgment. These values are provided in Table 2. To be conservative, all phosphorus from the discharge was assumed to be immediately "available" for algal growth when it enters the lake (i.e., total phosphorus [TP] is all dissolved orthophosphate [PO<sub>4</sub>]). No organic nitrogen was assumed present in the discharge.

Constituent	Application in CE-QUAL-W2	Discharge Concentrations (mg/L)
Biochemical Oxygen Demand (5-day)	Included as a CBOD group; assumed no organic P or organic N	10
Total Suspended Solids (TSS)	Assumed only inorganic solids (ISS = TSS)	15
Dissolved Oxygen (DO)	DO	4
Ammonia Nitrogen (NH <sub>3</sub> -N)	NH <sub>3</sub> -N	1
Nitrite and Nitrate (NO <sub>2</sub> +NO <sub>3</sub> )	NO <sub>3</sub>	20
Total Phosphorus (TP)	Assumed no organic P ( $TP = PO_4$ )	1

Table 2.	Assumptions	for point	nt source	discharge	concentrations.
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Notes: CBOD – carbonaceous biochemical oxygen demand; N - nitrogen; P – phosphorus; PO<sub>4</sub> – orthophosphate.

#### **Increases in Urbanization**

Five scenarios depict an increase in urbanization in the Lake Travis watershed 20 years into the future (for details in assumptions made regarding urbanization, see Appendix A). Four (#5, #8, #9, and #10) represent future urbanization without the HLWO in place and one (#6) portrays it in place. Urbanization was assumed to occur in the most common land uses that bordered currently urbanized land: brushy-rangeland, evergreen forest, and grass-rangeland. Development was modeled as low-density residential (<0.5 unit/acre, or on average 12% impervious). As a result, urbanization in the lower portion of the watershed model (adjacent to Lake Travis; see Figure 4) increased from 1.8% in the "current" conditions (i.e., calibration run) to 11.3% in the future scenario runs. Using the same approach, the urbanization in the upper portion of the watershed model (adjacent to the Pedernales River; see Figure 4) increased from 0.8% to 3.4%. Because the calibration of the watershed model used data from subbasins where most of the land was not urbanized or whose urbanization was grandfathered and is not affected by the HLWO, this future urbanization represents urbanization without the HLWO in place. In other words, the model parameters that were established during the calibration of the watershed model were set using data from areas without the HLWO in place. These same parameters were used on any "new" urbanized land in the future scenarios. Therefore, urban land introduced in the model for four future scenarios reflects the urbanization without the HLWO in place.

In terms of increased nutrient and organic matter loadings due to the urbanization without the HLWO in place, Table 3 shows the total watershed loads for the entire simulation and the percentage change from the calibration run.

Constituent	Total watershe	% Change	
Constituent	"Current" (Calibration) Future Urbanization		76 Change
Orthophosphate	5,559	5,655	2%
Organic Matter – Phosphorus	275,673	288,422	5%
Phosphorus - Algal	4,122	4,889	19%
Ammonia Nitrogen	170,043	181,450	7%
Nitrate	2,597,617	2,648,803	2%
Organic Matter – Nitrogen	848,587	906,003	7%
Nitrogen - Algal	63,934	76,682	20%
Organic Matter	9,993,734	11,796,059	18%
Algae	1,522,050	1,825,905	20%

Table 3. Changes in watershed loadings due to urbanization (no HLWO in place).

The scenario representing future urbanization *with* the HLWO in place (#6) was created in several steps. First, the differences in nutrient and organic loads between the base-calibration run and the future urbanization run (Scenario #5) were presumed to be due to urbanization *without* the

HLWO. Then, subbasins with at least 25% of their area within the boundary of the HLWO were identified (Figure 4). Next, best management practices, in accordance with the HLWO, were assumed to be 70% efficient, meaning that 30% of the load from the urban area enters the lake.<sup>1</sup> Finally, future loads with urbanization and the HLWO in place were calculated as the sum of the calibration load from both the upper (adjacent to the Pedernales River) and lower (adjacent to Lake Travis; Figure 4) models, the increase in load from the upper model due to increased urbanization (unaffected by the HLWO), and 30% of the increase in load from the lower model due to increased urbanization. The BMPs were applied to each daily load and each subbasin included in the lake model; on days when future urbanization loads were lower than those for the base calibration, the future urbanization loads were used.

#### **Increases in Upstream Boundary Conditions**

Three model scenarios (#7, #9, and #10) included the increase of upstream loadings by 10% to simulate potential future loadings coming over Max Starcke Dam (i.e., from Lake Marble Falls). The upstream loadings of algae, inorganic suspended solids (ISS), NH<sub>4</sub>, NO<sub>2</sub>+NO<sub>3</sub>, all organic matter groups, and PO<sub>4</sub> were increased (Table 4).

	Load for 23-year simulation period (metric tons)					
Constituent	10% of upstream load (change applied to upstream)	Total load to system (from upstream, tributaries, direct drainage) for calibration				
Inorganic Suspended Solids	31,534	23,603,800				
Orthophosphate	20	262				
Organic Matter - Phosphorus	88	3,760				
Phosphorus - Algal	5	95				
Ammonia Nitrogen	126	3,034				
Nitrite and Nitrate	606	33,155				
Organic Matter – Nitrogen	1,316	22,008				
Nitrogen - Algal	81	1,473				
Organic Matter	23,135	335,609				
Algae	1,918	35,059				

Table 4. Comparison of 10% increase in upstream load to current total load to LakeTravis.

#### SCENARIO RESULTS

Impacts of the changes in the watershed due to the scenarios on water quality in the lake were assessed at five locations: near the upstream boundary near Max Starcke Dam (Model Segment 6), at Turkey Bend (Segment 28), at Arkansas Bend (Segment 78), at the downstream boundary of Mansfield Dam (Segment 93), and in Hurst Cove (Segment 140; Figure 2). Assessment compared average and maximum of predicted daily average chlorophyll-*a* concentrations in the

<sup>&</sup>lt;sup>1</sup> It should be noted that the Best Management Practices (BMPs) treat runoff only in the newly urbanized areas, and that BMP retrofitting in established neighborhoods is not being modeled.

top two meters of the water column for each scenario during the summer months (June through September) to the model output from the current conditions (or calibration run). Chlorophyll-*a* concentrations were used to determine impact because algal blooms are potentially more important to stakeholders and because the parameter is linked to changes to nutrients such as phosphorus and nitrogen. The model was set up to print daily average results to an output file for the 23-year simulation period; for ease of comparison, however, the average and maximum of the daily average chlorophyll-*a* concentrations during summertime periods for the entire run were used in the presentation of the model results below.

In the figures, model results are shown as percent changes in chlorophyll-*a* concentrations from the current concentrations over the entire 23-year simulation period. These percent changes can be considered relative to the absolute summer surface water chlorophyll-*a* concentrations for the current, or calibration, run.<sup>2</sup> Model results for each simulated year are included in Appendix B. Table 5 presents the daily average summer surface water chlorophyll-*a* concentrations for current conditions.

	Daily Average Summer Chlorophyll-a (µg/L)			
Location	Mean	Max		
Near Max Starcke Dam	8.2	24.1		
Turkey Bend	5.7	14.2		
Arkansas Bend	6.6	14.2		
Mansfield Dam	3.7	10.5		
Hurst Cove	5.8	12.7		

Table 5. Mean and maximum summer surface water chlorophyll-*a* concentrations predicted for current conditions.

#### **Impact of Increases to Point Source Discharges (Scenarios #1 through #4)**

For all scenarios that include an increase in point source discharges, the model predicts an increase in summertime surface chlorophyll-*a* concentrations. The magnitude of the increase is related to the location and duration of the discharges and the lake characteristics at those places. Because of where the majority of the point sources enter Lake Travis (Figure 2), the largest changes in summer surface chlorophyll-*a* concentrations occurred in the downstream portion of the lake (Figure 5). For the scenario with constant point source discharges amounting to about 10 MGD (Scenario #1), average and maximum chlorophyll-*a* concentrations increased between 42% and 102% at Arkansas Bend, Mansfield Dam, and Hurst Cove compared to little overall

<sup>&</sup>lt;sup>2</sup> The model results were evaluated by pairing the scenario concentration and current concentration for each simulated year, dividing the difference between the scenario concentration and current concentration by the current concentration and multiplying by 100, and averaging the percent changes for each year over the entire 23-year simulation. In this manner, the average percent change captures the variability in scenario results during the entire run, which includes different hydrologic conditions. The percent change is not the change in the overall average (i.e., not the percent change between the average scenario and average current results) and should not, therefore, be used directly to compute an absolute summer surface water chlorophyll-*a* concentration but instead be used in a manner relative to other scenario results.

change near Max Starcke Dam and a 5% to 11% change at Turkey Bend. Allowing point sources to discharge only during wet-weather (Scenario #2) reduced the increase in summer surface chlorophyll-*a* concentrations predicted with constant point source discharges up to 80%.

Near Max Starcke Dam and Turkey Bend, the introduction of a 2 MGD point source (Scenario #3) resulted in algal growth proportional to increased nutrient loadings (Figure 5). The 22% and 23% increases in mean summer surface chlorophyll-*a* at Max Starcke Dam and Turkey Bend, respectively, were on par with the increase to nutrients (e.g., an addition of 64 metric tons of PO<sub>4</sub> by the 2 MGD point source was in-line with 24% of the total PO<sub>4</sub> load to the system). This signal was attenuated (e.g., diluted) by the time the water reached the downstream locations, but still showed a signal at Mansfield Dam with about an 2% increase in chlorophyll-*a*. The introduction of the loading as a point source instead of a non-point source was chosen due to the ease of implementation in the model; any difference in loading placement within the surface) presumably would be minimal as dilution and/or mixing would have occurred by the time water reaches the downstream assessment locations.

Scenario #4 shows the cumulative effects of the additional 2 MGD point source and the accumulated 10 MGD point sources (Figure 5). As expected, the 2 MGD point source dominated in the upper portion of the lake and then the accumulated 10 MGD point sources had a greater influence in the downstream portion.

#### **Impact of Increases in Urbanization (Scenarios #5, #6, and #8)**

For the scenarios that include an increase in urbanization, the model predicts smaller increases in summertime surface chlorophyll-*a* concentrations compared to scenarios with continuous point source discharges. At the downstream locations, increasing watershed urbanization 20 years into the future (Scenario #5) had a smaller impact on summer surface chlorophyll-*a* concentrations than increasing continuous point source discharges in the future (Scenario #1; Figure 6). Scenario #5 shows increases of summer surface chlorophyll-*a* of 2% to 4% at Arkansas Bend, Mansfield Dam, and Hurst Cove compared to 42% to 102% change for Scenario #1. Near Max Starcke Dam, urbanization increased chlorophyll-*a* concentrations less than point sources and at Turkey Bend, the impact of urbanization on average and maximum chlorophyll-*a* was generally low (2% increase). The combination of the two scenarios (Scenario #8) shows the cumulative increase of up to 101% in summer surface chlorophyll-*a* concentrations.

Having the HLWO in place 20 years into the future (Scenario #6) resulted in smaller, if any, increases in chlorophyll-*a* at all five locations than if the HLWO was not in place (Scenario #5; Figure 7). With the ordinance in place, the mean and maximum summer surface chlorophyll-*a* compared to the current conditions did not change or increased up to 4%. Without the ordinance in place, the percent changes ranged from 0% to 13%.

#### **Impact of Increases in Upstream Boundary Conditions (Scenario #7)**

The percent changes to mean summer surface chlorophyll-*a* concentrations for the scenario with a 10% increase in upstream loadings (Scenario #7) were higher near Max Starcke Dam and lower at the downstream locations (Figure 8). A 6% increase was predicted near Max Starcke Dam. This upstream signal was observable at Mansfield Dam and in Hurst Cove with 3% and 4% increases, respectively, compared to the current conditions.

## Impact of Scenario Combinations (Point Source – Constant and Wet-Weather Discharge, Urbanization, and Increased Upstream Loading) (Scenarios #9 and #10)

The results for Scenario #9 show the cumulative impacts of potential future point sources, increased urbanization 20 years into the future without the HLWO in place, and an increase to the upstream loadings by 10% (Figure 9). The percent changes in mean summer surface chlorophyll-a increased by 11% to 21% at the upstream locations (near Max Starcke Dam and Turkey Bend) and by 48% to 104% at the downstream locations (Arkansas Bend, Mansfield Dam, and Hurst Cove). This pattern reflects the fact that the majority of point source dischargers enter the lake at the downstream end and that point sources have the largest impact on summer surface chlorophyll-a of the three scenario areas tested. Allowing point sources to discharge only during wet-weather (Scenario #10) reduced the average and maximum daily average summer surface chlorophyll-a concentrations up to 76%; in other words, the increases in concentrations due to the constant point source discharges were reduced up to 76%.

#### Sensitivity to Point Source Water Quality Concentrations

Because the scenario results indicated that about 10 MGD of combined point sources have a substantial impact on summer surface chlorophyll-*a* concentrations, the sensitivity of the model to the assumed discharge concentrations for the point sources was tested using Scenario #1 as the original model run (Table 6). One sensitivity run tested the lake's response to a reduction in the nitrite and nitrate (NO<sub>2</sub>+NO<sub>3</sub>) concentration from 20 milligrams per liter (mg/L) to 4 mg/L. Another sensitivity run assessed the lake's response to assuming that none of the total phosphorus was immediately "available" for algal growth. To do this, the total phosphorus from the discharge was set to all organic (i.e.,  $PO_4 = 0 \text{ mg/L}$ ). The complete removal of orthophosphate is not achievable due to technological limitations, and therefore, this sensitivity represents a lower bound to predicted chlorophyll-*a* concentrations if  $PO_4$  levels are decreased. The last two sensitivities were performed to evaluate the lake's response to various reductions in BOD, total suspended solids (TSS), TP, and NO<sub>2</sub>+NO<sub>3</sub> concentrations from the point sources if advanced treatment was implemented at the treatment plants.

		Scenarios	s Sensitivity Testing					
Constituent	Application in CE-QUAL-W2	#1	Reduction in NO <sub>2</sub> +NO <sub>3</sub>	No immediately "available" P for algal growth	Advanced Treatment 1	Advanced Treatment 2		
			Discharge	Concentration (r	ng/L)			
Biochemical Oxygen Demand (5- day)	Included as a CBOD group; assumed no organic P or organic N	10	10	10	5	5		
Total Suspended Solids	Assumed only inorganic solids (ISS = TSS)	15	15	15	5	5		
Dissolved Oxygen	DO	4	4	4	4	4		
Ammonia Nitrogen	NH <sub>3</sub> -N	1	1	1	1	2		
Nitrite and Nitrate	NO <sub>3</sub>	20	4	20	10	4		
Total Phosphorus	Assumed no organic P ( $PO_4 = TP$ )	1	1	$1 (PO_4 = 0)$	1	0.15		

Table 6. Assumptions for sensitivity testing of point source discharge concentrations.

Reducing the nutrient concentrations in the constant point source discharges had favorable impacts on the summer surface chlorophyll-*a* concentrations (Figure 10). Compared to the scenario with constant discharges of about 10 MGD (Scenario #1), reducing the NO<sub>2</sub>+NO<sub>3</sub> concentration to 4 mg/L lowered the increase in summer surface chlorophyll-*a* concentrations up to 25%. Not allowing any phosphorus to be immediately "available" for algal growth resulted in reductions up to 84%. Decreasing the point source discharge concentrations to reflect advanced treatment reduced summer surface chlorophyll-*a* levels up to 16% using advanced treatment set 1 and up to 52% using advanced treatment set 2 concentrations; in other words, the increases in concentrations due to the constant point source discharges were reduced by up to 16% and 52%, respectively. Even with the increased levels of treatment, however, the impacts of the constant point source discharges are still observable in the model predictions.

#### **UNCERTAINTY IN SCENARIO RESULTS**

Uncertainties exist in the scenario predictions given the uncertainties in the model predictions. During the Phase 2 Lake Travis calibration, an upper-bound calibration was determined by changing three of the most sensitive model input parameters to simulate higher summer surface chlorophyll-*a* concentrations while still maintaining agreement with various measured data. This process is called a "bounding calibration" and provides an estimate of the upper-bound uncertainties on the chlorophyll-*a* concentrations predicted by the model. Each of the ten scenarios was rerun using this upper-bound calibration. These results, combined with the results from the original scenario runs, provide an "upper-range" of possible chlorophyll-*a* 

concentrations.<sup>3</sup> Figures 11 and 12 show the average and maximum daily average summer chlorophyll-*a* concentrations for all scenarios runs with the original calibration as the base and the concentrations with the bounding calibration as the base. The uncertainty in the model results is a function of location (there was less uncertainty in the model predictions at upstream locations) and predicted concentration (the higher the concentration, the higher the uncertainty in the model predictions). The hatched bars in the figures indicate the upper ranges of uncertainty in the model predictions for the scenarios. For the scenarios performed, the bands of uncertainty for the average summer surface chlorophyll-*a* ranged from zero up to  $2 \mu g/L$ .

#### CONCLUSIONS

From the ten scenarios and three sensitivities performed using the Lake Travis water quality model, the following conclusions can be made:

- Model results indicate increased point source dischargers would have the largest impact on lake water quality. Results are sensitive to assumptions made regarding discharge concentrations and nutrient availability.
- Requiring point sources to discharge during wet-weather would mitigate some of the impact. In the scenarios, loadings from the wastewater treatment plants were reduced to 12% of their load allowed during continuous discharge.
- Urbanization and upstream loading increases also have impacts lake-wide.
- Future urbanization impacts can likely be controlled with the HLWO. Maintaining the TCEQ Point Source Discharge Ban will aid in managing increased loads due to urbanization and increased loads from upstream. The HLWO aids in controlling chlorophyll-*a* increases due to urbanization.
- Changes in loadings are measurable lake-wide and not constrained to "localized" effects. Even a change in the upstream load can be "seen" at Mansfield Dam and in Hurst Cove.
- Because of model uncertainty, the model predictions for average summer surface chlorophyll*a* for these future scenarios could be up to 0.1 to 2.0  $\mu$ g/L higher (depending on scenario and assessment location) than the concentrations predicted using the base calibration.

#### REFERENCES

Anchor QEA and Parsons, 2009. Colorado River Environmental Models Phase 2: Lake Travis Final Report. Final draft submitted to LCRA on March 18, 2009; revised on May 11, 2009.

<sup>&</sup>lt;sup>3</sup> Because a lower-bound calibration was not determined, these results should be viewed as "conservative" or the most likely estimate (i.e., base calibration) and an upper-bound estimate (i.e., bounding calibration) of possible chlorophyll-a concentrations in the lake.

### **FIGURES**





**Figure 1.** Annual precipitation in Lake Travis watershed over simulation period. Based on National Climatic Data Center (NCDC) data at 17 stations surrounding Lake Travis.



Emily d\_drive PARcrm GIS Travis\_dischargers future\_permits lake\_travis\_futureWWTP\_flow\_modelseg\_20090511.mxd



Figure 3. Temporal and probability plot of flow for Sandy Creek.

Julian day 0 = 1/1/1984Flows from model input file (flow balance)



March 2009



#### Figure 5. Impacts of point sources on summer surface chlorophyll-a concentrations.

Percent changes from base case values calculated by pairing yearly results and then computing averages and maximums of daily model predictions over the 23-year simulation.

Surface summertime chl-a concentrations for the base case (calibration) run are shown in the bottom right corner.



#### Figure 6. Impacts of urbanization on summer surface chlorophyll-a concentrations.

Percent changes from base case values calculated by pairing yearly results and then computing averages and maximums of daily model predictions over the 23-year simulation.

Surface summertime chl-a concentrations for the base case (calibration) run are shown in the bottom right corner.





Base Case (μg/L)								
Location	Mean	Max						
Near Max Starcke Dam	8.2	24.1						
Turkey Bend	5.7	14.2						
Hurst Cove	5.8	12.7						
Arkansas Bend	6.6	14.2						
Mansfield Dam	3.7	10.5						

#### Figure 7. Impacts of future urbanization with HLWO on summer surface chlorophyll-a concentrations.

Percent changes from base case values calculated by pairing yearly results and then computing averages and maximums of daily model predictions over the 23-year simulation.

Surface summertime chl-a concentrations for the base case (calibration) run are shown in the bottom right corner.



#### Figure 8. Impacts of upstream loading on summer surface chlorophyll-a concentrations.

Percent changes from base case values calculated by pairing yearly results and then computing averages and maximums of daily model predictions over the 23-year simulation.

Surface summertime chl-a concentrations for the base case (calibration) run are shown in the bottom right corner.



#### Figure 9. Combined impacts on summer surface chlorophyll-a concentrations.

Percent changes from base case values calculated by pairing yearly results and then computing averages and maximums of daily model predictions over the 23-year simulation.

Surface summertime chl-a concentrations for the base case (calibration) run are shown in the bottom right corner.





of daily model predictions over the 23-year simulation.

Surface summertime chl-a concentrations for the base case (calibration) run are shown in the bottom right corner.

Surface was considered to be the top two meters of the water column. Summertime was assumed to be June through September. Tertiary treatment assumptions: 5/5/1/1 (CBOD/TSS/NH3/TP) & 10 mg/L NOx

Advanced treatment assumptions: 5/5/2/0.15 (CBOD/TSS/NH3/TP) & 4 mg/L NOx



#### Figure 11. Average daily mean summertime chlorophyll-a concentrations predicted in surface waters under different future scenarios for Lake Travis.

Surface = top 2 meters of water column; summertime = June through September

The model predicts daily average values for the 23-year calibration period. The values shown are the means of the yearly average predictions.

The solid bars indicate the model prediction using the calibration run (best estimate) and the hatched bars show the bounding estimate that reflects the uncertainty of the most sensitive model parameters. See the Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009) for details on the bounding calibration.

![](_page_23_Figure_0.jpeg)

#### Figure 12. Average daily maximum summertime chlorophyll-a concentrations predicted in surface waters under different future scenarios for Lake Travis.

Surface = top 2 meters of water column; summertime = June through September

The model predicts daily average values for the 23-year calibration period. The values shown are the means of the maximum daily average predictions.

The solid bars indicate the model prediction using the calibration run (best estimate) and the hatched bars show the bounding estimate that reflects the uncertainty of the most sensitive model parameters. See the Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009) for details on the bounding calibration.

### APPENDIX A ASSUMPTIONS REGARDING URBANIZATION

![](_page_24_Picture_1.jpeg)

#### CREMs Phase 2 Watershed Urbanization Assumptions March 25, 2008 Prepared by LCRA

Guiding Principle – Future urbanization condition in approximately 20 years.

#### **Upper Model**

#### Hwy 290/Pedernales River

Subwatersheds that include U.S. Highway 290 and the Pedernales River can anticipate more rapid urbanization rates than subwatersheds without major highways and the Pedernales River.

• Assume 4% of subwatershed becomes urbanized.

#### <u>Rural areas</u>

• Assume 1% of subwatershed becomes urbanized.

#### Urbanizing/Fredericksburg

For subwatersheds shown as urbanizing under present conditions (near Fredericksburg), we will assume that 15% of the total watershed will become urbanized in approximately 20 years.

• Assume 15% of subwatershed becomes urbanized.

#### Lower Model

#### <u>Rural areas</u>

• Assume 1% of subwatershed becomes urbanized.

#### Pedernales River

Anticipate more urbanization along the river as it nears Austin.

• Assume 3% of subwatershed becomes urbanized.

#### Upper Lake Travis

As we see today, more concentrated urbanization along the lake. Even though this area is more distant from Austin, the Marble Falls area is growing rapidly and will influence development patterns along the upper lake.

• Assume 5% of subwatershed becomes urbanized.

#### Urbanized areas

Areas that are near the lake, but somewhat distant from Austin and the Bee Cave/Lakeway area are anticipated to have less urbanization than land closer to the cities.

• Assume 15% of subwatershed becomes urbanized.

#### Heavily urbanized areas

Areas closer to Austin and along the Highway 71 corridor and have access to treated surface water will experience urbanization similar to what is found in the Bee Cave/Lakeway area today.

• Assume 20% of subwatershed becomes urbanized.

#### Super urbanized areas

Areas that include Lakeway, Bee Cave, Jonestown, Cedar Park, Leander, and Lago Vista are experiencing rapid growth. With urbanization in several watersheds already exceeding 20%, this category is necessary to illustrate subwatersheds with very high levels of urbanization.

• Assume 30% of subwatershed becomes urbanized.

#### LCRA Highland Lakes Watershed Ordinance Permitting

To put some context on actual development levels in the Lake Travis watershed, a review of the ordinance data base was performed to determine area permitted and developed since the ordinance inception in 1990. Over a 17-year period, approximately 77 square miles of land was converted to some form of urbanization via the development process. This results in almost 2,900 acres of land per year changing from woodlands and meadows to subdivisions, commercial centers, and office space.

The watershed ordinance jurisdiction includes a portion of Burnet and Llano County, so some of the ordinance jurisdiction is outside the Phase 2 CREMs watershed models area, however, the LCRA permit data base does not include the rapidly growing communities of Lakeway, Cedar Park, and Lago Vista that administer their own ordinance. Thus, the observed growth in these three cities is most likely equal to or greater than the amount of development in Burnet and Llano Counties over this time period. Therefore, an urbanization rate of approximately 2,900 acres per year for the Lake Travis watershed in Travis County is anticipated to compare closely to the urbanization rate in the lower model. The lower model spreadsheet computed an average urbanization rate of 2,482 acres per year (Table A-1).

Considering this rate of urbanization in the upper model which can be expected to experience less rapid urbanization due to the distance from Austin, the upper model area is computed to urbanize at a rate of 738 acres per year (Table A-2).

	Subwatershed		Existing	Existing	Future	Future
Subwatershed	Development	Total Area	Urban Area	%	%	Urban Area
	Туре	(acres)	(acres)	Urban/Sub	Urban/Sub	(acres)
1	Urbanized	20,269	1,202	5.9%	15.0%	3,040
2	Urbanized	6,551	33	0.5%	15.0%	983
3	Urbanized	3,319	14	0.4%	15.0%	498
4	Urbanized	11,321	-	0.0%	15.0%	1,698
5	Urbanized	3,873	-	0.0%	15.0%	581
6	Urbanized	4,395	2	0.0%	15.0%	659
7	Rural	6,460	-	0.0%	1.0%	65
8	Urbanized	310	-	0.0%	15.0%	47
9	Rural	4,460	-	0.0%	1.0%	45
10	Rural	2,703	-	0.0%	1.0%	27
11	Urbanized	4,301	-	0.0%	15.0%	645
12	Rural	291	-	0.0%	1.0%	3
13	Upper Lake Travis	2,505	-	0.0%	5.0%	125
14	Upper Lake Travis	7,415	50	0.7%	5.0%	371
15	Urbanized	19,061	66	0.3%	15.0%	2,859
16	Upper Lake Travis	1,303	-	0.0%	5.0%	65
17	Upper Lake Travis	1,471	-	0.0%	5.0%	74
18	Upper Lake Travis	2,950	-	0.0%	5.0%	148
19	Heavily Urbanized	129	-	0.0%	20.0%	26
20	Super Urbanized	6.314	67	1.1%	30.0%	1.894
21	Super Urbanized	4,541	9	0.2%	30.0%	1,362
22	Urbanized	93	-	0.0%	15.0%	 14
23	Urbanized	1,143	-	0.0%	15.0%	171
24	Rural	6.087	-	0.0%	1.0%	61
25	Irhanized	6.391	54	0.8%	15.0%	959
26	Unner Lake Travis	1,140	17	1.5%	5.0%	57
27	Unner Lake Travis	496	-	0.0%	5.0%	25
28	Urhanized	11.044	71	0.6%	15.0%	1.657
29	Urbanized	1.520	-	0.0%	15.0%	228
30	IIrhanized	5.385	26	0.5%	15.0%	808
31	Super Urbanized	4.950	827	16.7%	30.0%	1.485
32	Super Urbanized	4,749	21	0.4%	30.0%	1.425
- 33	Unner Lake Travis	6.291		0.0%	5.0%	315
34	Heavily I Irbanized	2 883	40	1 4%	20.0%	577
35	Super Urbanized	8 045	418	5.2%	30.0%	2 413
36	Super Urbanized	4 434	45	1.0%	30.0%	1 330
37	Upper Upbanized	-,0 - 3 540	84	2.4%	5.0%	177
38	Opper Lane Trans	2,040 8 962	131	1 5%	30.0%	2 689
30	Super Urbanized	1 65/	267	16.1%	30.0%	2,000
40	Super Urbanized	7 523	207	3 3%	30.0%	2 257
40	Urbanizod	10.067	2 <del>4</del> 5 50	0.5%	15.0%	1 510
42	Ulballizeu Padarnalas Rivor	6 5 7 9	50	0.0%	3.0%	107
42		0,079	ے 660	0.0%	3.0 <sup>7</sup> /0	137
40		J,∠JU 2,2JU	002	20.4%	30.0%	912
44	Super Urbanizeu	3,220	000	24.9%	30.0%	303
40	Heavily Urbanized	9/0	20	2.0%	20.0%	195
40	Super Urbanizeo	4,390	0∠	1.4%	30.0%	1,3/9

Table A-1. Urbanization assumed for scenarios for lower model.

D:\PARcrm\Documents\memos\Lake\_Travis\_Ph2\_scenarios\final\app\ CREMS Travis\_Watershed\_UrbanBreakdown 032508 (2), 021609.xls 3/12/2009 10:53 AM

	Subwatershed		Existing	Existing	Future	Future
Subwatershed	Development	Total Area	Urban Area	%	%	Urban Area
	Туре	(acres)	(acres)	Urban/Sub	Urban/Sub	(acres)
47	Heavily Urbanized	18,263	3,014	16.5%	20.0%	3,653
48	Heavily Urbanized	3,182	24	0.8%	20.0%	636
49	Heavily Urbanized	33	-	0.0%	20.0%	7
50	Super Urbanized	2,961	187	6.3%	30.0%	888
51	Pedernales River	6,740	-	0.0%	3.0%	202
52	Pedernales River	7	-	0.0%	3.0%	0
53	Pedernales River	5,643	-	0.0%	3.0%	169
54	Pedernales River	7,388	-	0.0%	3.0%	222
55	Pedernales River	5,526	-	0.0%	3.0%	166
56	Rural	5,312	-	0.0%	1.0%	53
57	Urbanized	9,319	44	0.5%	15.0%	1,398
58	Pedernales River	1,078	-	0.0%	3.0%	32
59	Pedernales River	18,126	-	0.0%	3.0%	544
60	Rural	4,199	-	0.0%	1.0%	42
61	Pedernales River	4,631	29	0.6%	3.0%	139
62	Urbanized	9,829	623	6.3%	15.0%	1,474
63	Pedernales River	5,464	-	0.0%	3.0%	164
64	Pedernales River	651	-	0.0%	3.0%	20
65	Pedernales River	2,286	-	0.0%	3.0%	69
66	Pedernales River	4,908	-	0.0%	3.0%	147
67	Rural	55,940	234	0.4%	1.0%	559
68	Rural	19,513	68	0.3%	1.0%	195
69	Rural	45,543	99	0.2%	1.0%	455
70	Super Urbanized	2,675	486	18.2%	30.0%	802
71	Super Urbanized	8,486	71	0.8%	30.0%	2,546
72	Super Urbanized	3,627	117	3.2%	30.0%	1,088
73	Rural	27,325	-	0.0%	1.0%	273
74	Super Urbanized	3,090	181	5.9%	30.0%	927
75	Urbanized	21,770	60	0.3%	15.0%	3,266
76	Urbanized	8,113	2	0.0%	15.0%	1,217
Total		520,319	9,331	1.8%	11.3%	58,932

Notes:

Assuming 20-year period for urbanization

2480 acres urbanized per year

	Subwatershed		Existing	Existing	Future	Future
Subwatershed	Development	Total Area	Urban Area	%	%	Urban Area
	Туре	(acres)	(acres)	Urban/Sub	Urban/Sub	(acres)
1	Rural	57,177	82	0.1%	1.0%	572
2	Rural	16,868	-	0.0%	1.0%	169
3	290/Pedernales	35,602	123	0.3%	4.0%	1,424
4	290/Pedernales	12,074	27	0.2%	4.0%	483
5	290/Pedernales	9,286	15	0.2%	4.0%	371
6	Rural	31,232	146	0.5%	1.0%	312
7	Rural	32,111	96	0.3%	1.0%	321
8	290/Pedernales	7,821	32	0.4%	4.0%	313
9	Rural	18,111	42	0.2%	1.0%	181
10	Urbanized	22,185	2,526	11.4%	15.0%	3,328
11	290/Pedernales	35,056	219	0.6%	4.0%	1,402
12	Rural	26,527	3	0.0%	1.0%	265
13	290/Pedernales	9,323	51	0.6%	4.0%	373
14	Urbanized	29,608	517	1.7%	15.0%	4,441
15	290/Pedernales	6,524	48	0.7%	4.0%	261
16	Urbanized	13,354	180	1.3%	15.0%	2,003
17	290/Pedernales	11,472	44	0.4%	4.0%	459
18	290/Pedernales	27,198	99	0.4%	4.0%	1,088
19	Rural	50,834	132	0.3%	1.0%	508
20	Rural	7,261	46	0.6%	1.0%	73
21	Rural	3,505	13	0.4%	1.0%	35
22	Rural	5,147	27	0.5%	1.0%	51
23	Rural	19,457	26	0.1%	1.0%	195
24	Rural	19,486	11	0.1%	1.0%	195
25	Rural	23,546	71	0.3%	1.0%	235
26	Rural	20,860	-	0.0%	1.0%	209
27	Rural	24,872	177	0.7%	1.0%	249
Total		576,497	4,753	0.8%	3.4%	19,516

Table A-2. Urbanization assumed for scenarios for upper model.

Notes:

Assuming 20-year period for urbanization

738 acres urbanized per year

### APPENDIX B SCENARIO RESULTS BY YEAR

![](_page_30_Picture_1.jpeg)

# Average of Predicted Daily Mean Chlorophyll-*a* Concentrations

- Near Max Starcke Dam (segment 6)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_31_Figure_5.jpeg)

		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
				2MGD		Urbaniza-	Urbaniza-					
				Point		tion 20	tion 20					
			10MGD	Source		Years	Years					
			Point	into		into	into				#2 + #5 +	
	Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
	Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 + 	(Wet	Base
Year	(in)	Sources	wthr)	Lаке	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#1	wthr)	Case
1984	27.6					not er	hough inforr	nation				
1985	31.6	6.2	6.2	8.2	8.2	6.2	6.2	6.8	6.2	6.9	6.9	6.2
1900	39.1	0.2	0.2	0.2	0.2	0.2	0.2	0.9 5.1	0.2	0.9 5 1	0.9 5 1	0.2
1088	22.3	4.0 5.6	4.0 5.6	4.5	5.6	5.6	4.0 5.6	6.2	5.6	6.2	6.2	4.0 5.6
1989	26.0	4.4	4.4	4.5	4.5	4.4	4.4	4.9	4 4	4.9	4.9	44
1990	31.6	11.0	11.0	12.7	12.7	10.9	11.0	12.1	11.0	12.1	12.1	11.0
1991	42.4	8.7	8.7	10.8	10.8	8.8	8.8	9.6	8.8	9.6	9.7	8.7
1992	40.9	6.3	6.3	6.3	6.3	6.3	6.3	6.9	6.3	6.9	6.9	6.3
1993	27.5	9.3	9.2	11.9	12.0	9.3	9.2	10.2	9.3	10.2	10.2	9.2
1994	34.7	8.7	8.7	8.7	8.7	8.7	8.6	9.6	8.6	9.5	9.5	8.7
1995	30.3	5.3	5.2	10.9	10.8	5.2	5.3	5.8	5.3	5.9	5.9	5.2
1996	27.4					not er	hough inform	nation			0.1	
1997	44.3	7.5	/.4	9.6	9.5	/.4	/.4	8.1	7.5	8.2	8.1	/.4
1998	37.6	11.4	11.4	16.2	16.0	14.6	14.5	12.0	14.7	12.8	12.8	11.4
2000	20.0	14.4	14.4	10.3	10.2	14.0 not er	14.5	15.9 nation	14.7	10.1	10.1	14.4
2000	38.0	6.0	61	69	69	62	6 1	66	62	6.8	6.8	6.1
2002	38.2	11.5	11.5	13.3	13.3	11.5	11.5	12.6	11.6	12.7	12 7	11.5
2003	25.6	11.3	11.3	12.2	12.2	11.4	11.3	12.5	11.4	12.6	12.6	11.3
2004	45.8	11.1	11.1	13.9	13.9	11.0	11.0	12.2	11.0	12.2	12.2	11.1
2005	23.2	5.6	5.6	7.1	7.1	5.6	5.6	6.2	5.6	6.2	6.2	5.6
2006	25.0					not er	hough inforr	nation				
	<b>∆vera</b> de	82	82	97	97	82	82	9.0	82	9.0	9.0	82
	Arciuge	0.2	0.2	0.7	0	0.2	0.2	0.0	0.2	0.0	0.0	0.2
	Average	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	0.2
	Average	#1	#2	#3 2MGD	#4	#5 Urbaniza-	#6 Urbaniza-	#7	#8	#9	#10	0.2
	Arenage	#1	#2	#3 2MGD Point	#4	#5 Urbaniza- tion 20	#6 Urbaniza- tion 20	#7	#8	#9	#10	
	Aronugo	#1	#2 10MGD	#3 2MGD Point Source	#4	#5 Urbaniza- tion 20 Years	#6 Urbaniza- tion 20 Years	#7	#8	#9	#10	0.2
	Atonigo	#1	#2 10MGD Point	#3 2MGD Point Source into	#4	#5 Urbaniza- tion 20 Years into	#6 Urbaniza- tion 20 Years into	#7	#8	#9	#10 #2 + #5 +	
	Total	#1	#2 10MGD Point Sources	#3 2MGD Point Source into Upstream	#4	#5 Urbaniza- tion 20 Years into Future	#6 Urbaniza- tion 20 Years into Future	#7	#8	#9	#10 #2 + #5 + #7	0.2
	Total Rainfall	#1 10MGD Point	#2 10MGD Point Sources (Wet	#3 2MGD Point Source into Upstream Part of	#4	#5 Urbaniza- tion 20 Years into Future without	#6 Urbaniza- tion 20 Years into Future with	#7 Increased Upstream	#8	#9 #1 + #5 +	#10 #2 + #5 + #7 (Wet	
Year	Total Rainfall (in)	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake	#4 #1 + #3	#5 Urbaniza- tion 20 Years into Future without HLWO	#6 Urbaniza- tion 20 Years into Future with HLWO	#7 Increased Upstream Loading	#8 #1 + #5	#9 #1 + #5 + #7	#10 #2 + #5 + #7 (Wet Wthr)	0.2
<u>Year</u> 1984	Total Rainfall (in) 27.6	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake	#4 #1 + #3	#5 Urbaniza- tion 20 Years into Future without HLWO not enough	#6 Urbaniza- tion 20 Years into Future with HLWO information	#7 Increased Upstream Loading	#8 #1 + #5	#9 #1 + #5 + #7	#10 #2 + #5 + #7 (Wet Wthr)	
<b>Year</b> 1984 1985	Total Rainfall (in) 27.6 31.6	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake	#4 #1 + #3 33	#5 Urbaniza- tion 20 Years into Future without HLWO not enough	#6 Urbaniza- tion 20 Years into Future with HLWO information 0	#7 Increased Upstream Loading	#8 #1 + #5	#9 #1 + #5 + #7	#10 #2 + #5 + #7 (Wet Wthr)	
Year 1984 1985 1986	Total Rainfall (in) 27.6 31.6 39.1	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake 33 32	#4 #1 + #3 33 32	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1	#7 Increased Upstream Loading	#8 #1 + #5	#9 #1+#5+ #7	#10 #2 + #5 + #7 (Wet Wthr)	
Year 1984 1985 1986 1987 1988	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.2	10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr) 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 33 32 6	#4 #1 + #3 33 32 6	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0 1	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1 0	#7 Increased Upstream Loading	#8 #1 + #5 1 0 1	#9 #1+#5+ #7	#10 #2 + #5 + #7 (Wet Wthr) 11 11 12 11	
Year 1984 1985 1986 1987 1988 1989	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26 0	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 33 32 6 0 2	#4 #1 + #3 33 32 6 0 3	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0 1 1	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1 0 0	#7 Increased Upstream Loading	#8 #1 + #5 1 0 1 1 0	#9 #9 #1 + #5 + #7 11 11 12 11	#10 #2 + #5 + #7 (Wet Wthr) 11 11 12 11	
Year 1984 1985 1986 1987 1988 1989 1990	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6	10MGD Point Sources 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	33 32 WGD Point Source into Upstream Part of Lake 33 32 6 0 2 2	#4 #4 33 32 6 0 3 16	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0 1 1 0 -1	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 0 -1 0 0 0 0	#7 Increased Upstream Loading 11 11 11 11 10 10	#8 #8 1 0 1 1 0 0	#9 #1 + #5 + #7 11 12 11 11 10	11 11 12 11 11 12 11 10 10	
Year 1984 1985 1986 1987 1988 1989 1990 1991	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4	10MGD Point Sources 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 33 32 6 0 2 15 24	#4 #4 #1 + #3 33 32 6 0 3 16 0 3 12	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0 1 1 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1 0 0 0 0 0 0	#7 Increased Upstream Loading 11 11 11 11 10 10 10	#8 #8 1 1 1 1 0 1 1 1 0 0 1	#9 #1 + #5 + #7 11 12 11 11 11 10 10	#10 #12 + #5 + #7 (Wet Wthr) 11 11 12 11 10 10	
Year 1984 1985 1986 1987 1988 1989 1990 1991 1992	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9	#1 10MGD Point Sources 0 0 0 0 0 -1 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 33 32 6 0 2 15 24 1	#4 #4 333 32 6 0 3 3 16 24 0	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0 1 1 0 -1 1 1	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1 0 0 0 0 0 0	#7 Increased Upstream Loading 11 11 11 10 10 10	#8 #8 1 0 1 1 0 0 0 1 0	#9 #1 + #5 + #7 11 11 12 11 11 11 10 10	#10 #2 + #5 + #7 (Wet Wthr) 11 11 12 11 10 10 10	
Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 33 32 6 0 2 15 24 1 29	#4 #4 33 33 32 6 0 3 3 16 24 0 30	#5 Urbaniza- tion 20 Years into Future without HLWO 1 0 1 1 0 -1 1 1 1 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1 0 0 0 0 0 0 0 0 0 0 0 0	#7 Increased Upstream Loading 11 11 11 10 10 10 10	#1 + #5 #1 - #5 1	#9 #1 + #5 + #7 11 11 12 11 11 10 10 10 11	#10 #2 + #5 + #7 (Wet Wthr) 11 11 12 11 10 10 10 10	
Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 33 32 6 0 2 15 24 1 1 29 0	#4 #4 33 32 6 0 3 3 16 24 0 30 0 0	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0 1 1 0 1 1 0 0 1 1 0 0 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1 0 -1 0 0 0 0 0 0 0 0 0 0 0	#7 Increased Upstream Loading 11 11 11 11 10 10 10 10 10 10 10	#1 + #5 #1 - #5 1 0 1 1 0 0 0 1 0 0 1 0 0 -1	#9 #1 + #5 + #7 11 11 12 11 11 10 10 10 10 11 10	#10 #2 + #5 + #7 (Wet Wthr) 11 11 12 11 10 10 10 10 10	
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Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 0 20.0	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3           2MGD           Point           Source           into           Upstream           Part of           Lake           33           32           6           0           2           15           24           1           29           0           108           29           3           13	#4 #4 33 32 6 0 3 3 16 24 0 3 0 0 107 29 3 13	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 1 0 -1 1 1 0 -1 1 1 0 0 -1 1 1 0 0 -1 1 1 0 0 -1 1 1 0 0 0 -1 1 0 0 0 -1 1 0 0 0 -1 0 0 0 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 0 -1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	#7 Increased Upstream Loading 11 11 11 10 10 10 10 10 10 10 10 10 10	#8 #8 1 0 1 1 0 0 1 1 0 0 0 1 0 0 1 0 0 1 2 2	#9 #1 + #5 + #7 11 11 11 12 11 11 10 10 10 11 10 13 10 12 12 12	#10 #2 + #5 + #7 (Wet wthr) 11 11 12 11 10 10 10 10 10 12 12 12	
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	Year 1984 1985 1986 1987 1988 1999 1990 1991 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006	Total Rainfall           Year         (in)           1984         27.6           1985         31.6           1986         39.1           1987         36.7           1988         22.3           1989         26.0           1990         31.6           1991         42.4           1992         40.9           1993         27.5           1994         34.7           1995         30.3           1996         27.4           1997         44.3           1998         37.6           1999         20.0           2000         33.9           2001         38.0           2002         38.2           2003         25.6           2004         45.8           2005         23.2           2006         25.0	#1           Year         Total Rainfall         10MGD Point           1984         27.6           1985         31.6         6.2           1986         39.1         6.2           1987         36.7         4.6           1989         26.0         4.4           1990         31.6         11.0           1991         42.4         8.7           1992         40.9         6.3           1993         27.5         9.3           1994         34.7         8.7           1995         30.3         5.3           1996         27.4         -           1997         44.3         7.5           1998         37.6         11.4           1999         20.0         14.4           2000         38.9         -           2001         38.0         6.0           2002         38.2         11.5           2004         45.8         11.1           2005         23.2         5.6	#1         #2           Total Rainfall         10MGD Point           Year         10MGD           1984         27.6           1985         31.6           1986         39.1           1987         36.7           1988         22.3           1989         26.0           1989         26.0           1989         31.6           1989         36.7           1989         36.7           1989         36.6           1989         26.0           1989         36.6           1990         31.6           11.0         11.0           1991         42.4           8.7         8.7           1995         30.3           1993         27.5           1994         34.7           8.7         5.2           1995         30.3           5.3         5.2           1996         27.4           1997         44.3           7.5         7.4           1998         37.6           11.4         11.4           1199         20.0           2	#1         #2         #3           Image: Product of the state of th	#1         #2         #3         #4           Image: Figure	#1         #2         #3         #4         #5           Image: Product Stress of Stress Str	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$

 Average
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 20
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 \\Emily\D\_Drive\PARcm\Documents\memos\Lake\_Travis\_Ph2\_scenarios\appendix\yearly\_results\AppendixByearly\_re

# Maximum of Predicted Daily Mean Chlorophyll-*a* Concentrations

- Near Max Starcke Dam (segment 6)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_32_Figure_5.jpeg)

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
-					Point		tion 20	tion 20					
Î				10MGD	Source		Years	Years					
7				Point	into		into	into				#2 + #5 +	
Ϋ́		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
Ξ		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	Base
	Voar	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
<u>.0</u>	1984	27.6		- /			not er	ough inform	nation			- /	Ouse
at	1985	31.6	17.5	17.5	24.5	24.3	21.0	18.4	18.5	21.0	21.9	21.9	17.5
Ľ.	1986	39.1	16.1	16.1	24.5	24.6	16.8	16.4	16.4	16.9	17.2	17.2	16.1
Ē	1987	36.7	87	87	89	9.0	10.5	9.3	9.3	10.5	10.6	10.9	87
e G	1988	22.3	19.9	19.8	19.8	19.8	24.8	21.4	20.4	24.9	25.6	25.5	19.8
é	1989	26.0	9.8	9.8	10.5	10.4	10.2	9.9	10.1	10.2	10.6	10.6	9.8
2	1990	31.6	17.7	17.7	26.8	26.8	17.7	17.7	19.4	17.7	19.4	19.4	17.7
õ	1991	42.4	36.3	36.2	36.2	36.3	37.1	36.5	37.0	37.2	38.1	38.0	36.2
~	1992	40.9	10.1	10.2	10.6	10.5	10.9	10.3	11.8	10.8	11.9	11.9	10.2
ų V	1993	27.5	54.2	54.1	54.1	54.2	55.7	54.6	55.4	55.9	57.3	57.2	54.1
	1994	34.7	19.4	19.4	20.5	20.5	19.4	19.3	21.4	19.5	21.5	21.5	19.3
ō	1995	30.3	12.2	12.2	29.5	29.5	12.2	12.1	13.6	12.2	13.6	13.6	12.1
Ē	1996	27.4					not er	nough inforr	nation				
Ē	1997	44.3	26.8	26.4	26.5	27.1	29.8	27.4	27.1	29.9	30.2	30.3	26.3
2	1998	37.6	35.6	35.1	35.2	35.6	55.4	41.4	36.5	56.5	58.1	57.3	35.2
	1999	20.0	25.9	25.7	25.8	25.3	37.8	30.0	27.0	38.2	39.5	39.2	25.7
X	2000	33.9					not er	nough inforr	nation				
<u>a</u>	2001	38.0	63.7	62.9	63.1	64.1	78.8	67.8	63.7	80.0	81.3	80.4	62.9
2	2002	38.2	22.9	22.7	22.7	22.9	23.7	22.8	23.7	23.7	24.8	24.7	22.7
	2003	25.6	38.7	38.6	38.7	38.8	45.3	40.7	40.0	45.6	47.0	46.9	38.6
	2004	45.8	15.2	15.2	20.9	21.0	15.2	15.2	16.8	15.2	16.8	16.8	15.2
	2005	23.2	10.2	10.2	18.1	18.1	10.3	10.2	11.5 notion	10.1	11.4	11.4	10.3
	2006	25.0	24.2	24.1	07.0	07.0			25.2	00.0	20.2	20.2	24.1
		Average	24.5	24.1	21.2	27.5	20.0	20.0	23.2	20.2	29.0	23.2	24.1
										r	1		
			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	1
			#1	#2	#3 2MGD	#4	#5 Urbaniza-	#6 Urbaniza-	#7	#8	#9	#10	
			#1	#2	#3 2MGD Point	#4	#5 Urbaniza- tion 20	#6 Urbaniza- tion 20	#7	#8	#9	#10	
			#1	#2	#3 2MGD Point Source	#4	#5 Urbaniza- tion 20 Years	#6 Urbaniza- tion 20 Years	#7	#8	#9	#10	
			#1	#2 10MGD Point	#3 2MGD Point Source into	#4	#5 Urbaniza- tion 20 Years into	#6 Urbaniza- tion 20 Years into	#7	#8	#9	#10 #2 + #5 +	
(9		Total	#1	#2 10MGD Point Sources	#3 2MGD Point Source into Upstream	#4	#5 Urbaniza- tion 20 Years into Future	#6 Urbaniza- tion 20 Years into Future	#7	#8	#9	#10 #2 + #5 + #7	
(%)		Total Rainfall	#1 10MGD Point	#2 10MGD Point Sources (Wet	#3 2MGD Point Source into Upstream Part of	#4	#5 Urbaniza- tion 20 Years into Future without	#6 Urbaniza- tion 20 Years into Future with	#7 Increased Upstream	#8	#9 #1 + #5 +	#10 #2 + #5 + #7 (Wet	
(%)	Year	Total Rainfall (in)	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake	#4 #1 + #3	#5 Urbaniza- tion 20 Years into Future without HLWO	#6 Urbaniza- tion 20 Years into Future with HLWO	#7 Increased Upstream Loading	#8 #1 + #5	#9 #1 + #5 + #7	#10 #2 + #5 + #7 (Wet Wthr)	
se (%)	<b>Year</b> 1984	Total Rainfall (in) 27.6	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake	#4 #1 + #3	#5 Urbaniza- tion 20 Years into Future without HLWO not enough	#6 Urbaniza- tion 20 Years into Future with HLWO information	#7 Increased Upstream Loading	#8 #1 + #5	#9 #1 + #5 + #7	#10 #2 + #5 + #7 (Wet Wthr)	
ase (%)	<b>Year</b> 1984 1985	Total Rainfall (in) 27.6 31.6	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake 40	#4 #1 + #3 39	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 5	#7 Increased Upstream Loading	#8 #1 + #5 20	#9 #1 + #5 + #7 25	#10 #2 + #5 + #7 (Wet Wthr) 25	
Case (%)	Year 1984 1985 1986	Total Rainfall (in) 27.6 31.6 39.1	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr) 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52	#4 #1 + #3 39 53	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 5 2	#7 Increased Upstream Loading	#8 #1 + #5 20 5	#9 #1 + #5 + #7 25 7	#10 #2 + #5 + #7 (Wet Wthr) 25 6	
e Case (%)	Year 1984 1985 1986 1987	Total Rainfall (in) 27.6 31.6 39.1 36.7	#1 10MGD Point Sources 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2	#4 #1 + #3 39 53 3	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6	#7 Increased Upstream Loading	#8 #1 + #5 20 5 20	#9 #1 + #5 + #7 25 7 21	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25	
se Case (%)	Year 1984 1985 1986 1987 1988 1989	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 20.0	#1 10MGD Point Sources 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7	#4 #1 + #3 39 53 3 0	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8	#7 Increased Upstream Loading	#8 #1 + #5 20 5 20 26	#9 #1 + #5 + #7 25 7 21 29	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29	
ase Case (%)	Year 1984 1985 1986 1987 1988 1989 1989	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 21.0	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 7	#4 #1 + #3 39 53 3 0 6 6	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1	#7 Increased Upstream Loading	#8 #1 + #5 20 5 20 26 5 0	#9 #1 + #5 + #7 25 7 21 29 8	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8	
Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1901	<b>Total</b> <b>Rainfall</b> (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 31.6 42.4	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 7	#4 #1 + #3 39 53 3 0 6 51 0 6	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 25	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0	#7 Increased Upstream Loading 6 3 3 10	#8 #1 + #5 20 26 5 0 26 5 0	#9 #1 + #5 + #7 25 7 21 29 8 10 5	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10	
n Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1990 1991	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 42.4	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4	#4 #1 + #3 39 53 3 0 6 51 0 2	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 25 5 0 2 2 5 0 2 2 7	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0 1	#7 Increased Upstream Loading	#8 #1 + #5 20 5 20 26 5 0 3 3	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17	
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from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 24.7	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 4 0 6	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 0 6 51 0 3 6 6	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 25 5 0 2 2 7 3 1	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 5 2 6 8 1 0 1 1 1 1 0	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11	#8 #1 + #5 20 26 5 0 3 6 3 1	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 11	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11	
e from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995	Total Rainfall (in) 27.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 4 0 6 149	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 3 0 6 149	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 5 20 25 5 0 25 5 0 2 25 5 0 2 25 5 0 2 2 5 0 2 2 1 0 2 1 0 0 2 1 1 0 0 2 1 0 0 2 1 0 1 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0 1 1 1 1 0 0	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12	#8 #1 + #5 20 26 5 0 26 5 0 3 6 3 1 0	<b>#9</b> <b>#1 + #5 +</b> <b>#7</b> 25 7 21 29 8 10 5 17 6 11	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12	
ge from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 7 51 0 4 0 6 143	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 0 6 4 143	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 25 5 0 25 7 3 1 0 0 0 0	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0 1 1 1 1 0 0 1 1 0 0 1 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12	#8 #1 + #5 20 26 5 20 26 5 0 3 6 3 1 0	<b>#9</b> <b>#1 + #5 +</b> <b>#7</b> <b>25</b> 7 21 29 8 10 5 17 6 11 12	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12	
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nange from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 4 0 6 143 0 1 0	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 0 6 51 0 3 1	#5 Urbaniza- tion 20 Years into Future without HLWO 5 20 25 5 20 25 5 0 25 5 0 22 7 3 3 1 0 0 not enough 13 57	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 5 2 6 8 1 0 1 1 1 1 1 0 0 1 1 1 1 1 0 0 0 1 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12	#8 #1 + #5 20 5 20 26 5 0 3 6 3 1 0 0	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 11 12 15 65	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12 15 63	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 7 51 0 4 0 4 0 6 143 1 0 0 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 1 0 0 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 0 6 51 0 3 3 0 6 51 0 3 3 0 53 3 2 2	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 20 25 5 0 0 25 3 1 0 0 13 5 7 47	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0 1 1 1 1 0 0 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1 1 0 0 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12 3 4 5	#8 #1 + #5 20 5 20 26 5 0 3 6 3 1 0 14 61 48	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 11 12 15 65 54	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12 15 63 52	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000	Total Rainfall (in) 27.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 511 0 4 0 4 0 6 143 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 0 6 143 3 1 1 -2	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 22 7 3 0 25 5 0 0 25 5 0 0 25 7 3 1 0 0 13 57 47 not enough	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0 1 1 1 0 0 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1 0 0 1 1 1 1 1 0 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12 12 3 4 5	#8 #1 + #5 20 26 5 20 26 5 0 3 6 3 1 0 0 14 61 48	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 11 12 15 65 54	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 29 8 10 5 17 6 11 12 15 63 52	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 7 51 0 4 0 6 143 1 0 0 0 1 3 1 0 0 0 1 3 1 0 0 1 1 0 0 0 1 1 0 0 0 1 1 0 0 0 1 1 0 0 0 1 1 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	#4 #1 + #3 39 53 3 0 6 51 3 0 6 51 0 3 0 6 143 0 6 143 3 1 -2 2	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 25 5 0 25 7 3 1 0 0 25 7 3 1 0 0 7 3 1 0 0 7 3 1 0 0 7 7 3 1 0 0 7 7 3 1 0 0 7 7 3 1 0 0 7 7 3 1 1 0 7 7 3 1 1 0 7 7 7 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0 1 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12 3 4 5	#8 #1 + #5 20 26 5 20 26 5 0 3 6 3 1 0 0 14 61 48 27	<b>#9</b> <b>#1 + #5 +</b> <b>#7</b> 25 7 21 29 8 10 5 17 6 11 12 15 65 54 29	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12 15 63 52 28	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.2	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 6 143 1 0 0 6 143 0 0 0 0 0 0 0 0 0 0 0 0 0	#4 #1 + #3 39 53 3 0 6 51 0 6 51 0 6 51 0 6 143 3 1 1 -2 2 1	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 25 5 0 20 25 5 0 25 5 0 20 25 5 0 25 5 0 20 25 5 0 25 5 0 20 25 5 0 25 5 0 20 25 5 0 25 5 0 20 25 5 5 0 25 5 5 0 25 5 5 0 25 5 0 25 5 5 0 25 5 5 0 25 5 5 0 25 5 5 0 25 5 5 0 25 5 5 0 25 5 5 5	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 0 1 1 1 1 1 0 0 0 information 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 11 12 12 3 4 5	#8 #1 + #5 20 5 20 26 5 0 3 6 3 1 0 0 14 61 48 27 5	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 11 12 15 65 54 29 9	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 29 8 10 5 11 12 15 63 52 28 9	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.0 38.2 25.6	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 4 0 6 143 0 6 143 0 0 0 0 0 0 0 0 0 0 0 0 0	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 0 6 51 0 3 1 1 -2 2 1 0	#5 Urbaniza- tion 20 Years into Future without HLWO 5 20 25 5 0 20 25 5 0 20 25 5 0 20 25 5 0 0 25 7 3 1 0 0 not enough 13 57 47 not enough 25 5 17	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 5 2 6 8 1 0 1 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12 3 4 5	#8 #1 + #5 20 5 20 26 5 0 3 6 3 1 0 14 61 48 27 5 18	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 5 17 6 5 11 12 15 65 54 29 9 22	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 3 10 5 17 6 11 12 15 63 52 28 9 22	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004	<b>Total</b> <b>Rainfall</b> (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.2 25.6 45.8	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 4 0 4 0 6 143 1 0 0 1 0 0 1 3 7	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 3 0 6 51 0 3 3 1 -2 2 1 0 3 8	#5           Urbaniza- tion 20           Years into           Future           without           HLWO           not enough           20           5           20           5           20           5           0           2           7           3           1           0           not enough           13           57           47           not enough           25           5           17           0	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 5 2 6 8 1 0 1 1 1 0 1 1 0 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1 0 0 1	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12 3 4 5	#8 #1 + #5 20 5 20 26 5 0 3 6 3 1 0 0 3 6 3 1 0 0 14 61 48 27 5 18 0	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 11 12 15 65 54 29 9 9 22 10	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12 15 63 52 28 9 22 10	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.2 25.6 45.8 23.2	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 4 0 6 143 1 0 0 143 1 0 0 143 1 0 0 143 1 0 0 1 37 77	#4 #1 + #3 39 53 3 0 6 51 0 3 3 0 6 51 0 3 3 0 6 51 0 3 3 1 1 -2 2 1 0 3 8 5 76	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 20 25 5 0 22 7 3 0 25 5 0 2 2 7 3 1 0 0 25 5 5 0 2 2 7 7 3 1 0 0 25 5 5 0 2 2 7 7 3 1 0 0 25 5 5 0 2 2 7 7 3 1 0 0 2 5 5 0 2 2 7 7 3 1 1 0 0 2 5 5 0 2 2 7 7 3 1 1 0 2 5 5 0 2 2 7 7 3 1 1 0 2 5 5 0 2 2 7 7 3 1 1 0 2 5 5 5 0 2 0 2 5 5 0 2 2 7 7 7 7 1 1 9 1 1 9 1 1 9 1 1 1 9 1 1 1 1	#6 Urbaniza- tion 20 Years into Future with HLWO information 5 2 6 8 1 2 6 8 1 1 0 1 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1	#7 Increased Upstream Loading 6 2 6 3 10 2 15 2 11 12 15 2 11 12 15 2 11 12 15 2 11 12 12	#8 #1 + #5 20 5 20 26 5 0 3 6 3 1 0 0 14 61 48 27 5 18 0 0 -1	#9 #1 + #5 + #7 25 7 21 29 8 10 5 17 6 11 12 15 65 54 29 9 22 10 11	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12 15 63 52 17 6 28 9 22 10 11	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.2 25.6 45.8 23.2 25.0	#1 10MGD Point Sources 0 0 0 0 0 0 0 0 0 0 0 0 0	#2 10MGD Point Sources (Wet Wthr) 0 0 0 0 0 0 0 0 0 0 0 0 0	#3 2MGD Point Source into Upstream Part of Lake 40 52 2 0 7 51 0 4 0 7 51 0 4 0 0 6 143 1 0 0 0 0 0 0 0 0 0 0 0 0 0	#4 #1 + #3 39 53 3 0 6 51 0 3 0 6 51 0 3 3 0 6 143 3 1 -2 2 1 0 38 76	#5 Urbaniza- tion 20 Years into Future without HLWO not enough 20 5 5 20 25 5 0 2 25 5 0 2 2 7 3 1 0 0 1 3 5 7 47 not enough 13 57 47 not enough 13 57 47 10 0 13 57 10 10 10 10 10 10 10 10 10 10 10 10 10	#6 Urbaniza- tion 20 Years into Future with HLWO informatior 5 2 6 8 1 0 1 1 1 1 0 0 0 informatior 4 18 17 informatior 8 17 informatior 8 17 informatior 0 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 informatior 0 information information info information info information info information info information info info info information info info info info info info info i	#7 Increased Upstream Loading 6 2 6 3 3 10 2 15 2 11 12 15 2 11 12 15 2 11 12 15 2 11 12 12	#8 #1 + #5 20 26 5 20 26 5 0 3 6 3 1 0 0 14 61 48 27 5 18 0 -1	<b>#9</b> <b>#1 + #5 +</b> <b>#7</b> 25 7 21 29 8 10 5 17 6 11 12 15 65 54 29 9 22 10 11	#10 #2 + #5 + #7 (Wet Wthr) 25 6 25 29 8 10 5 17 6 11 12 15 63 52 17 6 3 52 28 9 22 10 11	

\\Emily\D\_Drive\PARcm\Documents\memos\Lake\_Travis\_Ph2\_scenarios\appendix\yearly\_results\AppendixB\_yearlychla\_090312.ppt 3/12/09 Page 2 of 10

# Average of Predicted Daily Mean Chlorophyll-*a* Concentrations

- Turkey Bend (segment 28)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_33_Figure_5.jpeg)

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
$\widehat{}$				10MGD	Source		Years	Years					
1/				Point	into		into	into				#2 + #5 +	
Ŝ		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
1		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	Base
L D	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
<u>.</u>	1984	27.6	8.4	7.7	9.1	9.4	7.7	7.7	8.5	8.4	9.2	8.5	7.7
at	1985	31.6	9.0	8.2	10.3	11.0	8.1	7.9	8.4	9.0	9.3	8.5	8.0
L.	1986	39.1	5.0	4.4	5.6	6.1	4.4	4.3	4.6	5.1	5.4	4.8	4.3
<u>L</u>	1987	36.7	7.0	6.8	7.5	7.6	6.9	6.9	7.3	7.1	7.6	7.5	6.7
0	1988	22.3	8.7	8.6	10.0	10.0	8.7	8.6	9.4	8.7	9.5	9.4	8.7
2	1989	26.0	8.8	7.9	9.6	10.6	7.9	7.9	8.0	9.1	9.5	8.4	7.8
	1990	31.6	6.0	5.7	7.0	7.2	5.7	5.7	6.3	6.0	6.6	6.4	5.7
й I	1991	42.4	4.7	4.0	5.4	5.9	4.2	4.0	4.3	4.9	5.1	4.5	4.0
U	1992	40.9	11.2	11.2	11.8	11.8	11.2	11.2	12.2	11.3	12.3	12.3	11.2
מ	1993	27.5	3.7	3.4	4.0	4.4	3.5	3.4	3.4	3.9	4.0	3.7	3.3
÷ I	1994	34.7	13.2	13.1	14.2	14.2	13.1	13.1	14.2	13.3	14.3	14.2	13.1
ち	1995	30.3	4.7	4.2	5.0	5.5	4.1	4.2	4.5	4.8	5.1	4.7	4.2
0	1996	27.4	2.9	2.6	3.4	3.6	2.7	2.6	2.8	3.0	3.2	3.0	2.6
<u>e</u>	1997	44.3	6.5	6.5	7.0	7.2	6.4	6.3	6.8	6.5	6.9	6.9	6.4
g	1998	37.6	4.8	4.4	5.6	6.1	4.2	4.2	4.6	4.7	5.0	4.7	4.3
Lo Lo	1999	20.0	5.5	5.4	7.1	7.0	5.5	5.4	5.9	5.6	6.1	6.0	5.4
ē	2000	33.9	7.6	6.0	8.9	9.7	6.0	6.0	6.5	7.7	8.3	6.7	5.8
2	2001	38.0	3.4	3.0	4.5	4.8	3.0	2.9	3.2	3.4	3.6	3.3	2.9
٩.	2002	38.2	5.8	5.6	6.5	6.6	5.6	5.5	6.0	5.8	6.4	6.1	5.5
	2003	25.6	3.6	3.4	4.7	4.8	3.6	3.5	3.7	3.7	4.0	3.9	3.4
	2004	45.8	5.0	4.9	5.8	6.0	4.9	4.8	5.3	5.1	5.5	5.4	4.8
	2005	23.2	2.1	2.0	3.9	4.0	2.1	1.9	2.1	2.3	2.5	2.3	1.9
	2006	25.0	6.0	3.9	7.8	8.9	3.8	3.9	4.2	6.1	0.4	4.4	3.9
		Average	6.2	5.8	7.2	7.5	5.8	5.7	6.2	6.3	6.8	6.3	5./

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
					2MGD		Urbaniza-	Urbaniza-				
					Point		tion 20	tion 20				
				10MGD	Source		Years	Years				
				Point	into		into	into				#2 + #5 +
		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7
~		Bainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet
<u> </u>	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)
ő	1984	27.6	9	0	18	21	0	0	10	9	20	10
ő	1985	31.6	12	2	28	37	0	-1	5	12	16	6
Ú	1986	39.1	16	3	30	42	2	0	8	18	26	12
<u>а</u>	1987	36.7	4	1	11	14	3	3	8	6	14	11
8 S	1988	22.3	0	0	16	15	0	0	9	1	10	9
ສິ	1989	26.0	13	1	23	36	2	1	3	17	22	8
n	1990	31.6	5	1	22	26	1	0	11	6	16	12
<b>ر</b>	1991	42.4	17	1	36	48	4	1	7	21	29	13
S	1992	40.9	1	0	5	6	0	0	9	1	10	10
2	1993	27.5	14	3	23	35	6	3	4	19	23	12
+	1994	34.7	1	0	8	8	0	0	8	1	9	8
<u>e</u>	1995	30.3	12	1	20	31	-2	1	8	14	23	12
2°	1996	27.4	12	0	30	39	4	1	9	14	25	15
Ъ	1997	44.3	3	2	10	13	0	-1	7	2	9	8
č	1998	37.6	12	4	31	42	-2	-2	8	10	18	9
$\mathbf{C}$	1999	20.0	2	0	31	29	3	0	9	5	12	11
-	2000	33.9	29	2	53	67	2	3	12	32	42	14
	2001	38.0	17	3	52	63	2	0	8	17	23	12
	2002	38.2	5	2	19	20	2	1	9	6	16	12
	2003	25.6	3	0	37	39	4	1	8	7	15	13
	2004	45.8	3	1	20	24	2	0	10	5	14	12
	2005	23.2	14	4	106	111	10	3	10	24	34	23
	2006	25.0	54	-2	98	128	-3	-1	8	55	63	11
		Average	11	1	32	39	2	0	8	13	21	11

# Maximum of Predicted Daily Mean Chlorophyll-*a* Concentrations

- Turkey Bend (segment 28)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_34_Figure_5.jpeg)

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
$\widehat{}$					Point		tion 20	tion 20					
7				10MGD	Source		Years	Years					
Ð				Point	into		into	into				#2 + #5 +	
<u>–</u>		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
~		Bainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	Base
ð	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
<b>t</b> i	1984	27.6	12.2	12.0	12.9	13.4	11.9	12.0	13.1	12.2	13.6	13.1	12.0
LC LC	1985	31.6	27.0	26.2	28.5	28.6	26.1	25.9	26.8	26.5	27.1	26.8	26.2
J	1986	39.1	11.6	10.9	13.0	13.2	10.9	10.8	11.3	11.6	12.3	11.7	10.8
ē	1987	36.7	20.1	20.0	20.0	20.2	21.4	21.4	20.5	21.4	21.9	21.8	20.0
Ö	1988	22.3	20.2	20.3	21.1	21.0	20.2	20.2	21.5	20.1	21.3	21.3	20.3
	1989	26.0	19.7	18.4	20.0	21.6	18.0	19.3	18.4	20.5	20.6	18.0	19.5
S I	1990	31.6	13.9	13.7	14.1	14.4	13.8	13.6	14.7	14.0	15.0	14.9	13.6
0	1991	42.4	8.9	8.8	11.1	11.9	8.9	8.9	9.6	9.3	9.7	9.7	8.8
b	1992	40.9	28.2	28.2	28.4	28.5	28.1	28.1	30.5	28.2	30.4	30.7	28.1
<u> </u>	1993	27.5	8.8	8.3	8.8	9.4	8.9	8.8	8.3	9.3	9.5	9.1	8.1
는	1994	34.7	35.6	35.2	36.0	36.4	34.6	34.9	37.7	35.2	37.8	37.3	35.1
0	1995	30.3	7.9	7.8	8.2	8.3	8.0	7.8	8.6	8.1	8.9	8.8	7.8
F	1996	27.4	7.6	7.2	8.0	8.2	7.4	7.2	8.0	7.8	8.6	8.2	7.3
	1997	44.3	14.8	14.8	16.6	16.6	15.0	14.8	16.4	15.1	16.7	16.7	14.7
ũ	1998	37.6	8.4	7.4	10.5	12.2	7.3	7.1	7.6	9.1	9.8	8.2	6.9
. <u> </u>	1999	20.0	8.3	7.7	11.2	11.0	8.6	7.9	8.3	8.7	8.9	8.8	7.7
X	2000	33.9	14.4	12.4	15.3	15.7	12.4	12.9	13.8	14.2	15.8	13.7	12.5
19	2001	38.0	9.0	8.7	11.2	11.6	8.3	8.4	9.1	8.7	9.1	9.0	8.6
2	2002	38.2	20.6	20.2	20.2	20.6	20.5	20.7	20.6	21.0	21.5	21.2	20.1
	2003	25.6	12.9	13.0	15.1	15.0	13.2	13.1	14.5	13.0	14.2	14.3	13.1
	2004	45.8	10.1	10.0	11.8	11.7	10.3	10.1	11.0	10.6	11.5	11.3	10.0
	2005	23.2	3.8	3.4	9.2	9.3	4.0	3.4	3.7	4.0	4.4	4.6	3.4
	2006	25.0	14.7	12.1	17.3	19.5	12.0	12.5	13.3	14.7	16.5	13.7	11.7
		Average	14.7	14.2	16.0	16.4	14.3	14.3	15.1	14.9	15.9	15.3	14.2

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
					2MGD		Urbaniza-	Urbaniza-				
					Point		tion 20	tion 20				
				10MGD	Source		Years	Years				
				Point	into		into	into				#2 + #5 +
		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7
%		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet
j j	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)
e e	1984	27.6	2	0	7	11	-1	0	9	1	13	9
ğ	1985	31.6	3	0	9	9	-1	-1	2	1	3	2
Ö	1986	39.1	7	1	20	22	1	0	5	8	14	8
	1987	36.7	1	0	0	1	7	7	2	7	10	9
Se Se	1988	22.3	-1	0	4	3	-1	-1	6	-1	5	5
ä	1989	26.0	1	-6	3	11	-8	-1	-6	5	6	-8
Ώ	1990	31.6	2	1	4	6	1	0	8	3	10	10
_	1991	42.4	1	0	26	35	1	1	8	5	10	9
Ľ	1992	40.9	0	0	1	1	0	0	8	0	8	9
2	1993	27.5	8	2	8	16	9	8	2	15	17	12
Ē	1994	34.7	2	0	3	4	-1	-1	7	0	8	7
e	1995	30.3	1	1	6	7	2	0	11	3	14	13
Ő	1996	27.4	4	-1	10	13	1	-1	10	7	18	13
ЯГ	1997	44.3	1	1	12	13	2	1	11	2	13	14
9	1998	37.6	21	6	51	76	5	3	9	31	42	18
5	1999	20.0	8	0	46	43	12	3	7	14	16	14
0	2000	33.9	15	-1	22	26	-1	3	11	14	26	9
	2001	38.0	5	2	30	36	-3	-2	6	1	7	5
	2002	38.2	2	0	0	2	2	3	3	4	7	5
	2003	25.6	-2	-1	15	14	1	0	11	-1	8	9
	2004	45.8	1	0	18	17	3	1	10	6	15	13
	2005	23.2	13	0	175	178	18	1	9	20	31	38
	2006	25.0	26	3	48	67	3	7	14	26	42	17
		Average	5	0	23	27	2	1	7	8	15	10

\\Emily\D\_Drive\PARcm\Documents\memos\Lake\_Travis\_Ph2\_scenarios\appendix\yearly\_results\AppendixB\_yearlychla\_090312.ppt 3/12/09 Page 4 of 10

### Average of Predicted Daily Mean Chlorophyll-a Concentrations

- Hurst Creek (segment 140)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_35_Figure_5.jpeg)

#### Compared to Base Case

- Increase ≥ 50%
- Increase ≥ 10% and <50%
- □ Increase < 10%
- □ No Change
- Decrease < 10%
- Decrease  $\geq$  10% and < 50%

													r
			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
				10MGD	Source		Years	Years					
				Point	into		into	into				#2 + #5 +	
			10MCD	Sourcos	Unotroom		Euturo	Euturo	Inoropod			#2 + #3 +	
-		Iotai	Deint	Jources (Wet	Dort of		i uture	i uture	linetreem		#1 . #5 .	#1 ()Mot	_
ð		Rainfall	Point	(wet	Partor		without	with	Opstream		#1+#3+	(wet	Base
ц	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
$\sim$	1984	27.6	7.8	4.2	4.4	8.4	4.3	4.1	4.4	8.0	8.1	4.5	4.2
<u> </u>	1985	31.6	15.4	14.2	12.7	15.6	12.1	12.1	12.7	15.2	15.3	14.3	12.2
<u>.o</u>	1986	39.1	10.3	10.0	10.3	10.5	9.8	9.8	10.0	10.2	10.2	10.1	9.8
at	1987	36.7	8.5	8.1	6.8	8.7	6.7	6.8	6.9	8.4	8.6	8.3	6.6
2	1988	22.3	13.6	8.8	87	13.9	7.8	7.8	81	13.5	13.6	92	77
Ę	1989	26.0	9.5	94	93	9.6	9.0	9.0	9.0	93	9.5	9.5	9.0
Ō	1990	31.6	12.0	92	89	12.2	84	84	8.8	11.9	12.0	9.5	84
Q	1991	42.4	7 1	4.0	3.2	7.3	33	3.2	3.3	7.2	7.3	4.3	3.2
Ē	1002	40.9	9.6	9.2	8.1	0.8	7.7	77	8.4	9.6	0.8	9.6	7.8
N N	1002	40.5	3.0	3.2	2.0	7.0	2.0	2.0	2.0	9.0	7.0	3.0 4.5	2.7
0	1993	27.5	10.0	4.2	10.0	12.4	3.9	10.4	10.9	10.0	12.1	4.5	3.7 10 F
б	1994	34.7	7.0	6.0	10.8	7.4	10.3	10.4	6.7	7.1	7.0	6.0	10.5
<u> </u>	1995	30.3	1.2	0.0	0.9	7.4	0.2	0.5	0.7	7.1	1.2	0.9	0.5
~ ~	1996	27.4	4.5	2.1	2.4	4.9	2.3	2.1	2.1	4.6	4.7	2.5	2.0
0	1997	44.3	10.1	8.2	5.8	10.2	5.6	5.6	5.9	10.0	10.2	8.4	5.6
Ð	1998	37.6	8.8	5.4	4.8	8.9	4.8	4.7	4.8	8.7	8.9	5.8	4.7
Ō	1999	20.0	11.1	7.8	4.5	10.9	4.7	4.7	4.8	11.0	11.0	7.6	4.8
ъ,	2000	33.9	6.2	2.3	2.5	6.3	2.6	2.3	2.3	6.1	6.1	2.5	2.4
0	2001	38.0	11.5	5.2	4.6	11.7	4.4	4.1	4.3	11.5	11.6	5.8	4.0
5	2002	38.2	7.9	6.1	5.9	7.9	5.9	5.9	5.9	7.8	7.9	6.2	5.8
<	2003	25.6	10.4	6.3	5.1	10.8	4.8	4.7	4.8	10.4	10.5	6.6	4.7
	2004	45.8	9.9	8.4	5.9	10.4	5.5	5.4	5.6	9.9	10.1	8.7	5.4
	2005	23.2	7.6	2.3	1.2	8.0	1.2	1.1	1.1	7.5	7.7	2.4	1.1
	2006	25.0	10.9	4.8	5.0	11.3	4.3	4.2	4.3	10.8	10.9	4.9	4.3
		<b>Average</b>	9.0	69	6.2	0.0	59	5.8	60	95	97	71	58
		Average	0.0	0.5	0.2	9.0	0.0	5.0	0.0	0.0	3.7	7.1	5.0
		- Arciugo	44	40	40	9.0		5.0 #C	0.0	#0	<i></i>	#10	5.0
		Arciuge	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	5.0
		Avenage	#1	#2	#3 2MGD	#4	#5 Urbaniza-	#6 Urbaniza-	#7	#8	#9	#10	0.0
		Avenuge	#1	#2	#3 2MGD Point	#4	#5 Urbaniza- tion 20	#6 Urbaniza- tion 20	#7	#8	#9	#10	0.0
		Aronago	#1	#2 10MGD	#3 2MGD Point Source	#4	#5 Urbaniza- tion 20 Years	#6 Urbaniza- tion 20 Years	#7	#8	#9	#10	0.0
			#1	#2 10MGD Point	#3 2MGD Point Source into	#4	#5 Urbaniza- tion 20 Years into	#6 Urbaniza- tion 20 Years into	#7	#8	#9	#10 #2 + #5 +	0.0
		Total	#1 10MGD	#2 10MGD Point Sources	#3 2MGD Point Source into Upstream	#4	#5 Urbaniza- tion 20 Years into Future	#6 Urbaniza- tion 20 Years into Future	#7	#8	#9	#10 #2 + #5 + #7	0.0
(%)		Total Rainfall	#1 10MGD Point	#2 10MGD Point Sources (Wet	#3 2MGD Point Source into Upstream Part of	#4	#5 Urbaniza- tion 20 Years into Future without	#6 Urbaniza- tion 20 Years into Future with	#7 Increased Upstream	#8	#9 #1 + #5 +	#10 #2 + #5 + #7 (Wet	0.0
(%)	Year	Total Rainfall (in)	#1 10MGD Point Sources	#2 10MGD Point Sources (Wet Wthr)	#3 2MGD Point Source into Upstream Part of Lake	#4 #1 + #3	#5 Urbaniza- tion 20 Years into Future without HLWO	#6 Urbaniza- tion 20 Years into Future with HLWO	#7 Increased Upstream Loading	#8	#9 #1 + #5 + #7	#10 #2 + #5 + #7 (Wet Wthr)	0.0
(%) e	<b>Year</b> 1984	Total Rainfall (in) 27.6	#1 10MGD Point Sources 88	#2 10MGD Point Sources (Wet Wthr) 0	#3 2MGD Point Source into Upstream Part of Lake 5	#4 #1 + #3 101	#5 Urbaniza- tion 20 Years into Future without HLWO 3	#6 Urbaniza- tion 20 Years into Future with HLWO	#7 Increased Upstream Loading 5	#8 #1 + #5 93	#9 #1 + #5 + #7 96	#10 #2 + #5 + #7 (Wet Wthr) 8	0.0
se (%)	<b>Year</b> 1984 1985	Total Rainfall (in) 27.6 31.6	#1 10MGD Point Sources 88 26	#2 10MGD Point Sources (Wet Wthr) 0 17	#3 2MGD Point Source into Upstream Part of Lake 5 4	#4 #1 + #3 101 28	#5 Urbaniza- tion 20 Years into Future without HLWO 3 0	#6 Urbaniza- tion 20 Years into Future with HLWO -1 -1	#7 Increased Upstream Loading 5 4	#8 #1 + #5 93 25	#9 #1 + #5 + #7 96 25	#10 #2 + #5 + #7 (Wet Wthr) 8 18	0.0
ase (%)	<b>Year</b> 1984 1985 1986	Total Rainfall (in) 27.6 31.6 39.1	#1 10MGD Point Sources 88 26 5	#2 10MGD Point Sources (Wet Wthr) 0 17 1	#3 2MGD Point Source into Upstream Part of Lake 5 4 4	#4 #1 + #3 101 28 6	#5 Urbaniza- tion 20 Years into Future without HLWO 3 0 -1	#6 Urbaniza- tion 20 Years into Future with HLWO -1 -1 0	#7 Increased Upstream Loading 5 4 2	#8 #1 + #5 93 25 3	#9 #1 + #5 + #7 96 25 4	#10 #2 + #5 + #7 (Wet Wthr) 8 18 2	0.0
Case (%)	Year 1984 1985 1986 1987	Total Rainfall (in) 27.6 31.6 39.1 36.7	#1 10MGD Point Sources 88 26 5 5 29	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23	#3 2MGD Point Source into Upstream Part of Lake 5 4 4 3	#4 #1 + #3 101 28 6 31	#5 Urbaniza- tion 20 Years into Future without HLWO 3 0 -1 2	#6 Urbaniza- tion 20 Years into Future with HLWO -1 -1 -1 0 2	#7 Increased Upstream Loading 5 4 2 4	#8 #1 + #5 93 25 3 27	#9 #1 + #5 + #7 96 25 4 30	#10 #2 + #5 + #7 (Wet Wthr) 8 18 2 2 26	0.0
e Case (%)	Year 1984 1985 1986 1987 1988	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3	#1 10MGD Point Sources 88 26 5 29 76	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23 15	#3 2MGD Point Source into Upstream Part of Lake 5 4 4 3 3 12	#4 #4 #1 + #3 101 28 6 31 81	#5 Urbaniza- tion 20 Years into Future without HLWO 3 0 -1 2 2	#6 Urbaniza- tion 20 Years into Future with HLWO -1 -1 -1 0 2 1	#7 Increased Upstream Loading 5 4 2 4 5	#8 #8 93 25 3 25 3 27 75	#9 #1 + #5 + #7 96 25 4 30 77	#10 #2 + #5 + #7 (Wet Wthr) 8 18 2 26 19	0.0
se Case (%)	Year 1984 1985 1986 1987 1988 1989	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0	#1 10MGD Point Sources 88 26 5 29 76 6	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23 15 4	#3 2MGD Point Source into Upstream Part of Lake 5 4 4 3 12 4	#4 #4 #1 + #3 101 28 6 31 81 7	#5 Urbaniza- tion 20 Years into Future without HLWO 0 -1 2 2 0	#6 Urbaniza- tion 20 Years into Future with HLWO -1 -1 -1 0 2 1 0	#7 Increased Upstream Loading 5 4 2 4 5 5 0	#8 #8 93 25 3 27 75 3	#9 #1 + #5 + #7 96 25 4 30 77 6	#10 #2 + #5 + #7 (Wet Wthr) 8 18 2 26 19 6	
ase Case (%)	Year 1984 1985 1986 1987 1988 1989 1990	Total Rainfall (in) 27.6 39.1 36.7 22.3 26.0 31.6	#1 10MGD Point Sources 88 26 5 29 76 6 6 43	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23 15 4 10	#3 2MGD Point Source into Upstream Part of Lake 5 4 4 3 12 4 6	#1 + #3 #1 + #3 101 28 6 31 81 7 46	#5 Urbaniza- tion 20 Years into Future without HLWO 0 -1 2 2 0 0	#6 Urbaniza- tion 20 Years into Future with HLWO -1 -1 -1 0 2 1 0 0	#7 Increased Upstream Loading 5 4 2 4 5 0 5	#8 #8 #1 + #5 93 25 3 27 75 3 42	#9 #1 + #5 + #7 96 25 4 30 77 6 44	#10 #2 + #5 + #7 (Wet Wthr) 8 18 2 26 19 6 14	
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Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.2 25.6 45.2	#1 10MGD Point Sources 88 26 5 29 76 6 43 124 24 112 27 11 128 80 89 132 153 189 35 122 27	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23 15 4 10 27 18 14 8 4 4 10 27 18 14 8 4 4 4 4 4 4 4 4 4 4 4 5 5 27 18 14 8 4 4 4 5 5 27 18 14 8 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5	#3           2MGD           Point           Source           into           Upstream           Part of           Lake           5           4           3           12           4           6           1           4           3           21           3           -5           3           -5           16           1           10	#1 + #3 #1 + #3 101 28 6 31 81 7 46 129 26 111 28 13 145 83 92 128 13 145 83 92 128 159 195 35 131	#5 Urbaniza- tion 20 Years into Future without HLWO 3 0 -1 2 2 0 0 -1 2 2 0 0 -1 2 2 0 0 0 6 0 0 4 -2 -5 15 1 4 4 -2 7 11 1 3 0 0	#6           Urbaniza- tion 20           Years           into           Future           with           HLWO           -1           -1           0           2           1           0           0           0           0           0           0           0           0           0           1           0           0           1           -6           3           1           -6           3           1           0	#7 Increased Upstream Loading 5 4 2 4 5 0 5 4 9 4 3 3 8 5 4 0 0 -4 8 8 3 3 3 0 0 -4 8 8 3 3 3 0 0 0 -4 8 8 3 3 0 0 0 -4 8 8 3 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	#8 #8 93 25 3 27 75 3 27 75 3 27 75 3 27 75 3 27 23 114 25 9 134 25 9 134 79 86 129 134 79 86 129 134 79 34 122 91	#9 #1 + #5 + #7 96 25 4 30 77 6 4 30 77 6 4 30 77 6 11 126 111 26 111 26 111 26 111 139 83 90 131 151 193 93 6 24 90 24 90	#10 #10 #2 + #5 + #7 (Wet Wthr) 8 18 2 26 19 6 14 35 24 20 8 7 25 51 24 20 8 7 25 51 24 20 8 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 51 24 20 8 7 7 25 20 8 7 7 25 20 8 7 7 25 20 8 7 7 20 8 7 7 20 8 7 7 25 20 8 7 7 20 8 7 7 20 8 7 7 20 8 7 7 7 20 8 7 7 20 8 7 7 20 8 7 7 7 20 8 7 7 7 20 8 7 7 20 8 8 7 7 7 25 8 20 8 7 7 7 25 8 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.0 38.2 25.6 45.8 20.0	#1 10MGD Point Sources 88 26 5 29 76 6 43 124 24 24 24 24 24 21 27 11 128 80 89 132 153 189 35 122 85 5 5 5 27 122 85 5 5 5 28 5 5 29 29 29 20 20 20 20 20 20 20 20 20 20	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23 15 4 10 27 18 14 8 4 4 10 27 18 14 8 4 4 4 4 4 4 4 4 4 4 4 4 5 5 5 5 5 5 5 5 5 5 5 5 5	#3           2MGD           Point           Source           into           Upstream           Part of           Lake           5           4           3           12           4           3           5           21           3           -5           3           -5           3           16           1           10           10           10	#1 + #3 #1 + #3 101 28 6 31 81 7 46 129 26 131 28 13 145 83 92 128 159 159 155 35 131 93 95	#5           Urbaniza- tion 20           Years           into           Future           without           HLWO           3           0           -1           2           0           -1           2           0           -1           2           0           6           0           6           0           6           0           4           -2           7           11           3           2           7           11           3           2	#6           Urbaniza- tion 20           Years           into           Future           with           HLWO           -1           0           2           1           0           2           1           0           0           0           0           0           0           0           0           0           1           -6           3           1           0	#7  Increased Upstream Loading 5 4 2 4 5 0 5 4 9 4 3 3 8 5 4 0 -4 8 3 3 3 3 3 3 4 5 5 4 5 5 4 5 5 5 5 5 5 5	#8 #8 93 25 3 25 3 27 75 3 42 127 23 42 127 23 114 25 9 134 25 9 134 25 9 134 25 9 134 25 9 3 42 127 23 114 25 3 127 3 42 127 3 42 127 3 42 5 3 42 5 5 3 42 5 5 3 42 5 5 3 42 5 5 5 3 42 5 5 5 3 42 5 5 5 5 5 3 42 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	#9 #1 + #5 + #7 96 25 4 30 77 6 44 30 77 6 44 131 26 111 26 11 139 83 90 131 151 151 193 36 124 88	#10 #10 #2 + #5 + #7 (Wet Wthr) 8 8 8 8 2 26 19 6 14 35 24 20 8 7 25 5 11 24 20 8 7 25 5 11 24 24 20 8 7 7 25 5 11 24 24 20 8 7 7 25 5 5 11 24 24 20 8 7 7 25 5 5 11 24 24 20 8 7 7 25 5 5 11 24 24 26 11 27 27 27 27 27 27 27 27 27 27 27 27 27	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005	Total Rainfall (in) 27.6 31.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.2 25.6 45.8 23.2 25.6	#1 10MGD Point Sources 88 26 5 29 76 6 43 124 24 24 24 24 24 27 11 128 80 89 132 153 189 35 122 85 599 155	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23 15 4 10 27 18 14 8 4 4 4 4 4 4 6 16 64 -8 32 4 35 56 112 12	#3           2MGD           Point           Source           into           Upstream           Part of           Lake           5           4           3           12           4           3           5           21           3           -5           3           -5           3           16           1           10           10           10           14	#1 + #3 #1 + #3 101 28 6 31 81 7 46 129 26 111 28 13 145 83 92 128 13 145 83 92 128 159 195 35 35 131 93 637 167	#5           Urbaniza- tion 20           Years           into           Future           without           HLWO           3           0           -1           2           0           -1           2           0           -1           2           0           6           0           6           0           6           0           6           0           6           1           4           -2           7           11           3           2           7           11           3           2           7           1           3           2           7           1           3           2           7	#6           Urbaniza- tion 20           Years           into           Future           with           HLWO           -1           0           2           1           0           0           0           0           0           0           1           0           0           1           0           1           0           1           0           1           0           1           0           1           0           1           0           2           1           0           2           1           0           2	#7 Increased Upstream Loading 5 4 2 4 5 0 0 5 4 9 4 3 3 8 5 4 0 0 -4 8 3 3 3 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	#8 #8 93 25 3 27 75 3 42 127 23 42 127 23 114 25 9 9 134 79 86 129 134 79 86 129 149 191 34 122 84 551 55	#9 #1 + #5 + #7 96 25 4 30 77 6 44 131 26 44 131 26 111 26 111 26 111 26 111 139 83 90 131 151 193 36 124 88 606 152	#10 #10 #2 + #5 + #7 (Wet Wthr) 8 8 8 2 26 19 6 14 35 24 20 8 7 25 51 14 35 24 20 8 7 25 51 24 60 3 3 47 7 7 40 62 123	
Change from Base Case (%)	Year 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006	Total Rainfall (in) 27.6 39.1 36.7 22.3 26.0 31.6 42.4 40.9 27.5 34.7 30.3 27.4 44.3 37.6 20.0 33.9 38.0 38.2 25.6 45.8 23.2 25.6	#1 10MGD Point Sources 88 26 5 29 76 6 43 124 24 112 27 11 128 80 89 132 153 189 35 122 85 599 155 127 85 599 155 127 127 127 128 153 153 153 153 153 153 153 153	#2 10MGD Point Sources (Wet Wthr) 0 17 1 23 15 4 10 27 18 14 8 4 4 4 4 4 4 6 64 4 4 4 5 5 6 112 12 22 22 22	#3         2MGD         Point         Source         into         Upstream         Part of         Lake         5         4         3         12         4         3         5         21         3         5         21         3         -5         3         -5         3         16         1         10         10         14         7	#1 + #3 101 28 6 31 81 7 46 129 26 111 28 13 145 83 92 128 159 195 35 131 93 637 166 166	#5 Urbaniza- tion 20 Years into Future without HLWO 3 0 -1 2 2 0 0 -1 2 2 0 0 0 -1 2 2 0 0 0 -1 2 2 0 0 0 -1 2 2 0 0 0 -1 2 2 0 0 0 -1 2 2 0 0 0 -1 2 2 0 0 1 5 -5 -5 -5 -5 -7 -7 -7 -7 -7 -7 -7 -7 -7 -7 -7 -7 -7	#6           Urbaniza- tion 20           Years           into           Future           with           HLWO           -1           0           2           1           0	#7 Increased Upstream Loading 5 4 2 4 5 0 5 4 9 4 3 3 8 5 4 9 4 3 3 8 5 4 9 4 3 3 8 5 4 9 4 3 3 8 5 4 9 4 5 4 9 4 5 4 9 4 5 4 9 4 5 4 9 4 5 4 9 4 5 4 9 4 5 4 9 4 5 4 5 4 9 4 5 6 6 7 7 8 8 5 4 8 5 4 8 5 4 8 5 4 8 5 4 8 5 4 8 5 4 8 5 4 8 5 4 4 5 6 6 7 8 8 5 4 8 5 4 8 5 4 8 3 8 5 4 4 9 4 4 5 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 4 4 8 3 3 8 5 6 6 7 8 8 8 5 7 8 8 8 8 8 8 8 8 8 8 8 8 8	#8 #8 93 25 3 27 75 3 27 75 3 42 127 23 3 42 127 23 114 25 9 9 134 79 86 129 149 191 34 122 84 591 154	#9 #1 + #5 + #7 96 25 4 30 77 6 44 131 26 111 26 111 26 111 139 83 90 131 151 151 193 83 90 131 151 151 193 83 90 131	#10 #10 #2 + #5 + #7 (Wet Wthr) 8 8 18 2 2 6 19 6 6 14 35 24 20 8 8 7 25 51 24 20 8 8 7 25 51 24 60 3 3 47 7 7 40 62 123 15 22	

# Maximum of Predicted Daily Mean Chlorophyll-*a* Concentrations

- Hurst Creek (segment 140)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_36_Figure_5.jpeg)

#### Compared to Base Case

- Increase ≥ 50%
- □ Increase ≥ 10% and <50%
- Increase < 10%</p>
- No Change
- Decrease < 10%
- Decrease ≥ 10% and < 50%</li>
   Decrease ≥ 50%

1			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
				10MGD	Source		Years	Years					
$\widehat{}$				Point	into		into	into				#2 + #5 +	
J/[		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
2 r		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	Base
)	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
L L	1984	27.6	16.8	8.7	9.4	18.2	9.1	8.9	9.3	17.6	17.4	9.5	8.7
<u>.0</u>	1985	31.6	27.4	26.9	21.2	27.6	21.4	21.2	21.9	27.5	27.6	27.4	21.0
at	1986	39.1	23.2	25.4	27.0	23.2	26.5	26.6	26.6	23.1	23.1	25.4	26.6
tr	1987	36.7	22.5	21.9	16.9	22.7	17.4	17.3	17.7	22.0	23.5	23.0	16.5
C.	1988	22.3	32.0	15.7	15.4	33.1	13.6	13.5	13.8	32.2	32.1	16.7	13.3
e e	1989	26.0	16.6	16.7	17.0	16.7	16.6	16.2	16.4	16.7	16.6	17.1	16.1
č	1990	31.6	29.3	19.9	20.1	29.8	19.4	19.6	20.2	29.3	29.9	20.5	19.6
ō	1991	42.4	12.8	8.5	5.6	12.9	5.3	5.0	5.7	12.8	12.8	8.5	5.5
U U	1992	40.9	22.7	20.6	16.3	23.0	15.3	15.6	17.0	22.4	23.1	21.9	15.7
ъ	1993	27.5	22.9	10.1	8.9	23.2	8.7	8.6	9.0	23.1	23.4	10.3	8.6
<u> </u>	1994	34.7	30.8	25.5	22.2	31.0	20.8	21.3	22.0	30.7	30.9	25.2	21.4
<u>L</u>	1995	30.3	19.8	19.5	19.1	20.2	18.5	18.1	18.9	19.9	20.1	20.1	18.1
O	1996	27.4	11.4	5.8	6.3	12.2	6.9	6.0	5.8	12.4	12.6	7.4	5.6
L L	1997	44.3	17.5	17.4	11.4	18.5	11.1	11.0	11.5	17.1	18.1	18.2	10.9
ur l	1998	37.6	17.4	15.0	14.5	17.5	14.3	14.2	14.5	17.2	17.5	15.2	14.1
JL JL	1999	20.0	19.0	15.0	7.9	18.7	7.3	7.0	7.4	18.5	18.5	14.5	7.1
. <u> </u>	2000	33.9	14.1	4.3	4.3	14.1	4.8	4.3	4.4	14.2	13.9	4.8	4.5
X	2001	38.0	23.8	14.8	11.9	24.4	11.4	10.7	11.2	23.9	24.0	15.9	10.7
19	2002	38.2	18.4	12.4	11.4	18.5	11.5	11.6	7.0	18.2	18.3	13.1	11.3
2	2003	25.6	17.3	12.6	8.2	18.2	10.0	12.0	7.8	17.5	17.5	12.8	/.b
	2004	45.8	20.5	19.0	14.1	21.3	13.3	13.2	13.4	20.4	21.0	19.4	13.3
	2005	23.2	15.2	15.1	3.0	15.8	2.9	2.8	2.9	15.2	15.5	15.0	2.8
	2006	∠5.0	28.7	15.1	10.4	29.2	13.4	13.3	13.7	28.6	28.5	15.3	10.7
		Average	20.9	15.0	13.4	21.3	12.9	12.8	13.2	20.9	21.1	10.1	12.7

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
					2MGD		Urbaniza-	Urbaniza-				
					Point		tion 20	tion 20				
				10MGD	Source		Years	Years				
				Point	into		into	into				#2 + #5 +
		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7
%		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet
<b>.</b> )	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)
e	1984	27.6	93	0	7	108	5	2	7	102	100	10
as	1985	31.6	31	28	1	32	2	1	4	31	32	31
õ	1986	39.1	-13	-4	1	-13	0	0	0	-13	-13	-4
	1987	36.7	36	32	2	37	5	5	7	33	42	39
Se Se	1988	22.3	141	18	16	149	3	2	4	143	142	26
ä	1989	26.0	3	4	6	4	3	0	2	4	3	6
B	1990	31.6	50	2	3	52	-1	0	3	50	53	5
C	1991	42.4	133	54	2	134	-4	-9	4	132	132	55
n	1992	40.9	45	32	4	47	-3	0	9	43	47	40
2	1993	27.5	166	17	4	170	1	1	5	169	172	20
ţ	1994	34.7	44	19	3	45	-3	-1	3	43	44	18
Je	1995	30.3	9	8	6	11	2	0	4	10	11	11
ĉ	1996	27.4	103	3	12	118	23	8	4	121	125	31
a	1997	44.3	60	59	4	69	1	0	5	57	66	67
Ч Ч	1998	37.0	23	5	3	24		1	3	101	24	8
0	1999	20.0	169	F	12	164	3	-1	5	101	162	106
	2000	33.9	211	-5	-4	213	0	-5	-2	210	200	6
	2001	30.U 20 2	62	39	12	64	2	0	5	62	62	49
	2002	25.6	128	66	8	140	2	1	4	121	130	60
	2003	25.0 45.8	55	43	6	60	0	-1	2	53	58	46
	2004	23.2	446	176	6	468	4	1	3	446	458	177
	2006	25.0	114	13	18	117	-1	-1	2	113	112	14
	2000	Average	97	32	6	102	3	0	1	98	100	37

# Average of Predicted Daily Mean Chlorophyll-*a* Concentrations

- Arkansas Bend (segment 78)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_37_Figure_5.jpeg)

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
$\widehat{}$				10MGD	Source		Years	Years					
1/				Point	into		into	into				#2 + #5 +	
Ĵ		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
-)		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	Base
⊆	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
0	1984	27.6	8.7	5.5	6.2	9.3	5.7	5.5	5.6	9.2	9.3	5.7	5.5
ati	1985	31.6	17.0	14.6	14.2	17.5	13.4	13.1	13.8	16.9	17.1	14.9	13.3
Lo Lo	1986	39.1	10.9	10.2	10.5	11.3	10.0	10.0	10.1	10.9	11.0	10.4	10.0
Jt	1987	36.7	8.4	8.0	7.7	8.7	7.6	7.6	7.8	8.6	8.8	8.4	7.5
ē	1988	22.3	13.2	9.8	10.5	14.2	9.4	9.3	9.7	13.2	13.6	10.4	9.2
<u>o</u>	1989	26.0	11.0	10.1	10.1	11.3	9.8	9.8	9.8	11.2	11.2	10.3	9.8
	1990	31.6	11.2	9.0	9.3	11.8	8.7	8.7	9.1	11.3	11.7	9.5	8.7
8	1991	42.4	6.6	4.2	3.9	6.7	4.1	3.9	4.0	6.9	7.1	4.7	3.9
0	1992	40.9	10.4	9.7	9.5	10.7	9.2	9.1	9.9	10.4	10.9	10.4	9.1
g	1993	27.5	7.4	5.5	5.2	7.5	5.2	5.1	5.3	7.4	7.5	5.7	5.1
<u> </u>	1994	34.7	15.2	13.3	13.4	15.5	12.7	12.8	13.4	15.2	15.4	13.7	12.8
· ·	1995	30.3	7.9	6.9	7.1	8.2	6.4	6.8	7.0	7.8	8.0	7.2	6.7
0	1996	27.4	4.5	2.3	2.7	5.0	2.6	2.4	2.4	4.8	5.0	2.8	2.2
Ð	1997	44.3	8.7	7.8	6.7	8.9	6.6	6.5	6.8	8.7	9.0	8.1	6.5
ō	1998	37.6	8.3	6.0	5.7	8.5	5.5	5.3	5.6	8.5	8.7	6.5	5.3
ื่อ	1999	20.0	10.6	8.0	6.6	10.5	6.6	6.6	6.8	10.4	10.5	7.9	6.7
5	2000	33.9	7.0	2.8	3.2	7.4	3.4	2.9	2.9	6.9	7.0	3.1	3.1
>	2001	38.0	9.5	5.1	4.8	10.0	4.5	4.2	4.4	9.7	9.9	5.7	4.1
<	2002	38.2	7.1	5.6	5.5	7.1	5.7	5.6	5.6	7.2	7.4	6.0	5.4
	2003	25.6	8.7	6.3	5.5	9.2	5.1	5.0	5.1	8.8	8.9	6.6	4.9
	2004	45.8	7.9	6.2	6.0	8.5	5.5	5.4	5.7	7.9	8.2	6.5	5.4
	2005	23.2	4.1	1.9	1.5	4.3	1.3	1.3	1.3	4.1	4.2	2.0	1.3
	2006	25.0	11.2	4.9	5.3	11.9	4.5	4.4	4.5	11.2	11.2	5.1	4.5
		Average	9.4	7.1	7.0	9.7	6.7	6.6	6.8	9.4	9.6	7.5	6.6

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
					2MGD		Urbaniza-	Urbaniza-				
					Point		tion 20	tion 20				
				10MGD	Source		Years	Years				
				Point	into		into	into				#2 + #5 +
$\widehat{\circ}$		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7
$\hat{\circ}$		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet
0	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)
Š	1984	27.6	58	0	11	67	3	-1	2	66	68	3
ğ	1985	31.6	27	9	6	31	0	-2	3	27	28	12
O	1986	39.1	9	3	6	13	0	0	2	9	10	5
d)	1987	36.7	13	6	3	16	2	2	4	14	18	13
õ	1988	22.3	43	7	14	55	2	1	5	44	48	13
g	1989	26.0	12	3	4	15	1	0	0	14	15	5
m	1990	31.6	30	3	7	36	1	0	6	30	35	9
	1991	42.4	71	10	2	75	7	2	4	79	84	22
5	1992	40.9	13	6	4	17	0	0	8	13	20	14
2	1993	27.5	45	7	2	46	2	0	3	46	47	12
ф а	1994	34.7	19	4	5	21	0	0	5	19	21	8
<u>e</u>	1995	30.3	17	3	6	21	-5	0	4	16	19	7
ဦ	1996	27.4	105	3	23	126	17	7	7	118	125	26
a	1997	44.3	34	20	3	37	1	0	4	34	39	24
ĩ	1998	37.6	57	13	8	61	3	1	5	60	64	22
O	1999	20.0	59	20	-1	58	-1	-1	2	56	57	19
-	2000	33.9	123	-11	2	135	7	-8	-7	119	123	0
	2001	38.0	131	25	16	143	10	2	7	137	140	39
	2002	38.2	30	3	1	31	4	3	4	32	36	10
	2003	25.6	76	28	12	88	3	1	3	78	81	33
	2004	45.8	45	15	11	56	2	0	4	46	50	20
	2005	23.2	221	50	18	244	5	2	4	225	231	61
	2006	25.0	150	11	19	167	0	-1	1	150	151	14
		Average	60	10	8	68	3	0	3	62	66	17

\\Emily\D\_Drive\PARcm\Documents\memos\Lake\_Travis\_Ph2\_scenarios\appendix\yearly\_results\AppendixB\_yearlychla\_090312.ppt 3/12/09 Page 7 of 10

### Maximum of Predicted Daily Mean Chlorophyll-a Concentrations

- Arkansas Bend (segment 78)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_38_Figure_5.jpeg)

-11

-1

-20

91

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
				"-	2MGD	<i>"</i> .	Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
<u> </u>				10MCD	Source		Vooro	Vooro					
ò				Doint	into		into	into				#2 . #5 .	
Ц			101400	Courses	lingtroom		Eutore	Eutoma	Increased			#2 + #3 +	
)		Iotal	Deint	Sources	Dort of		Future	Future	Increased		#1 . #5 .	#1 ()Not	_
		Rainfall	Point		Part of	#1 . #2			Upstream	#1 . #5	#1 + #3 +	(wet	Base
.9	Year	(in)	Sources	wunr)	Lake	#1+#3	HLWO	HLWO	Loading	#1+#3	#1	wunr)	Case
at	1984	27.6	16.2	12.8	14.2	17.8	12.3	11.7	12.4	16.9	17.6	12.9	12.8
tr	1985	31.6	27.1	26.8	26.2	28.5	26.1	26.1	26.5	27.4	28.0	26.9	26.1
C	1986	39.1	26.4	24.5	26.6	28.4	23.5	23.2	23.7	26.8	26.9	25.4	23.1
Ö.	1987	36.7	16.3	16.2	16.2	16.7	16.0	16.2	16.1	16.7	17.8	16.3	16.1
	1988	22.3	26.9	18.3	20.7	30.4	17.7	17.7	17.6	26.9	27.3	18.7	17.5
2	1989	26.0	17.8	16.2	16.9	17.9	16.1	16.0	16.1	18.1	17.8	17.0	15.9
õ	1990	31.6	23.0	19.1	19.6	23.8	18.8	18.6	19.9	23.2	24.2	20.5	18.2
5	1991	42.4	12.1	7.0	6.7	12.2	6.8	6.4	6.4	12.0	12.1	7.5	6.1
ο Ο	1992	40.9	24.7	23.5	22.3	25.3	21.4	21.3	23.3	24.7	26.0	25.3	21.4
-	1993	27.5	14.4	11.0	10.7	14.7	11.1	10.4	10.6	15.0	15.2	11.7	10.4
う	1994	34.7	34.0	31.6	32.8	36.1	30.7	30.7	34.0	33.8	36.9	34.2	30.8
5	1995	30.3	16.4	14.5	15.0	17.3	14.3	14.1	14.8	16.6	17.2	15.3	14.1
8	1996	27.4	11.8	8.0	9.3	13.1	9.7	8.4	8.2	13.9	14.3	10.3	7.8
n	1997	44.3	13.1	12.1	11.1	13.3	11.0	10.9	11.2	13.2	13.5	12.6	10.9
3	1998	37.6	14.0	12.9	12.4	14.4	12.5	12.1	12.4	14.4	14.8	13.9	12.0
÷	1999	20.0	16.8	12.8	12.1	17.1	11.3	11.0	11.5	16.8	16.9	13.3	11.0
6	2000	33.9	12.9	5.6	6.9	13.0	8.1	5.8	5.7	13.2	13.6	6.4	7.1
Š	2001	38.0	17.5	13.4	12.1	18.5	11.4	10.8	11.3	17.8	18.4	14.4	10.8
~	2002	38.2	16.5	10.9	10.8	16.6	11.3	11.0	11.2	16.6	16.8	11.8	10.5
	2003	25.6	14.4	10.2	9.2	14.6	8.5	8.3	8.4	14.4	14.7	10.7	8.2
	2004	45.8	18.6	18.7	18.6	18.7	18.4	18.7	18.7	18.4	18.6	18.6	18.6
	2005	23.2	C.7	4.4	3.0	7.9	2.7	2.7	2.0	C.7	7.0	4.5	2.7
l	2006	25.0	19.5	15.1	15.2	20.0	14.7	14.0	10.0	20.0	10.2	16.0	14.2
		Average	10.0	10.1	10.0	19.4	14.5	14.2	14.7	10.7	19.2	10.0	14.2
			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
				10MGD	Source		Years	Years					
				Point	into		into	into				#2 + #5 +	
		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
8		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	
<u> </u>	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	
ЗG	1984	27.6	27	0	12	39	-4	-8	-3	32	38	1	
ő	1985	31.6	4	3	1	10	0	0	2	5	7	3	
Ö	1986	39.1	14	6	15	23	2	1	2	16	17	10	
0	1987	36.7	1	0	1	4	-1	1	0	4	11	1	
ŝ	1988	22.3	54	4	18	74	1	1	1	54	56	7	
ö	1989	26.0	12	2	6	13	1	0	1	13	12	7	
ШÓ.	1990	31.6	27	5	8	31	3	2	9	28	33	13	
~	1991	42.4	97	14	10	99	11	4	5	96	98	22	
	1992	40.9	16	10	4	19	0	0	9	15	22	18	
2	1993	27.5	39	6	3	42	6	0	2	44	46	13	
Ţ	1994	34.7	10	2	6	17	0	0	10	10	20	11	
ē	1995	30.3	17	3	6	23	1	0	5	18	22	9	
D D	1996	27.4	51	3	19	68	24	8	6	78	83	33	
аг	1997	44.3	20	12	2	22	1	1	3	22	24	16	
ų	1998	37.6	17	8	3	20	5	2	4	20	24	16	

Change

2000

\\Emily\D\_Drive\PARcm\Documents\memos\Lake\_Travis\_Ph2\_scenarios\appendix\yearly\_results\AppendixB\_yearlychla\_090312.ppt 3/12/09 Page 8 of 10

81 63

20.0

33.9

38.0

38.2

25.6

45.8

23.2

25.0

Average

-21

-3

13

-1

-1

-19

# Average of Predicted Daily Mean Chlorophyll-*a* Concentrations

- Mansfield Dam (segment 93)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_39_Figure_5.jpeg)

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
				10MGD	Source		Years	Years					
-				Point	into		into	into				#2 + #5 +	
ð		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
́д –		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	Base
Ē	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
ration	1984	27.6	4.1	2.4	2.5	4.2	2.5	2.5	2.5	4.3	4.3	2.6	2.4
Ē	1985	31.6	9.0	8.0	7.5	9.1	7.5	7.4	7.8	9.0	9.3	8.2	7.4
ntra	1986	39.1	8.9	8.2	8.2	9.1	7.9	7.9	8.0	8.9	8.9	8.3	7.9
	1987	36.7	6.1	5.3	5.2	6.3	5.1	5.1	5.2	6.1	6.4	5.7	5.0
9	1988	22.3	6.3	4.5	4.6	6.7	4.4	4.3	4.3	6.5	6.6	4.8	4.2
a Conce	1989	26.0	7.5	6.1	6.2	7.6	5.9	5.8	5.9	7.7	7.7	6.5	5.8
	1990	31.6	9.2	6.8	7.0	9.5	6.7	6.6	6.9	9.2	9.4	7.2	6.6
	1991	42.4	3.2	2.2	2.0	3.2	2.1	1.9	2.1	3.2	3.3	2.4	2.0
	1992	40.9	4.3	3.8	3.6	4.4	3.5	3.3	3.7	4.3	4.6	4.2	3.4
	1993	27.5	3.3	2.5	2.3	3.3	2.4	2.3	2.3	3.4	3.5	2.7	2.2
<u> </u>	1994	34.7	5.3	4.4	4.4	5.4	4.2	4.3	4.3	5.3	5.3	4.4	4.3
<u>_</u>	1995	30.3	6.2	5.6	5.6	6.3	5.1	5.5	5.6	6.1	6.2	5.7	5.5
0	1996	27.4	2.6	1.2	1.3	2.7	1.3	1.2	1.3	2.6	2.7	1.4	1.2
d)	1997	44.3	3.8	3.3	3.0	3.9	2.9	2.8	3.0	3.9	4.0	3.5	2.9
ŏ	1998	37.6	4.6	3.6	3.4	4.6	3.4	3.4	3.4	4.7	4.8	3.8	3.3
ຕິ	1999	20.0	3.5	2.7	2.3	3.4	2.6	2.5	2.5	3.6	3.7	2.9	2.5
	2000	33.9	3.4	1.4	1.5	3.4	1.6	1.5	1.5	3.4	3.5	1.6	1.5
×	2001	38.0	3.6	2.7	2.5	3.5	2.5	2.4	2.5	3.6	3.8	3.0	2.4
ک ک	2002	38.2	5.3	4.5	4.5	5.3	4.5	4.4	4.5	5.3	5.4	4.7	4.4
	2003	25.6	3.8	2.9	2.5	3.8	2.8	2.5	2.5	4.2	4.3	3.3	2.4
	2004	45.8	6.6	4.6	4.4	6.9	4.0	3.9	4.1	6.7	6.7	4.9	3.9
	2005	23.2	2.1	1.1	0.8	2.1	0.8	0.7	0.8	2.2	2.2	1.2	0.7
	2006	25.0	6.2	3.0	3.0	6.4	2.7	2.7	2.7	6.1	6.1	3.1	2.7
		Average	5.2	4.0	3.8	5.3	3.8	3.7	3.8	5.2	5.3	4.2	3.7

1			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
					2MGD		Urbaniza-	Urbaniza-				
					Point		tion 20	tion 20				
				10MGD	Source		Years	Years				
				Point	into		into	into				#2 + #5 +
$\bigcirc$		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7
<u>)</u>		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet
0	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)
S I	1984	27.6	68	0	5	71	5	2	3	76	79	8
om Base Ca	1985	31.6	22	8	0	22	1	0	5	21	25	11
	1986	39.1	14	4	5	15	0	0	2	13	14	6
	1987	36.7	22	7	4	25	3	2	5	23	29	15
	1988	22.3	52	9	11	62	6	3	4	56	59	16
	1989	26.0	30	6	7	32	3	1	1	33	33	12
	1990	31.6	39	4	7	44	1	0	4	39	43	9
	1991	42.4	56	10	1	58	4	-5	4	59	64	17
	1992	40.9	26	11	5	31	2	-2	10	28	37	23
2	1993	27.5	46	10	2	48	7	3	5	52	56	21
ч -	1994	34.7	24	3	1	25	-1	0	1	23	23	2
e l	1995	30.3	14	2	3	16	-6	0	2	12	14	4
2° I	1996	27.4	119	4	9	127	9	3	1	124	130	18
а	1997	44.3	32	15	3	35	2	-1	5	34	37	21
Ë	1998	37.6	38	8	2	38	4	1	3	40	44	15
U I	1999	20.0	42	10	-5	38	4	0	0	4/	48	16
-	2000	33.9	120	-6	0	124	6	-5	-2	122	127	5
	2001	38.0	52	13	6	51	/	2	8	55	62	26
	2002	38.2	21	3	2	22	2	1	3	22	24	1
	2003	25.6	59	19	4	61	17	5	3	17	80	40
	2004	45.8	67	18	10	/5	2	0	3	68	70	23
	2005	23.2	189	51	7	194	7	2	4	196	201	64
	2006	25.0	128	10	13	138	2	-1	1	125	127	14

### Maximum of Predicted Daily Mean Chlorophyll-a Concentrations

- Mansfield Dam (segment 93)
- Summertime (June thru Sept)
- Top two meters of water column

![](_page_40_Figure_5.jpeg)

#### Compared to Base Case

- Increase ≥ 50%
- Increase  $\geq$  10% and <50%
- □ Increase < 10%
- □ No Change
- Decrease < 10%
- □ Decrease  $\geq$  10% and < 50%
- Decrease ≥ 50%

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	
					2MGD		Urbaniza-	Urbaniza-					
					Point		tion 20	tion 20					
Ĺ				10MGD	Source		Years	Years					
ð				Point	into		into	into				#2 + #5 +	
ЦЩ.		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7	
$\sim$		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet	Base
E	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)	Case
Ę	1984	27.6	7.1	4.8	4.8	7.2	5.1	4.9	4.8	7.6	7.7	5.5	4.8
centra	1985	31.6	23.8	23.6	22.5	23.9	22.8	22.4	23.6	23.7	24.3	23.5	22.3
	1986	39.1	25.9	25.9	25.8	25.7	25.8	25.9	25.9	25.8	25.7	25.7	25.9
	1987	36.7	17.8	16.8	16.3	18.0	16.5	16.4	16.8	18.0	18.7	17.7	16.0
	1988	22.3	11.3	10.4	10.4	13.4	10.8	10.9	10.4	12.0	12.6	9.3	10.7
Ĕ	1989	26.0	16.8	11.4	11.8	17.0	11.1	11.0	11.4	16.8	16.9	12.0	11.0
-a Co	1990	31.6	29.6	25.1	25.9	29.7	24.3	24.0	25.1	29.5	29.5	26.1	24.1
	1991	42.4	8.3	6.7	6.1	8.3	6.0	5.6	6.7	8.3	8.4	6.7	6.1
	1992	40.9	9.6	8.4	7.8	10.1	7.4	7.1	8.4	9.5	10.2	9.1	7.4
	1993	27.5	7.8	5.4	5.0	8.0	5.4	4.9	5.4	8.7	9.0	6.4	4.8
4	1994	34.7	13.8	12.4	12.4	14.1	12.0	12.2	12.4	13.8	13.8	12.3	12.1
U О	1995	30.3	18.6	17.9	18.1	18.7	17.8	17.8	17.9	18.5	18.6	18.1	17.8
_	1996	27.4	6.5	3.1	3.0	6.8	3.4	3.1	3.1	6.5	6.6	3.6	3.0
	1997	44.3	11.0	9.1	8.8	11.6	8.4	8.2	9.1	11.1	11.6	10.0	8.3
	1998	37.6	12.8	12.6	12.4	12.8	12.4	12.3	12.6	12.8	12.8	12.6	12.3
F	1999	20.0	7.7	5.3	4.5	7.5	4.9	4.7	5.3	8.0	8.1	5.5	4.7
. <u>×</u>	2000	33.9	7.5	3.3	3.4	7.5	3.5	3.3	3.3	7.3	7.6	3.9	3.3
ื่อ	2001	38.0	9.8	8.4	7.6	9.8	7.9	7.8	8.4	10.0	10.5	9.1	7.7
Σ	2002	38.2	15.0	11.4	11.1	15.1	11.5	11.2	11.4	14.9	15.1	12.0	11.1
	2003	25.6	7.4	6.3	4.6	7.5	6.7	5.3	6.3	8.6	8.7	7.7	4.6
	2004	45.8	17.0	13.4	12.5	17.1	12.4	12.4	13.4	16.8	16.9	13.7	12.3
	2005	23.2	6.2	4.5	3.1	6.1	3.2	3.0	4.5	6.3	6.7	4.8	3.0
	2006	25.0	11.3	7.8	8.1	12.0	6.9	7.2	7.8	11.3	11.4	8.0	7.4
		Average	13.2	11.0	10.7	13.4	10.7	10.5	11.0	13.3	13.5	11.5	10.5

			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
					2MGD		Urbaniza-	Urbaniza-				
					Point		tion 20	tion 20				
				10MGD	Source		Years	Years				
				Point	into		into	into				#2 + #5 +
		Total	10MGD	Sources	Upstream		Future	Future	Increased			#7
~		Rainfall	Point	(Wet	Part of		without	with	Upstream		#1 + #5 +	(Wet
ase (	Year	(in)	Sources	Wthr)	Lake	#1 + #3	HLWO	HLWO	Loading	#1 + #5	#7	Wthr)
	1984	27.6	47	0	-2	50	7	3	0	58	59	13
	1985	31.6	7	6	1	7	2	0	6	6	9	5
Ú	1986	39.1	0	0	0	0	0	0	0	0	0	0
om Base	1987	36.7	11	5	2	13	3	3	5	13	17	11
	1988	22.3	6	-2	-3	26	1	3	-2	13	18	-13
	1989	26.0	53	4	7	55	1	1	4	54	54	9
	1990	31.6	23	4	7	23	1	0	4	22	22	8
	1991	42.4	37	10	1	37	-2	-8	10	36	38	10
	1992	40.9	30	14	6	37	0	-4	14	29	39	23
5	1993	27.5	63	11	3	67	12	2	11	81	87	33
ч- -	1994	34.7	14	2	3	16	-1	0	2	14	14	1
Ð	1995	30.3	4	1	2	5	0	0	1	4	5	2
ဦ	1996	27.4	116	5	1	127	13	3	5	118	122	20
ਸ	1997	44.3	32	10	6	39	2	-1	10	34	40	20
Ë	1998	37.6	4	2	1	4	1	0	2	4	4	2
0	1999	20.0	65	13	-3	61	5	1	13	72	73	18
-	2000	33.9	127	1	2	126	7	-1	1	122	129	17
	2001	38.0	26	8	-1	27	1	1	8	29	36	18
	2002	38.2	36	3	1	37	4	1	3	35	36	9
	2003	25.6	62	38	0	63	47	16	38	88	89	69
	2004	45.8	38	9	1	39	0	0	9	37	37	11
	2005	23.2	108	51	4	102	6	1	51	110	124	61
	2006	25.0	54	6	10	63	-6	-2	6	54	55	8
		Average	42	9	2	44	4	1	9	45	48	16

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