Appendix D

Water Quality Technical Report

Appendix D
Water Quality Technical Report

This report is a summary of the *Final Las Vegas Wash Modeling Report* dated August 2003 (Black & Veatch 2003a), the *Lake Mead Water Quality Modeling Report* (Black &Veatch 2005b), and the *Lake Mohave Modeling Report* (J.E. Edinger 2003). These reports describe the modeling efforts conducted for the Systems Conveyance and Operations Program (SCOP) to determine the effects of the SCOP to the watershed. The modeling effort encompassed the Las Vegas Wash, Lake Mead, and downstream through Lake Mohave. Impacts are discussed primarily in terms of the water-quality standards presented in Table D.0-1.

Table D.0-1 Water Quality Standards.

	Las Vegas Wash (Upper and Lower)		**Inner Las Vegas Bay**		**Lake Mead**	
Parameter[1]	**RMHQ**	**Beneficial Uses Criteria**	**RMHQ**	**Beneficial Uses Criteria**	**RMHQ**	**Beneficial Uses Criteria**
Temperature (°C)	ΔT=0[2]	—	ΔT=0[2]	ΔT=2[2]	ΔT=0[2]	ΔT=2[2]
pH (Standard Unit)	—	6.5-9.0	95% of samples ≤8.9	6.5-9.0	95% of samples ≤8.8	6.5-9.0
Dissolved oxygen (DO) (mg/L)	—	Aerobic conditions desirable	—	≥5	—	≥5[3]
Chlorophyll *a* (µg/L)	—	—	—	[4]	[4]	—
Un-ionized ammonia as N (mg/L)	—	—	—	4-day aver. ≤0.05 Single value ≤0.45[5]	—	4-day aver. ≤0.05 Single value ≤0.45[5]
Total dissolved solids (mg/L)	95% samples: Upper LVW[6] ≤1,900, Lower LVW ≤2,400	≤3,000	[7]	≤3,000	[7]	≤1,000
Chloride (mg/L)	—	—	—	—	[8]	≤400[8]
Sulfate (mg/l)	—	—	—	—	[8]	≤500[8]
Total suspended solids (mg/l)	—	≤135[9]	—	≤25	—	≤25
Nitrate-N (mg/L)	—	≤10	—	≤90	—	≤10
Nitrite-N (mg/L)	—	≤1	—	≤5	—	≤1
Total inorganic nitrogen (mg/L)	95% samples: Upper LVW ≤20, Lower LVW ≤17	—	95% samples ≤5.3	—	95% of samples ≤4.5	—
Turbidity (NTU)[10]	—	—	≤10 of natural conditions	≤25	≤10 of natural conditions	≤25

Table D.0-1 Water Quality Standards (continued).

	Las Vegas Wash (Upper and Lower)		Inner Las Vegas Bay		Lake Mead	
Parameter[1]	**RMHQ**	**Beneficial Uses Criteria**	**RMHQ**	**Beneficial Uses Criteria**	**RMHQ**	**Beneficial Uses Criteria**
Fecal coliform (MPN/100mL)[11]	—	Point Source Only ≤200/400[12]	—	Point Source Only ≤200/400[12]	—	≤200/400[12]
E. Coli 30-day Log Mean	—	—	—	—	— —	≤126 ≤235
Color (Platinum-Cobalt Scale Units)	—	—	—	—	≤10 of natural conditions	—

Notes:

[1] Unless mentioned otherwise, requirements or criteria refer to single value.

[2] ΔT means change in temperature. Maximum allowable increase in temperature above water temperature at the boundary of an approved mixing zone.

[3] In the epilimnion or average in water column during periods of non-stratification.

[4] The requirements for chlorophyll *a* are:

- Not more than one monthly mean in a calendar year at Station 3 may exceed 45 µg/L.
- The mean for chlorophyll *a* in summer (July 1-September 30) must not exceed 40 µg/L at Station 3, and the mean for 4 consecutive summer years must not exceed 30 µg/L. The sample must be collected from the center of the channel and must be representative of the top 5 meters (m) (16 feet [ft]) of the channel. "Station 3" means the center of the channel at which the depth is from 16 to 18 m (52 to 59 ft).
- The mean for chlorophyll *a* in the growing season (April 1-September 30) must not exceed 16 µg/L at LM4 and 9 µg/L at LM5. LM4 is located just outside of the Las Vegas Bay launch ramp and marina, next to buoy RW "1". LM5 is located next to buoy RW "A" with the southshore landmark of Crescent Island.
- The mean for chlorophyll *a* in the growing season (April 1-September 30) must not exceed 5 µg/L in the open water of Boulder Basin, Virgin Basin, Gregg Basin, and Pierce Basin. The single value must not exceed 10 µg/L for more than 5 percent of the samples.
- Not less than two samples per month must be collected between the months of March and October. During the months when only one sample is available, that value must be used in place of the monthly mean.

[5] LVW = Las Vegas Wash.

[6] The 4-day average for the concentration of un-ionized ammonia in the vertical column of water and the four-sample rolling average for each interval sampled must not exceed 0.05 mg/l more often than once every 3 years. The daily value for this average must account for diurnal fluctuation. Data must be collected at Station 2 from at least three locations between the surface and total depth. This standard is not applicable to the area between Station 2 and the confluence of the Las Vegas Wash. The single value must not exceed 0.45 mg/l more often than once every 3 years. "Station 2" means the center of the channel at which the depth is 10 m.

[7] Flow weighted annual average concentration ≤723 mg/L measured below Hoover Dam.

[8] The combination of this constituent with other constituents comprising TDS must not result in the violation of the TDS standards for Lake Mead and the Colorado River.

[9] Not applicable when flows are greater than 110 percent of average flow as measured at the nearest gauge.

[10] Nephelometric Turbidity Unit.

[11] Most Probable Number per 100mL (1 deciliter).

[12] Based on a minimum of not less than 5 samples taken over a 30-day period, the fecal coliform bacterial level must not exceed a log mean of 200 MPN/100mL nor must be more than 10 percent of the total samples taken during any 30-day period exceed 400 MPN/100 mL.

Source: NAC, Chapter 445A.195-201.

The Las Vegas Wash was modeled to determine what effects to water quality the projected amounts of effluent and removal of effluent would have on the Las Vegas Wash. The water quality in Lake Mead and downstream of Hoover Dam was modeled to determine the effects of the SCOP alternatives on the water quality in the Las Vegas Bay, Boulder Basin, and at the Southern Nevada Water Authority (SNWA) Intakes, the Hoover Dam Intakes, and downstream of Hoover Dam. The Las Vegas Wash Model output defines some of the input parameters for the Boulder Basin (Lake Mead) model.

Table D.0-2 presents the concentration and mass loading for parameters in the effluent (discharge) that were considered in the modeling effort. The parameters presented are consistent with the parameters addressed throughout the modeling process, and values presented are based on projected flow increases. Also presented in the table are the mass loading for parameters that are removed from Lake Mead via the SNWA intakes. The concentrations are used for comparison purposes only and not intended to represent proposed final concentrations. The final concentrations of all parameters discharged into Lake Mead will be determined through the permitting process administered by NDEP.

It is important to note that the effluent parameters would be mixed with Lake Mead waters and dilution of the concentrations would occur. Therefore, the concentrations presented in Table D.0-2 are not necessarily the concentrations that would be observed at the inner Las Vegas Bay, Boulder Beach, SNWA intakes, or Hoover Dam Discharge.

D.1 Las Vegas Wash Model

The Las Vegas Wash Model was created to determine the effects of various effluent quantities to Las Vegas Wash water quality and to determine the amount of effluent that should remain in the Las Vegas Wash. The Las Vegas Wash is generally known as the reach from Vegas Valley Drive downstream to Lake Las Vegas and is the drain for the entire Las Vegas Valley. It collects urban runoff, treatment plant effluents, and groundwater seeps.

The SCOP Water Quality Modeling Subcommittee decided to model the Las Vegas Wash using a mass balance approach. The mass balance approach assumes whatever enters the cell is equal to what exits the cell plus any losses through the cell. Two constituents, temperature and phosphorus, were modeled using methods other than flow-weighted mass balancing.

Temperature is modeled using three methods in the Las Vegas Wash Model. To calculate the total wetland influent, a flow-weighted mass balance is used on all of the wetland cell's influent sources to determine the composite influent into the wetland cell. Temperature change within the wetland cell is calculated using temperature equations that calculate the effect of air temperature on the water temperature. Finally, a modification to the effluent temperature may be made by applying a temperature change due to evaporation. Within the Las Vegas Wash Model, it is expected that phosphorus is removed from the system through sedimentation. A sedimentation rate constant of 2.74 centimeter per day (cm/day) was used to determine how much phosphorus is removed in each wetland cell.

The Las Vegas Wash Model was created in a Microsoft Excel workbook format.

D.1.1 Las Vegas Wash Model Methodology and Assumptions

The SCOP Water Quality Modeling Subcommittee identified five parameters for modeling. Members of the subcommittee included representatives from the Clean Water Coalition (CWC), City of Henderson

Table D.0-2 Mass Loading of Discharge and Intake Parameters.

			Las Vegas Wash	Current Flows			Projected 2030 Flows			Projected 2050 Flows		
			30 MGD flow	383 MGD Influent	153 MGD Effluent		750 MGD Influent	300 MGD Effluent		1000 MGD Influent	400 MGD Effluent	
Parameter	**Intake Concentration (mg/L)**	**Effluent Discharge Concentration (mg/L)**	**Mass Loading (lbs/day)**	**Mass Loading (lbs/day)**	**Mass Loading (lbs/day)**	**Net Loading (lbs/day)**	**Mass Loading (lbs/day)**	**Mass Loading (lbs/day)**	**Net Loading (lbs/day)**	**Mass Loading (lbs/day)**	**Mass Loading (lbs/day)**	**Net Loading (lbs/day)**
Total Dissolved Solids	570.00	1,144.00	286,229	1,820,705	1,459,767	(360,939)[1]	3,565,350	2,862,288	(703,062)[1]	4,753,800	3,816,384	(937,416)[1]
Total Phosphorus	0.0045	0.20	50	14	255	241	28	500	472	38	667	630
Soluble Phosphorus	0.0044	0.15	38	14	191	177	28	375	348	37	500	464
Total Nitrogen	0.48	16.70	4,178	1,533	21,310	19,776	3,002	41,783	38,781	4,003	55,711	51,708
Ammonia	0.015	0.26	65	48	332	284	94	651	557	125	867	742
Bromide	0.081	0.20	50	259	255	(4)[1]	507	500	(6)[1]	676	667	(8)[1]
Sulfate	240	330	82,566	766,613	421,087	(345,526)	1,501,200	825,660	(675,540)[1]	2,001,600	1,100,880	(900,720)[1]
Chloride	82	250	62,550	261,926	319,005	57,079	512,910	625,500	112,590	683,880	834,000	150,120

Note:

[1] A greater mass loading of these substances is removed from Lake Mead through the SNWA drinking water intakes than is added through the effluent discharge.

(COH), City of Las Vegas (CLV), Clark County Water Reclamation District (CCWRD), National Park Service (NPS), U.S. Bureau of Reclamation (Reclamation), and SNWA. The parameters selected for evaluation include:

- Flow,
- Temperature,
- Total inorganic nitrogen (TIN),
- Total phosphorus (TP), and
- Total dissolved solids (TDS).

The Las Vegas Wash model accounts for wetlands formed or expected to form behind the 22 erosion control structures (ECSs) and the potential for the creation of wetland areas outside the main channel. It was assumed that these off-channel wetlands would most likely be created in the Duck Creek Channel and along the northern side of the Las Vegas Wash between the outlets of the Monson Channel and Duck Creek.

The inflows to the Las Vegas Wash, accounted for in the Las Vegas Wash Model, include flows from the Las Vegas Creek, Sloan Channel, Flamingo Wash, three wastewater treatment facilities, Monson Channel, Duck Creek, groundwater seep, and C-1 Channel. A base flow, not including effluent, of 20 million gallons per day (mgd) in the Las Vegas Wash was assumed based upon the Las Vegas Wash Comprehensive Adaptive Management Plan (LVWCC 2000).

Once the model was created in the spreadsheets, it was necessary to compare the results calculated within the model to those measured at the lower end of the Las Vegas Wash. Data is regularly collected at Northshore Road, which is just downstream of Lake Las Vegas, and thus downstream of the area covered by the Las Vegas Wash Model. Since only five ECSs were in place when the data were collected, those were the only ECSs included in the calibration/verification model runs.

D.1.2 Las Vegas Wash Model Input Data

Effluent data were collected directly from the three treatment plants for the years from 1997 to 2001 and were input to the model for calibration purposes. Year 2002 data was used as baseline conditions (Table D.1-1). Water-quality data from the Las Vegas Wash and its tributaries were collected from the COH. Weather data were collected from the United States Geological Survey (USGS) website. Groundwater quality information was gathered from the groundwater seeps by SNWA.

The CLV, CCWRD, and COH each provided compiled wastewater effluent data for inclusion in the model. The data set included water quantity and quality. The CLV also provided Las Vegas Wash and Lake Mead water quality data, which were used in the preliminary model runs and for verification of the model results. Weather data, including rainfall, evapotranspiration, wind, and solar radiation data were obtained via the internet.

D.1.3 Las Vegas Wash Model Results

Modeling was conducted to determine the effects of different amounts of treated effluent flow in the Las Vegas Wash. The non-effluent base flow of 20 mgd was left in the Las Vegas Wash for each of the

Table D.1-1 Baseline Water Quality Conditions in the Las Vegas Wash.

Parameter	LW0.55
Temperature (°C) [°F]	22.6 [72.7]
Perchlorate (µg/L)	NA[1]
Conductivity (µS/cm)	2344
Dissolved Oxygen (mg/L)	8.9
Chlorophyll (µg/L)	NA
Total Phosphorus (mg/L)	0.2
Soluble Phosphorus (mg/L)	0.1
Total Inorganic Nitrogen (mg/L)	16
Nitrate (mg/L)	15.8
Total Ammonia Nitrogen (mg/L)	0.1
Un-ionized Ammonia (mg/L)	NA
Bromide (mg/L)	NA
Sulfate (mg/L)	633
Chloride (mg/L)	309
Fecal Coliform (MPN/100mL)[2]	231
pH	8.3

Notes:

[1] NA = Not available.

[2] Most probable number per 100 ml (1 deciliter).

Source: COH 2002d.

modeling runs. The variable was the amount of effluent added to the Las Vegas Wash from the three treatment plants. All 22 (existing and planned) ECSs were included in each of these model runs. The off-channel wetlands were not used in the model runs. The model uses the 2002 average effluent flow of 153 mgd of treated effluent and the projected effluent flows in the Las Vegas Wash of 300 mgd, which is the projected 2030 flow under the No Action Alternative, and 50 mgd, which is the amount of flow that would remain in the Las Vegas Wash under the action alternatives.

D.1.3.1 No Action Alternative

Under the No Action Alternative, there would be an increase in effluent flows, but no expected increase in groundwater/urban runoff base flows in the Las Vegas Wash. Despite the increased population of the Las Vegas Valley, surfacing groundwater and urban over-watering are not expected to increase because of water-conservation measures.

Table D.1-2 presents the modeling results if 300 mgd of flows remain in the Las Vegas Wash. Dry weather urban discharge and intercepted shallow groundwater currently contribute about 20 mgd, which is almost 15 percent of the annual flows in the Las Vegas Wash. The shallow groundwater contains high levels of TDS and many other substances including selenium. Although non-point source base flows

would remain the same under the No Action Alternative, there would be increased dilution of groundwater constituents because effluent flows would increase. The Las Vegas Wash Model shows that TDS concentrations would decrease from 1,675 to 1,361 mg/L (Table D.1-2). Selenium concentrations would decrease from 2.5 µg/L in the baseline conditions to 2.0 µg/L in the year 2030 conditions because of increased dilution.

Table D.1-2 Las Vegas Wash Baseline Conditions and Modeling Results for the No Action Alternative[1] in 2030.

Parameter	Baseline Conditions[2]	No Action Alternative[3]
Effluent Flow (mgd [cfs])	150 [231]	300 [462]
Temperature (°C [°F])	23 [73]	21 [69]
Total Inorganic Nitrogen (mg/L) – 95th percentile	16.0	14.2
Total Phosphorus (mg/L)	0.2	0.2
Total Dissolved Solids (mg/L)	1,675	1,361
Selenium (mg/L)	2.5	2.0

Notes:

1 Location: LW 0.55 (Figure D.2-1). This table is for comparison purposes. Other baseline parameters for the Las Vegas Wash are shown on Table D.2-2.

2 *Source: COH 2002d.*

3 *Source: Black and Veatch 2004d.*

Under the No Action Alternative, parameters contained within wastewater effluent discharges in 2030 are expected to remain as they were in 2002, except that flows would increase. The presence of constituents such as endocrine-disrupting compounds and other emerging compounds of concern would increase as effluent flows to the inner Las Vegas Bay increase. The wastewater treatment facilities would be expanded to provide greater capacity for the increased wastewater flows, using current conventional treatment processes. However, with increased flows, the treatment plants would not be able to meet the TMDL for phosphorus of 334 lbs/day in the Las Vegas Wash at Northshore Road.

For the projected annual effluent flow of 400 mgd (616 cfs) by 2050, the predicted concentrations are very similar to the 300 mgd (462 cfs) scenario, except that the TDS values for 400 mgd (616 cfs) are slightly lower due to more dilution, and concentrations of effluent parameters are slightly higher. The Las Vegas Wash Model predicts that with annual effluent flows of 400 mgd (616 cfs) the TDS would be 1,314 mg/L and concentrations of effluent parameters such as TIN would be 14.3 mg/L. This would be an improvement compared to baseline conditions (Table 3.1-3). Table D.1-2 shows that the 95th percentile RMHQ standard for TIN of 17 mg/L (Table 3.1-2) would not be exceeded in the Las Vegas Wash.

D.1.3.2 Action Alternatives

Under the action alternatives, a minimum of 30 mgd (46 cfs) of effluent would remain in the Las Vegas Wash. Together with 20 mgd (31 cfs) of base flow, the total flow in the Las Vegas Wash is expected to

be at least 50 mgd (77 cfs). This scenario was modeled assuming a total of 50 mgd (77 cfs) of combined base flow and effluent would remain in Las Vegas Wash.

Reducing the flow in the Las Vegas Wash to 50 mgd (77 cfs) (30 mgd [46 cfs] effluent plus 20 mgd [31 cfs] base flow) would result in higher concentrations of substances associated with groundwater and urban runoff such as TDS and selenium (Table D.1-3). The concentrations of these constituents would increase because less effluent flows would provide less dilution of the non-effluent related constituents.

Table D.1-3 shows that the reduced flows of effluent in the Las Vegas Wash would result in lower concentrations of substances associated with effluent such as TIN and TP. The Las Vegas Wash waste load allocations (WLAs) would be attained for all effluent-related parameters.

Table D.1-3 Las Vegas Wash Baseline Conditions and Modeling Results for the Boulder Islands and Las Vegas Bay Alternatives.[1]

Parameter	Baseline Conditions[2]	Boulder Islands & Las Vegas Bay Alternatives[3]
Effluent Flow (mgd [cfs])	150 [231]	30 [46]
Temperature (°C [°F])	23 [73]	20 [68]
TIN (mg/L)	16.0	6.1
TP (mg/L)	0.2	0.1
TDS (mg/L)	1,675	2,500
Selenium (mg/L)	2.5	5.0

Notes:

[1] Location: LW 0.55 (See Figure D.2-1). This table is for comparison purposes. Other baseline parameters for the Las Vegas Wash are shown on Table D.2-2.

[2] *Source: COH 2002d.*

[3] *Source: Black and Veatch 2004.*

D.2 Lake Mead Model

The Lake Mead Model was created to determine the effects of various effluent quantities and discharge locations to the water quality of Lake Mead. Boulder Basin, located immediately upstream of Hoover Dam, is the main study area of this project. The principal inflows to Boulder Basin are from the Colorado River via the Narrows, from the Virgin and Muddy rivers, and from the Las Vegas Wash, which discharges into Boulder Basin through the Las Vegas Bay. There are also two principal outflows from Boulder Basin, through four outlet towers at Hoover Dam and through the SNWA intakes located at Saddle Island.

The goals of the data collection and analysis efforts for the Lake Mead Water Quality Model are to:

- Develop an understanding of the reservoir mixing and biochemistry,
- Prepare input data files for the Boulder Basin model, and
- Calibrate and validate the model.

D.2.1 Lake Mead Model Methodology, Calibration, and Confidence Level

Water-quality impacts to Lake Mead from each of the alternate discharge locations were analyzed using two steps: a hydrodynamic simulation and a biochemical simulation. Two separate models were used to perform the analysis: the ELCOM (Estuary and Lake Computer Model) and the CAEDYM (Computational Aquatic Ecosystem Dynamic Model). The ELCOM is a stand-alone three-dimensional hydrodynamic code, whereas CAEDYM is a water-quality module that uses ELCOM as its hydrodynamic "driver". The outcome of the hydrodynamic simulation, ELCOM, is a detailed characterization of water movement and mixing in the Lake, coupled with a description of the thermal stratification. The bio-chemical simulation, CAEDYM, computes interactions between biological organisms and the chemistry of their nutrient cycle. The coupled models proved to be an effective tool to study the spatial and temporal relationships between physical, biological, and chemical variables in Lake Mead. These models are described in detail in the *Lake Mead Water Quality Modeling Report* (Black & Veatch 2005b).

The SCOP Water Quality Modeling Subcommittee identified the parameters and conditions that would be included in the modeling effort. Two Lake elevations, three effluent flow quantities, and three total phosphorus loading scenarios were modeled. The two Lake elevations selected for modeling include:

- 1,178 ft (359 m) – The Lake elevation on January 1, 2002; and
- 1,000 ft (30 m) – The elevation selected by the Subcommittee to represent the probable lowest elevation of Lake Mead considering the historic 15-year below-normal precipitation cycle.

Variations of effluent flows were addressed by modeling three scenarios.

- 150 mgd - The effluent flow quantities in 2002 (baseline),
- 300 mgd - The projected effluent flows for year 2030, and
- 400 mgd – The projected effluent flows for year 2050.

The parameters modeled for the previously mentioned scenarios include:

- Chlorophyll *a,*
- Secchi Depth,
- Nitrates and TIN,
- Ammonia (NH4)
- Un-ionized Ammonia (uiNH4),
- Dissolved Oxygen (DO),
- Tracer for Effluent,
- Fecal Coliform,
- Conductivity,
- Bromide,
- TP,
- Perchlorate,
- Chloride,
- Sulfate,
- Temperature,
- pH,
- Biological Oxygen Demand (BOD), and
- Total Nitrogen.

The TP loading scenarios that were evaluated in the model include:

- 334 lbs/day through the Las Vegas Wash (No Action Alternative),
- 275 lbs/day through the Boulder Islands Diffuser (Boulder Island Alternatives),
- 275 lbs/day through the Las Vegas Bay Diffuser (Las Vegas Bay Alternative),
- 467 lbs/day through the Boulder Islands Diffuser (Boulder Island Alternatives), and
- 467 lbs/day through the Las Vegas Bay Diffuser (Las Vegas Bay Alternative).

For the No Action Alternative, a maximum phosphorus loading of 334 lbs/day was modeled based on the TMDL WLA for the Las Vegas Wash. It is important to note that phosphorus loadings of 467 lbs/day and 592 lbs/day, which would occur with flow increases expected in years 2030 and 2050, respectively, would exceed the Las Vegas Wash WLA. Therefore, treatment processes would need to be improved to meet the TMDL WLA requirements for phosphorus with the increased flows.

The TP loading of 592 lbs/day for year 2050 flows was extrapolated from three sets of model runs (300 mgd at 275 lbs/day, 300 mgd at 467 lbs/day, and 400 mgd at 275 lbs/day). Extrapolation, rather than modeling, was deemed appropriate for the 592 lbs/day TP loading because it is unlikely that this loading would occur. The modeling results for 275 lbs/day loading of TP are not presented in this appendix, but are described in detail in the *Lake Mead Water Quality Modeling Report* (Black &Veatch 2005b).

Model sample locations were also determined by the Subcommittee. The complete list of model sample locations is presented in the *Lake Mead Water Quality Modeling Report* (Black & Veatch 2005b. The model locations most relevant to the alternatives analyzed in the SCOP Environmental Impact Statement (EIS) are the Inner Bay (LVB1.85 M), Inner Bay (LVB2.7), Boulder Basin (CR346.4), Boulder Beach, Hoover Dam Discharge, and SNWA Intake (Figure D.2-1). It is important to note that LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The Hoover Dam discharge data considered the upper and lower intakes combined, and the SNWA intake data considered the lower intake only.

Extensive data collection and model calibration was conducted. Model calibration and validation were required prior to applying the model to the analysis of the alternatives. Model calibration was conducted in two phases: an ELCOM calibration followed by a CAEDYM calibration. The ELCOM calibration focused on physical parameters such as temperature, conductivity, perchlorate, and fecal coliform. The CAEDYM calibration considered chemical and biological parameters such as chlorophyll, nutrients, DO, and pH. The model calibration was complete when the agreement between the model results and the field data was considered adequate. Model Calibration is discussed in detail in the *Lake Mead Water Quality Modeling Report* (Black & Veatch 2005b).

A medium grid (600 m grid size) was used for the modeling effort (Figure D.2-2). The ELCOM water quality variables that were included in the simulations are temperature, conductivity, perchlorate, fecal coliform, chloride, sulfate, bromide, and salinity. The ELCOM tracers that were included in the simulation were tracers for the effluent, Las Vegas Wash baseflow, stormwater, and Colorado River inflow. The CAEDYM variables that were included in selected simulations are BOD, DO, TP, SP, NO3, NH3, TN, pH, and chlorophyll.

For initial screening purposes, the original alternate discharge locations evaluated for the ELCOM/ CAEDYM runs were Las Vegas Bay, Callville Bay, Promontory Point, Hemenway Wall, and Boulder Islands. The results of the modeling indicated that the discharge locations that best meet the purpose and need for the SCOP and maintain water quality standards are the Boulder Islands and Las Vegas Bay discharge locations.

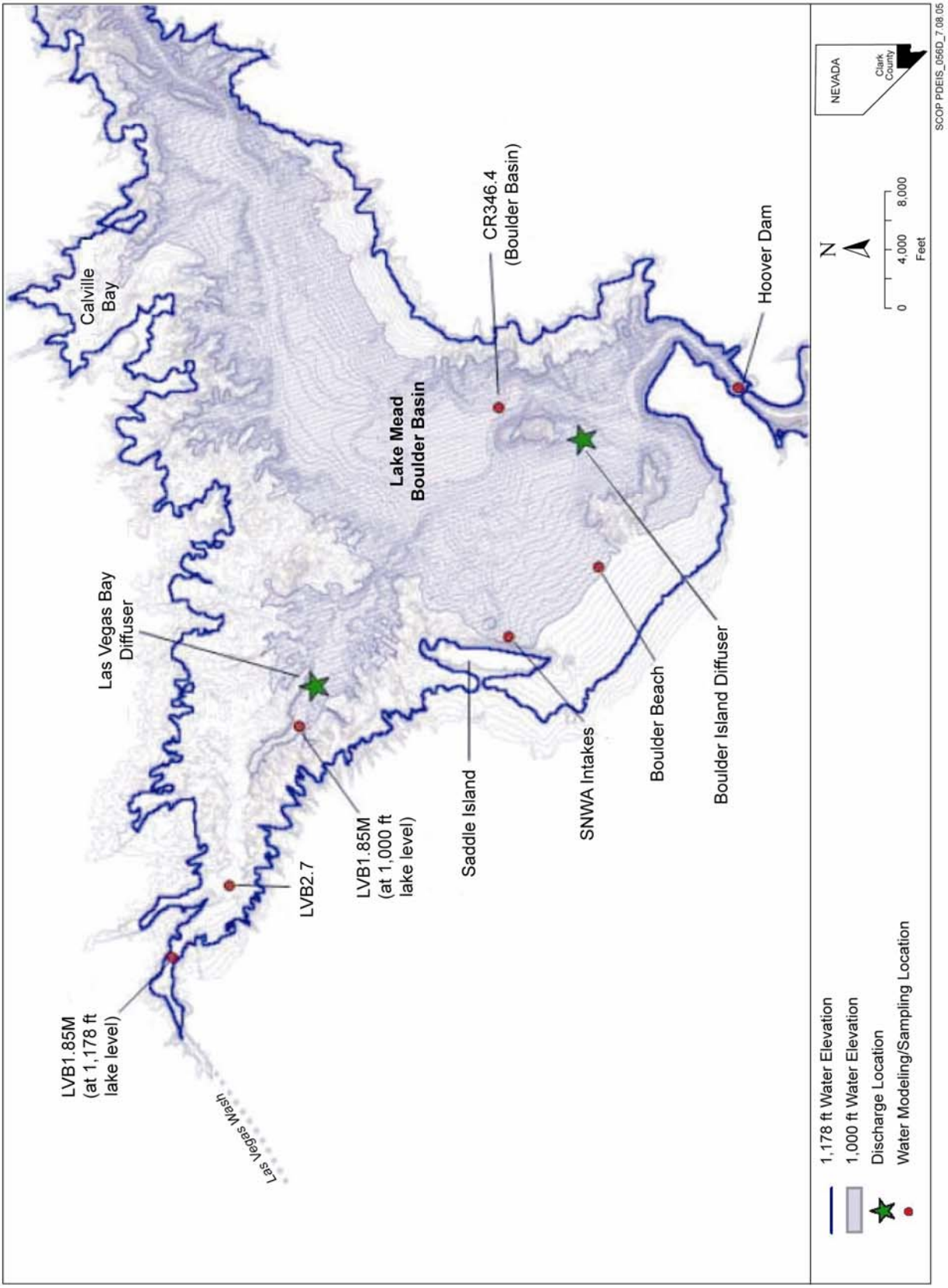

Figure D.2-1 Water Quality Modeling/Sampling and Discharge Locations in Lake Mead.

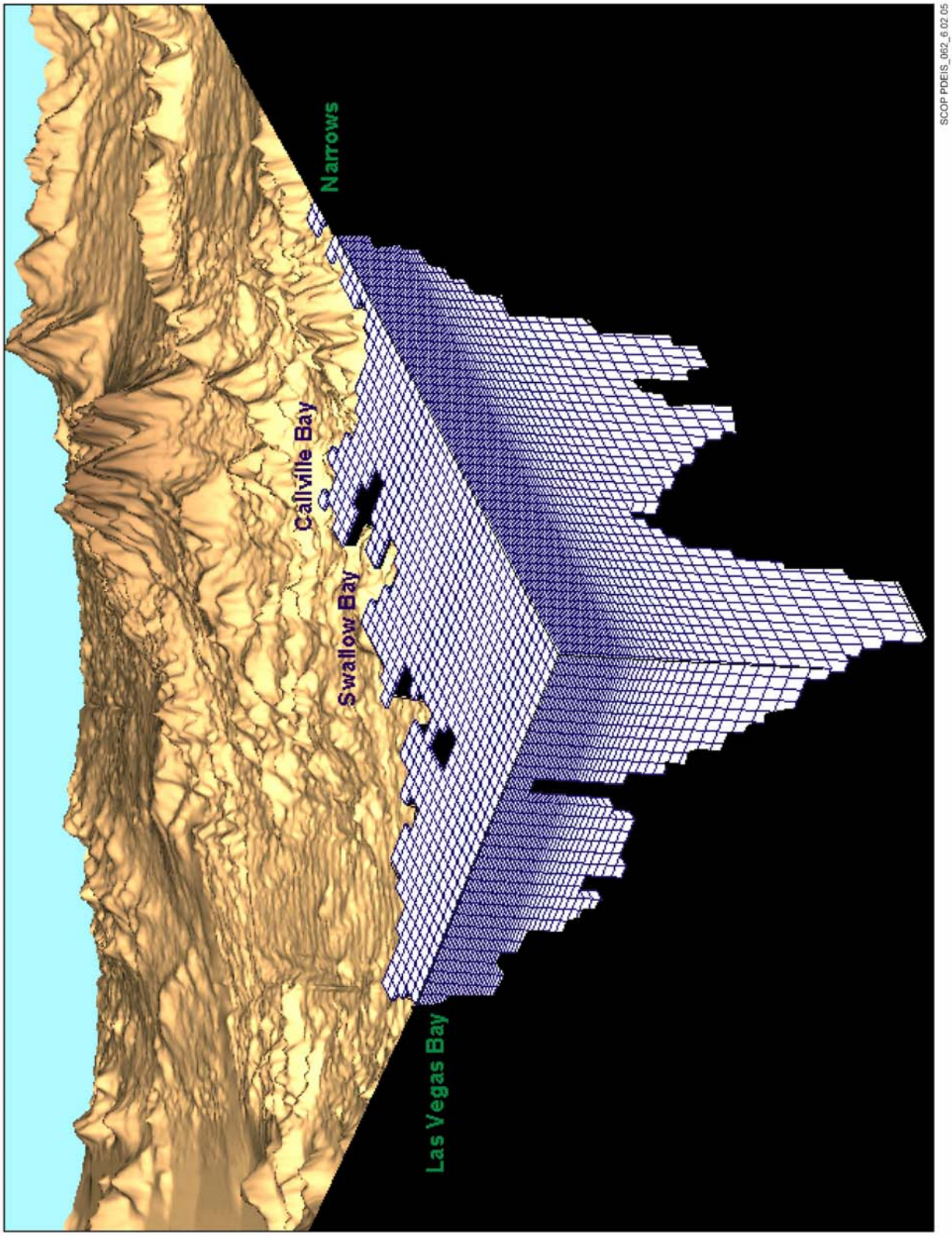

Figure D.2-2 600-meter Grid.

The Boulder Islands and Las Vegas Bay scenarios consist of discharging 270 mgd of the effluent through a diffuser located at one of these locations, with the remaining 30 mgd of effluent being discharged into the Las Vegas Wash. The discharges are assumed to always be located below the thermocline unless specified otherwise. A surface discharge through Las Vegas Wash (No Action Alternative) was also simulated, consisting of discharging the future 300 mgd of effluent flow into the Las Vegas Wash. In addition, several Las Vegas Wash/Las Vegas Bay Combined and Las Vegas Wash/Boulder Islands Combined cases were simulated to evaluate the effects of a range of scenarios with varying proportions of effluent being discharged through the Las Vegas Wash and a diffuser located at either Las Vegas Bay or Boulder Islands. These Combined case simulations are discussed further in the *Lake Mead Water Quality Modeling Report* (Black & Veatch 2005b).

All of these alternative simulations used meteorological data, Colorado River inflow volumes, water quality, tracer concentrations, and Hoover Dam release volumes from 2002. The limnology of Lake Mead was also considered and additional information regarding Lake Mead limnology is presented in the *Lake Mead Water Quality Modeling Report* (Black & Veatch 2005b).

The confidence levels for ELCOM/CAEDYM predictions of yearly averages for various modeled substances (except chlorophyll *a*) were estimated based upon comparisons of perchlorate field data and calibration model results for a 3-year period (2000 through 2003). Initially, confidence levels for perchlorate yearly averages were computed based on a method of analysis that closely follows that used in determining model confidence level estimates for chlorophyll *a*. The computed confidence levels for perchlorate were then used to determine confidence levels for other substances that are considered in the ELCOM/CAEDYM model. Perchlorate was chosen since it is a conservative substance that enters Boulder Basin predominantly through the Las Vegas Wash. Perchlorate is not a parameter in the effluent but enters the Las Vegas Wash through a series of groundwater seeps. In addition, there are 40 to 60 perchlorate measurements available per year in the Las Vegas Wash, which enables meaningful statistical analysis. On the other hand, most other conservative substances computed in the model have significant contributions from both the Narrows and the effluent, making a direct estimate of confidence level difficult.

The errors of the model output are identified by determining the differences between the field and model averages. These errors are then combined over the four calendar years using the conservative "Root Mean Square" (RSM) method (Lorden 2004). Specifically, the RMS error is obtained by averaging the squares of the errors and taking the square root of the result. The percent RMS errors generally range from 10.4 percent to 13.5 percent. Based upon these results, a reasonable value to use to estimate model confidence limits for the annual average perchlorate value is 13 percent.

Confidence levels for the model estimates of conservative substances other than perchlorate (eg. effluent tracer, chloride, bromide) are also assumed to be 13 percent. A similar analysis for chlorophyll *a* indicated confidence levels of 35 percent (Lorden 2004). This difference in confidence levels is attributed to the fact that the predictions for conservative substances are more accurate than those for chlorophyll. This is a result of the uncertainty in model input parameters such as algae growth rates and their dependence on other factors such as water temperature, phosphorus concentrations, and solar radiation.

Other non-conservative parameters in Lake Mead such as phosphorus and nitrogen are expected to have confidence levels somewhere between 13 percent and 35 percent. This is a result of the belief that confidence levels for such substances are expected to be lower than those for chlorophyll, but higher than those for conservative substances. Due to lack of reliable field data, especially for phosphorus, the confidence levels for such parameters are simply estimated at 25 percent.

The estimated model confidence limits for all modeled parameters are shown in Table D.2-1. It should be noted that the percentage model confidence limits for each parameter are relative to the change in concentration above the background level.

Table D.2-1 Estimated Model Confidence Levels for Parameters.

Parameter	Estimated *Percentage*[1] Model Confidence Levels (percent)
Temperature (°C [°F])	13
Perchlorate (µg/L)	13
Effluent Tracer (%)	13
Conductivity (µS/cm)	13
Total Dissolved Solids (mg/L)	13
Dissolved Oxygen (mg/L)	25
Chlorophyll (µg/L)	35
Total Phosphorus (mg/L)	25
Total Nitrogen (mg/L)	25
Total Ammonia Nitrogen (mg/L)	25
Un-ionized Ammonia (mg/L)	25
Bromide (mg/L)	13
Sulfate (mg/L)	13
Chloride (mg/L)	13

Note:

[1] Relative to the difference between model estimate and background level.

D.2.2 Lake Mead Model Input Data

Water quality data was obtained from the CLV, CCWRD, COH, SNWA, Reclamation, USGS, Basic Management Inc. (BMI), and the Nevada Division of Environmental Protection (NDEP) for the Lake Mead Model. Data collected included flow rates and water quality data for the effluent, Las Vegas Wash inflow, SNWA intakes, BMI intake, Hoover Dam discharges, and Boulder Basin data. Meteorological and water quality data for Boulder Basin and upstream areas of Lake Mead were also collected. Unless otherwise specified for the wastewater effluent data, all temperature, pH, DO, and fecal coliform data were measured using instantaneous (field) or grab samples.

The ELCOM/CAEDYM alternative runs were modeled using “base” conditions from 2002 (Table D.2-2). Year 2002 was selected as the baseline year for the following reasons:

- Prior to year 2000, a limited amount of water quality data is available for Lake Mead;
- A significant amount of data is available for years 2000, 2001, and 2002;
- Year 2001 was an atypical year concerning algal growth in Lake Mead, so it was eliminated from consideration;

- Year 2002 data is representative of typical conditions in Lake Mead including algal growth years; and
- Year 2002 Lake elevation was lower, which is expected to be typical in the future.

Meteorological data, Colorado River inflow volumes, water quality, tracer concentrations, Hoover Dam release volumes, and initial water surface elevations were used to define the meteorological and hydrologic conditions. Actual flow rates for the baseflow and stormwater components of the Las Vegas Wash were also used for each simulation year. The Narrows inflow rates for the alternative runs were adjusted slightly to maintain the same water levels as obtained in 2002. This was needed due to the projected increase in both the effluent discharge and SNWA withdrawals. Lake Mead limnological information was obtained from the University of Nevada, Las Vegas (UNLV) (1980 and 2002) and from Dr. Jim LaBounty (LaBounty and Horn 1997). Wastewater treatment process and effluent phosphorous information was obtained from the *SCOP Process Assessment* (Black & Veatch 2004b).

The input data for the alternatives characterized the Las Vegas Wash flows and water quality at the point of discharge to Boulder Basin (i.e., the composite flow), where the flow includes baseflow, possibly stormwater, and effluent. The water quality and tracer concentrations for the Las Vegas Wash in the alternative runs were computed based on a flow-weighted average of the baseflow, stormwater, and effluent components that are expected to comprise the Las Vegas Wash in 2030 and 2050. It was assumed that future baseflow and stormwater flow quality could be accurately defined using 2002 data.

The tables in the following sections present data that are the result of modeling. The parameter concentrations may be presented using up to four significant figures depending on the concentration level. Confusion may occur because the value presented in the table is below the minimum detection limit for that parameter. This may cause one to doubt the reliability of the modeling results. However, the main purpose of the following tables is to present a *direct* comparison between various project scenarios under *identical* operating conditions and general assumptions.

Table D.2-2 Baseline Modeled Water Quality Conditions in Boulder Basin (1,178 ft [359 m] Lake level for Year 2002 effluent flows of 150 mgd [231 cfs] and TP = 292 lbs/day).[1]

Parameter	Inner Bay (LVB1.85M)[2]	Inner Bay (LVB2.7)	Boulder Basin (CR346.4)	Boulder Beach	Hoover Dam Discharge[3]	SNWA Intake[4]
Temperature (°C[°F])	20.3 [68.5]	20.3 [68.5]	19.6 [67.3]	19.3 [66.7]	13.2 [55.8]	13.0 [55.4]
Perchlorate (µg/L)	45.2	46.7	12.9	13.9	6.6	5.8
Conductivity (µS/cm)	1085	1094	947	952	901	896
Total Dissolved Solids (mg/L)[5]	687	693	599	603	570	567
Dissolved Oxygen (mg/L)	8.7	8.7	8.3	8.3	7.7	7.5
Chlorophyll (µg/L)	12.4	12.4	2.0	2.1	≤ 0.01	≤ 0.01
Secchi Depth (m)	3.2	3.2	8.5	8.8	ND[6]	ND[6]
Total Phosphorus (mg/L)	0.018	0.018	0.005	0.005	0.005	0.004
Soluble Phosphorus (mg/L)	0.009	0.009	0.003	0.003	0.004	0.004
Total Nitrogen (mg/L)	1.61	1.68	0.42	0.44	0.34	0.36

Table D.2-2 Baseline Modeled Water Quality Conditions in Boulder Basin (1,178 ft [359 m] Lake level for Year 2002 effluent flows of 150 mgd [231 cfs] and TP = 292 lbs/day)[1] (continued).

Parameter	Inner Bay (LVB1.85M)[2]	Inner Bay (LVB2.7)	Boulder Basin (CR346.4)	Boulder Beach	Hoover Dam Discharge[3]	SNWA Intake[4]
Total Inorganic Nitrogen (mg/L)[7]	1.57	1.64	0.40	0.43	0.32	0.33
Total Ammonia Nitrogen (mg/L)	0.012	0.013	0.010	0.011	0.014	0.019
Un-ionized Ammonia (mg/L)	0.0008	0.0008	0.0002	0.0004	0.0002	0.0003
Bromide (mg/L)	0.106	0.107	0.086	0.087	0.080	0.080
Sulfate (mg/L)	295	297	257	259	243	242
Chloride (mg/L)	107	108	85	85	79	78
Fecal Coliform (MPN/dL)[8]	1.0	1.1	0.0	0.0	0.0	0.0
pH	8.1	8.1	8.0	8.0	7.7	7.7

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was sampled within the top 5 m (16 ft). All data is the annual average, except for chlorophyll and Secchi depth, which includes the annual seasonal average (see note 5).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary.

3 Hoover Dam discharge data is from upper and lower intakes combined.

4 SNWA intake data is from the lower intake only.

5 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

6 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

7 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

8 Most Probable Number per 100 ml (1 deciliter).

Source: Black & Veatch 2004d.

D.2.3 Lake Mead Model Results

The results presented in this section refer to the Phase II ELCOM/CAEDYM alternative runs with a discharge below the thermocline and with the baseline conditions presented in Table D.2-2. The intention of evaluating the alternatives is to estimate their impact on water quality in Lake Mead.

It is possible that future water quality conditions in Lake Mead would be different than those shown in the tables presented in the following subsections. The differences would be a result of different hydrologic, physical, and biochemical conditions within the Colorado River system. However, the main purpose of the following tables is to present a *direct* comparison between various project scenarios under *identical* operating conditions and general assumptions.

D.2.3.1 No Action Alternative

Under the No Action Alternative the CWC would not construct pipelines to transport effluent from the treatment facilities. Current, conventional treatment processes would continue to be used to meet the requirements set by the NDEP through the National Pollutant Discharge Elimination System (NPDES) permitting program. The modeling results for the No Action Alternative with flows of 300 mgd (462 cfs) at Lake levels of 1,178 ft (359 m) and 1,000 ft (30 m) are discussed in this section. The TP loading for these model runs was 334 lbs/day, which is the TMDL WLA for the Las Vegas Wash. It is important to

note that increases in the TP that would result from flow increases were not modeled for the No Action Alternative because the WLA in the Las Vegas Wash cannot be exceeded. Using current, conventional treatment processes, flows of 300 mgd (462 cfs) would have a TP loading of 467 lbs/day, which exceed the WLA. Similarly, flows of 400 mgd (616 cfs) would have a TP loading of 592 lbs/day, which exceed the WLA. Therefore, the effluent in the Las Vegas Wash would exceed regulatory limits for TP. To eliminate these exceedances, improved treatment processes would need to be implemented.

D.2.3.1.1 No Action Alternative at a Lake Level of 1,178 ft (359 m)

Table D.2-3 presents the modeling results for the No Action Alternative with flows of 300 mgd (462 cfs) at a Lake level of 1,178 ft (359 m). The data presented in Table D.2-3 shows that the concentrations of most parameters increased under these conditions. However, the increases are minimal and do not result in exceedances of water quality standards (Table D.0-1). Therefore, some parameters not significantly affected by the No Action Alternative receive no further discussion.

Table D.2-4 and Figure D.2-3 show that the No Action Alternative does not improve existing elevated chlorophyll concentrations in the inner Las Vegas Bay. Phosphorus loadings entering the Lake through Las Vegas Wash would continue as they are under baseline conditions, and would continue to produce elevated chlorophyll concentrations in the inner Las Vegas Bay. In the inner Las Vegas Bay, phosphorus is mixed into the epilimnion where there is sufficient light for algae to grow. Chlorophyll concentrations in the vicinity of Boulder Basin CR 346.4 and Boulder Beach would also increase under the No Action Alternative at a Lake level of 1,178 ft (359 m). Phosphorous concentrations at the Hoover Dam discharge and SNWA intakes would remain below the epilimnion and would not receive sufficient light for algae growth and chlorophyll production.

Modeling results indicate that perchlorate concentrations decrease under the No Action Alternative. This decrease is due to two main factors: 1) Treatment of perchlorate-contaminated groundwater in the vicinity of the Las Vegas Wash has been effective in reducing the concentration of perchlorate that enters Lake Mead via the Las Vegas Wash, and 2) The increase in effluent flows through the Las Vegas Wash provides increased dilution of the perchlorate-contaminated groundwater.

Secchi depth, which is a measure of the water transparency in a lake to a specific depth, is a concern for the LMNRA. Under the No Action Alternative, Secchi depth in the inner Las Vegas Bay would not increase noticeably. Secchi depth at the other sampling locations would decrease.

D.2.3.1.2 No Action Alternative at Lake Level of 1,000 ft (30 m)

Table D.2-5 shows water quality under the No Action Alternative at a Lake level of 1,000 ft (30 m) for the year 2030 with annual effluent flows of 300 mgd (462 cfs) and a TP loading of 334 lbs/day. The data shows that the concentrations of most parameters increased under these conditions. However, the increases are minimal and do not result in exceedances of water quality standards (Table D.0-1). Again, it is important to note that increases in the TP that would result from flow increases were not modeled for the No Action Alternative because the TMDL in the Las Vegas Wash cannot be exceeded. Using current, conventional treatment processes, flows of 300 mgd (462 cfs) would have a TP loading of 467 lbs/day, which exceed the TMDL for the Las Vegas Wash. Therefore, the effluent in the Las Vegas Wash would exceed regulatory limits for TP. To eliminate these exceedances, improved treatment processes would need to be implemented.

Table D.2-3 Lake Mead Modeling Results for the No Action Alternative[1]
(1,178 ft [359 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 334 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	20.6 [69.1]	20.3 [68.5]	20.6 [69.1]	19.6 [67.3]	19.6 [67.3]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	13.2 [55.8]	13.0 [55.4]	13.0 [55.4]
Perchlorate (µg/L)	45.2	10.2	46.7	10.9	12.9	3.2	13.9	3.4	6.6	1.7	5.8	1.5
Conductivity (µS/cm)	1085	1,167	1094	1,187	947	972	952	979	901	913	896	907
Total Dissolved Solids (mg/L)[5]	687	739	693	751	599	615	603	620	570	578	567	574
Dissolved Oxygen (mg/L)	8.7	8.7	8.7	8.7	8.3	8.2	8.3	8.2	7.7	7.5	7.5	7.5
Chlorophyll (µg/L)	12.4	12.9	12.4	12.9	2.0	3.0	2.1	3.2	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01
Secchi Depth (m)	3.2	3.3	3.2	3.3	8.5	7.0	8.8	6.9	ND[6]	ND[6]	ND[6]	ND[6]
Total Phosphorus (mg/L)	0.018	0.026	0.018	0.028	0.005	0.005	0.005	0.006	0.005	0.005	0.004	0.004
Soluble Phosphorus (mg/L)	0.009	0.018	0.009	0.019	0.003	0.004	0.003	0.004	0.004	0.005	0.004	0.004
Total Nitrogen (mg/L)	1.61	3.36	1.68	3.66	0.42	0.68	0.44	0.74	0.34	0.45	0.36	0.46
Total Inorganic Nitrogen (mg/L)[7]	1.57	3.25	1.64	3.54	0.40	0.66	0.43	0.72	0.32	0.43	0.33	0.43
Nitrate (mg/L)	1.56	3.20	1.63	3.49	0.39	0.64	0.42	0.70	0.31	0.42	0.31	0.41
Total Ammonia Nitrogen (mg/L)	0.012	0.045	0.013	0.050	0.010	0.014	0.011	0.014	0.014	0.016	0.019	0.021

Table D.2-3 Lake Mead Modeling Results for the No Action Alternative[1]
(1,178 ft [359 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 334 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Un-ionized Ammonia (mg/L)	0.0008	0.002	0.0008	0.002	0.0002	≤0.001	0.0004	≤0.001	0.0002	≤0.001	0.0003	≤0.001
Bromide (mg/L)	0.106	0.116	0.107	0.119	0.086	0.089	0.087	0.089	0.080	0.081	0.080	0.080
Sulfate (mg/L)	295	290	297	294	257	257	259	258	243	244	242	243
Chloride (mg/L)	107	129	108	133	85	92	85	93	79	83	78	82
Fecal Coliform (MPN/dL)[8]	1.0	1.3	1.1	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ph	8.1	8.0	8.1	8.0	8.0	8.0	8.0	8.0	7.7	7.7	7.7	7.7

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the mean seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 Hoover Dam discharge data is from upper and lower intakes combined.

4 SNWA data is for intake located at 1,000 ft (30 m).

5 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

6 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

7 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

8 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-4 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the No Action Alternative[1] (1,178 ft [359 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 334 lbs/day).

Location[3]	**Chlorophyll (µg/L)**[2]	
	Baseline Conditions	**No Action Alternative**
Inner Bay (LVB 1.85M)[4]	12.4	12.9
Inner Bay (LVB 2.7)	12.4	12.9
Boulder Basin (CR 346.4)	2.0	3.0
Boulder Beach	2.1	3.2
Hoover Dam[5]	≤0.01	≤0.01
SNWA Intake[6]	≤0.01	≤0.01

Notes:

1 This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

2 Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

3 Sampling/monitoring locations are shown on Figure D.2-1.

4 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

5 Hoover Dam discharge data is from upper and lower intakes combined.

6 SNWA data is for intake located at 1,000 ft (30 m).

Source: Black and Veatch 2004d.

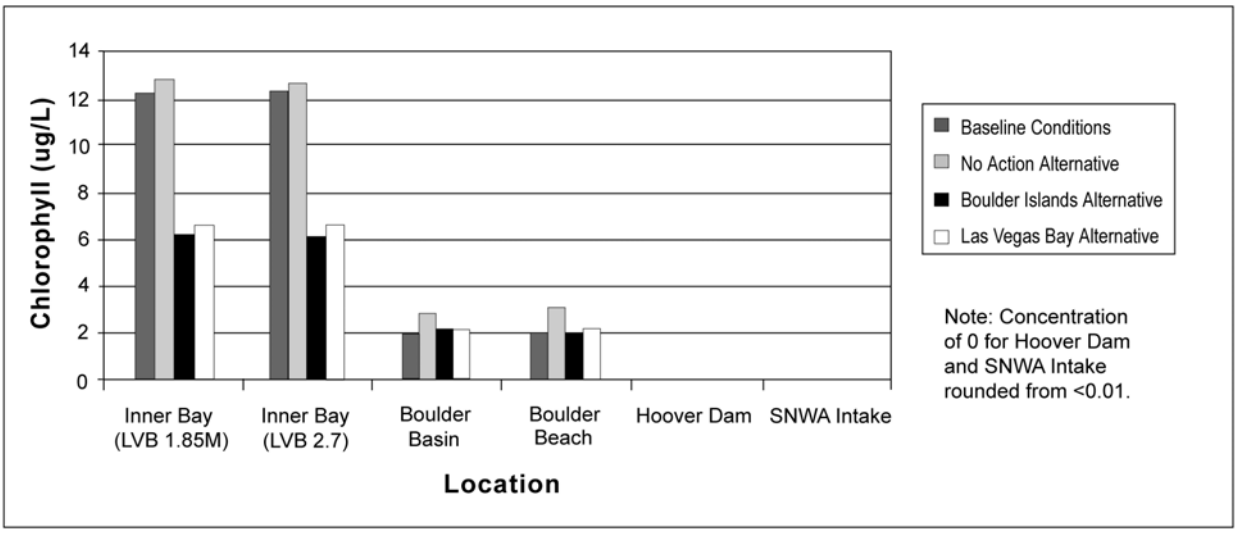

Figure D.2-3 Chlorophyll Concentrations under the No Action, Boulder Islands, and Las Vegas Bay Alternatives for year 2030 at a Lake Level of 1,178 ft (359 m).

Table D.2-5 Lake Mead Modeling Results for the No Action Alternative[1]
(1,000 ft (30 m)Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 334 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [685]	20.6 [69.1]	20.3 [68.5]	ND	19.6 [67.3]	19.6 [67.3]	19.3 [66.7]	19.5 [67.1]	13.2 [55.8]	14.8 [58.6]	13.0 [55.4]	ND
Perchlorate (µg/L)	45.2	11.1	46.7	ND	12.9	3.5	13.9	4.1	6.6	1.7	5.8	ND
Conductivity (µS/cm)	1085	1,180	1094	ND	947	971	952	987	901	911	896	ND
Total Dissolved Solids (mg/L)[6]	687	747	693	ND	599	615	603	625	570	577	567	ND
Dissolved Oxygen (mg/L)	8.7	8.4	8.7	ND	8.3	8.1	8.3	8.2	7.7	7.4	7.5	ND
Chlorophyll (µg/L)	12.4	11.1	12.4	ND	2.0	5.0	2.1	5.9	≤ 0.01	≤ 0.01	≤ 0.01	ND
Secchi Depth (m)	3.2	4.7	3.2	ND	8.5	6.6	8.8	6.4	ND[7]	ND[7]	ND[7]	ND[7]
Total Phosphorus (mg/L)	0.018	0.030	0.018	ND	0.005	0.006	0.005	0.008	0.005	0.006	0.004	ND
Soluble Phosphorus (mg/L)	0.009	0.021	0.009	ND	0.003	0.004	0.003	0.004	0.004	0.005	0.004	ND
Total Nitrogen (mg/L)	1.61	3.92	1.68	ND	0.42	1.01	0.44	1.18	0.34	0.65	0.36	ND
Total Inorganic Nitrogen (mg/L)[8]	1.57	3.79	1.64	ND	0.40	0.97	0.43	1.14	0.32	0.62	0.33	ND
Nitrate (mg/L)	1.56	3.73	1.63	ND	0.39	0.95	0.42	1.12	0.31	0.59	0.31	ND

Table D.2-5 Lake Mead Modeling Results for the No Action Alternative[1]
(1,000 ft (30 m)Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 334 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Total Ammonia Nitrogen (mg/L)	0.012	0.058	0.013	ND	0.010	0.021	0.011	0.023	0.014	0.027	0.019	ND
Un-ionized Ammonia (mg/L)	0.0008	0.003	0.0008	ND	0.0002	≤0.001	0.0004	≤0.001	0.0002	≤0.001	0.0003	ND
Bromide (mg/L)	0.106	0.120	0.107	ND	0.086	0.090	0.087	0.092	0.080	0.082	0.080	ND
Sulfate (mg/L)	295	292	297	ND	257	257	259	259	243	244	242	ND
Chloride (mg/L)	107	134	108	ND	85	94	85	97	79	83	78	ND
Fecal Coliform (MPN/dL)[9]	1.0	1.4	1.1	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND
Ph	8.1	8.0	8.1	ND	8.0	8.1	8.0	8.1	7.7	7.8	7.7	ND

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the mean seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

4 Hoover Dam discharge data is from the lower intake only.

5 No data exists for the SNWA 1,000-ft (30-m) intake.

6 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

7 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

8 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

9 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d .

Table D.2-6 and Figure D.2-4 show that the No Action Alternative with a Lake level of 1,000 ft (30 m) increases chlorophyll concentrations in Boulder Basin. Chlorophyll levels at Boulder Basin (CR 346.4) and Boulder Beach would equal or exceed the water quality standard of 5 µg/L for open water of Boulder Basin.

Modeling results indicate that perchlorate concentrations decrease under the No Action Alternative at a Lake elevation of 1,000 ft (30 m). This decrease is due to the factors discussed in Section D.2.3.1.1.

Under the No Action Alternative at a Lake level of 1,000 ft (30 m), Secchi depth in the inner Las Vegas Bay would increase by approximately 1.5 m (4.9 ft). However, at the Boulder Basin, Boulder Beach, and Hoover Dam Discharge locations the Secchi depth decreases as much as 2.4 m (7.9 ft).

Total phosphorus concentrations at Hoover Dam would increase compared to baseline conditions (Figure D.2-5) at lower Lake levels, but the increase would be minimal and would not exceed water quality standards (Table D.0-1).

Table D.2-6 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the No Action Alternative[1] (1,000 ft [30 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 334 lbs/day).

Location[3]	**Chlorophyll (µg/L)**[2]	
	Baseline Conditions	**No Action Alternative**
Inner Bay (LVB 1.85M)[4]	12.4	11.1
Inner Bay (LVB 2.7)[5]	12.4	ND
Boulder Basin (CR 346.4)	2.0	5.0
Boulder Beach	2.1	5.9
Hoover Dam[6]	0	≤ 0.01
SNWA Intake[7]	0	ND

Notes:

1 This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

2 Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the seasonal average (April 1 to September 30).

3 Sampling/monitoring locations are shown on Figure D.2-1.

4 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

5 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

6 Hoover Dam discharge data is from the lower intake only.

7 No data exists for the SNWA 1,000-ft (30-m) intake.

Source: Black and Veatch 2004d.

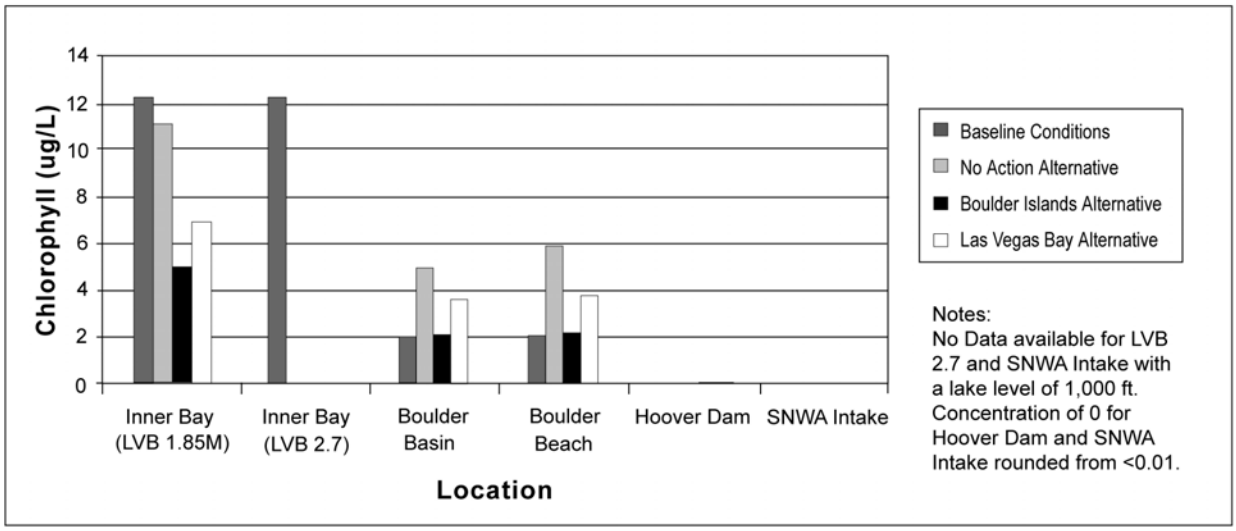

Figure D.2-4 Chlorophyll Concentrations under the No Action, Boulder Islands, and Las Vegas Bay Alternatives for year 2030 at a Lake Level of 1,000 ft (30 m).

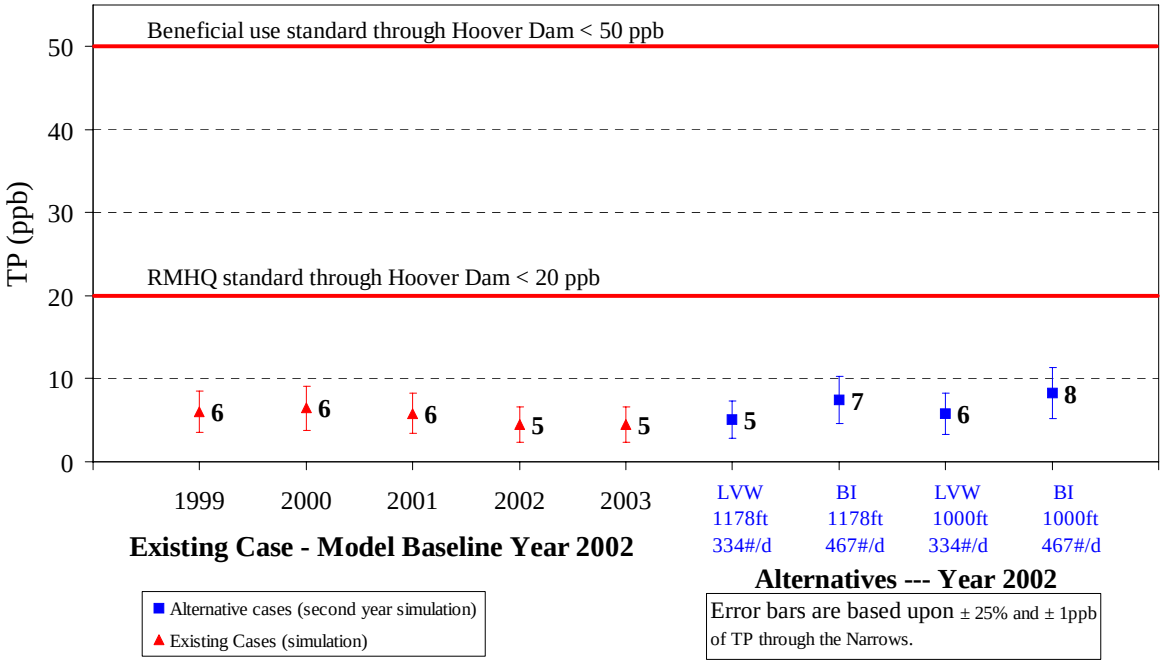

Figure D.2-5 Simulated Annual Average Total Phosphorus at Hoover Dam.

D.2.3.2 Boulder Islands Alternatives (North and South)

The Boulder Islands North Alternative and Boulder Islands South Alternative each include a pipeline that would bypass the majority of the lower Las Vegas Wash via the EI. Highly treated effluent discharged from each of the treatment facilities would be collected and transported to a receiving area in the vicinity of the Boulder Islands. Current, conventional treatment processes would continue to be used to meet the requirements set by the NDEP through the NPDES permitting program. Plant optimization would be implemented when current treatment processes alone could not treat wastewater to levels needed to meet water-quality objectives. The modeling results for the Boulder Islands Alternatives with flows of 300 mgd (462 cfs) and 400 mgd (616 cfs) at Lake levels of 1,178 ft (359 m) and 1,000 ft (30 m) are discussed in this section. The TP loading would be 467 lbs/day and 592 lbs/day, respectively, which is the achievable loading that would be attained using current, conventional treatment processes.

D.2.3.2.1 Boulder Islands North and South Alternatives at Lake Level of 1,178 ft (359 m)

Table D.2-7 presents the modeling results for the Boulder Islands Alternatives with flows of 300 mgd (462 cfs) at a Lake level of 1,178 ft (359 m). The data shows that the concentrations of all the parameters analyzed in the inner Las Vegas Bay decrease under these conditions. The concentrations of most parameters increase in the vicinity of Boulder Basin (CR 346.4) and Boulder Beach, but the increases are minimal and do not result in exceedances of water-quality standards (Table D.0-1).

Table D.2-8 and Figure D.2-3 show that the Boulder Islands Alternatives reduces chlorophyll concentrations in the inner Las Vegas Bay (Figure D.2-2). Chlorophyll concentrations in the Boulder Basin (CR 346.4) increase slightly, but remain well below water-quality standards.

Secchi depth would increase at all locations. Secchi depth in the inner Las Vegas Bay would increase as much as 2.6 m (8.5 ft).

Total Phosphorus concentrations at Hoover Dam would increase minimally under the Boulder Islands Alternative (Figure D.2-5).

Table D.2-9 presents the modeling results for the Boulder Islands Alternatives with flows of 400 mgd (616 cfs) at a Lake level of 1,178 ft (359 m). The data shows that the concentrations of all the parameters analyzed in the inner Las Vegas Bay decrease compared to baseline conditions, but increase compared to year 2030 concentrations.

The 2050 flows result in parameter concentration increases slightly higher than seen for the 2030 flows. The increases do not result in exceedances of water-quality standards (Table D.0-1).

Table D.2-10 and Figure D.2-6 show that with flows of 400 mgd, the Boulder Islands Alternatives reduce chlorophyll concentrations in the inner Las Vegas Bay. Chlorophyll concentrations in the Boulder Basin (CR 346.4) increase slightly, but remain well below water-quality standards.

Secchi depth would increase in the inner Las Vegas Bay by approximately 2.1 m (6.9 ft). Secchi depth in the Boulder Basin (CR 346.4) and at Boulder Beach would decrease approximately 0.4 m (1.3 ft) and 0.7 m (2.3 ft), respectively.

Total Phosphorus concentrations at Hoover Dam would increase under the Boulder Islands Alternative with 2050 flows (Figure D.2-5).

Table D.2-7 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,178 ft [359 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 685]	20.1 [68.2]	20.3 [68.5]	20.0 [68.0]	19.6 [67.3]	19.6 [67.3]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	13.3 [55.9]	13.0 [55.4]	13.0 [55.4]
Perchlorate (µg/L)	45.2	11.5	46.7	11.8	12.9	3.0	13.9	3.2	6.6	1.6	5.8	1.4
Conductivity (µS/cm)	1085	1,047	1094	1,050	947	957	952	961	901	915	896	905
Total Dissolved Solids (mg/L)[5]	687	663	693	665	599	606	603	608	570	579	567	573
Dissolved Oxygen (mg/L)	8.7	8.5	8.7	8.5	8.3	8.3	8.3	8.3	7.7	7.6	7.5	7.5
Chlorophyll (µg/L)	12.4	6.3	12.4	6.3	2.0	2.2	2.1	2.1	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01
Secchi Depth (m)	3.2	5.8	3.2	5.8	8.5	9.4	8.8	9.7	ND[6]	ND[6]	ND[6]	ND[6]
Total Phosphorus (mg/L)	0.018	0.009	0.018	0.009	0.005	0.007	0.005	0.007	0.005	0.008	0.004	0.006
Soluble Phosphorus (mg/L)	0.009	0.006	0.009	0.006	0.003	0.005	0.003	0.005	0.004	0.007	0.004	0.005
Total Nitrogen (mg/L)	1.61	0.88	1.68	0.88	0.42	0.58	0.44	0.58	0.34	0.52	0.36	0.46
Total Inorganic Nitrogen (mg/L)[7]	1.57	0.84	1.64	0.85	0.40	0.56	0.43	0.56	0.32	0.50	0.33	0.43
Nitrate (mg/L)	1.56	0.83	1.63	0.84	0.39	0.55	0.42	0.55	0.31	0.48	0.31	0.41
Total Ammonia Nitrogen (mg/L)	0.012	0.014	0.013	0.014	0.001	0.013	0.011	0.013	0.014	0.018	0.019	0.021

Table D.2-7 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,178 ft [359 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Un-ionized Ammonia (mg/L)	0.0008	≤0.001	0.0008	≤0.001	0.0002	≤0.001	0.0004	≤0.001	0.0002	≤0.001	0.0003	≤0.001
Bromide (mg/L)	0.106	0.098	0.107	0.098	0.086	0.086	0.087	0.087	0.080	0.081	0.080	0.080
Sulfate (mg/L)	295	279	297	280	257	255	259	256	243	244	242	242
Chloride (mg/L)	107	102	108	103	85	89	85	89	79	83	78	81
Fecal Coliform (MPN/dL)[8]	1.0	0.9	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ph	8.1	8.0	8.1	8.0	8.0	7.9	8.0	7.9	7.7	7.7	7.7	7.7

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the mean seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 Hoover Dam discharge data is from upper and lower intakes combined.

4 SNWA data is for intake located at 1,000 ft (30 m).

5 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

6 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

7 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

8 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d [348].

Table D.2-8 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Boulder Islands Alternative[1] (1,178 ft [359 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day).

Location[3]	**Chlorophyll (µg/L)**[2]	
	Baseline Conditions	**Boulder Islands Alternative**
Inner Bay (LVB 1.85M)[4]	12.4	6.3
Inner Bay (LVB 2.7)	12.4	6.3
Boulder Basin (CR 346.4)	2.0	2.2
Boulder Beach	2.1	2.1
Hoover Dam[5]	0	0
SNWA Intake[6]	0	0

Notes:

[1] This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

[2] Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

[3] Sampling/monitoring locations are shown on Figure D.2-1.

[4] M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

[5] Hoover Dam discharge data is from upper and lower intakes combined.

[6] SNWA data is for intake located at 1,000 ft (30 m).

Source: Black and Veatch 2004d.

Table D.2-9 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,178 ft [359 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	20.0 [68.0]	20.3 [68.5]	20.0 [68.0]	19.6 [67.3]	19.6 [67.3]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	13.3 [55.9]	13.0 [55.4]	13.0 [55.4]
Perchlorate (µg/L)	45.2	11.4	46.7	11.6	12.9	3.0	13.9	3.2	6.6	1.6	5.8	1.4
Conductivity (µS/cm)	1085	1053	1094	1056	947	965	952	969	901	920	896	909
Total Dissolved Solids (mg/L)[5]	687	667	693	668	599	611	603	613	570	582	567	576
Dissolved Oxygen (mg/L)	8.7	8.5	8.7	8.5	8.3	8.3	8.3	8.2	7.7	7.5	7.5	7.5
Chlorophyll (µg/L)	12.4	7.4	12.4	7.4	2.0	2.7	2.1	2.7	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01
Secchi Depth (m)	3.2	5.3	3.2	5.3	8.5	8.1	8.8	8.1	ND[6]	ND[6]	ND[6]	ND[6]
Total Phosphorus (mg/L)	0.018	0.011	0.018	0.011	0.005	0.008	0.005	0.008	0.005	0.009	0.004	0.007
Soluble Phosphorus (mg/L)	0.009	0.007	0.009	0.007	0.003	0.006	0.003	0.006	0.004	0.008	0.004	0.006
Total Nitrogen (mg/L)	1.61	0.93	1.7	0.94	0.4	0.67	0.4	0.66	0.3	0.58	0.4	0.51
Total Inorganic Nitrogen (mg/L)[7]	1.61	0.90	1.61	0.90	0.41	0.64	0.41	0.64	0.31	0.56	0.32	0.47
Nitrate (mg/L)	1.56	0.88	1.63	0.89	0.39	0.63	0.42	0.63	0.31	0.54	0.31	0.45
Total Ammonia Nitrogen (mg/L)	0.012	0.015	0.013	0.015	0.010	0.014	0.011	0.014	0.014	0.018	0.019	0.022

Table D.2-9 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,178 ft [359 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Un-ionized Ammonia (mg/L)	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Bromide (mg/L)	0.106	0.099	0.107	0.099	0.086	0.087	0.087	0.088	0.080	0.082	0.080	0.081
Sulfate (mg/L)	295	280	297	280	257	256	259	257	243	245	242	243
Chloride (mg/L)	107	104	108	104	85	90	85	91	79	84	78	82
Fecal Coliform (MPN/dL)[8]	1.0	0.9	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pH	8.1	8.0	8.1	8.0	8.0	8.0	8.0	8.0	7.7	7.7	7.7	7.7

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 Hoover Dam discharge data is from upper and lower intakes combined.

4 SNWA data is for intake located at 1,000 ft (30 m).

5 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

6 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

7 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

8 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-10 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Boulder Islands Alternative[1] (1,178 ft [359 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day).

Location[3]	Chlorophyll (µg/L)[2]	
	Baseline Conditions	Boulder Islands Alternative
Inner Bay (LVB 1.85M)[4]	12.4	7.4
Inner Bay (LVB 2.7)	12.4	7.4
Boulder Basin (CR 346.4)	2.0	2.7
Boulder Beach	2.1	2.7
Hoover Dam[5]	0	0
SNWA Intake[6]	0	0

Notes:

[1] This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

[2] Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

[3] Sampling/monitoring locations are shown on Figure D.2-1.

[4] M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

[5] Hoover Dam discharge data is from upper and lower intakes combined.

[6] SNWA data is for intake located at 1,000 ft (30 m).

Source: Black and Veatch 2004d.

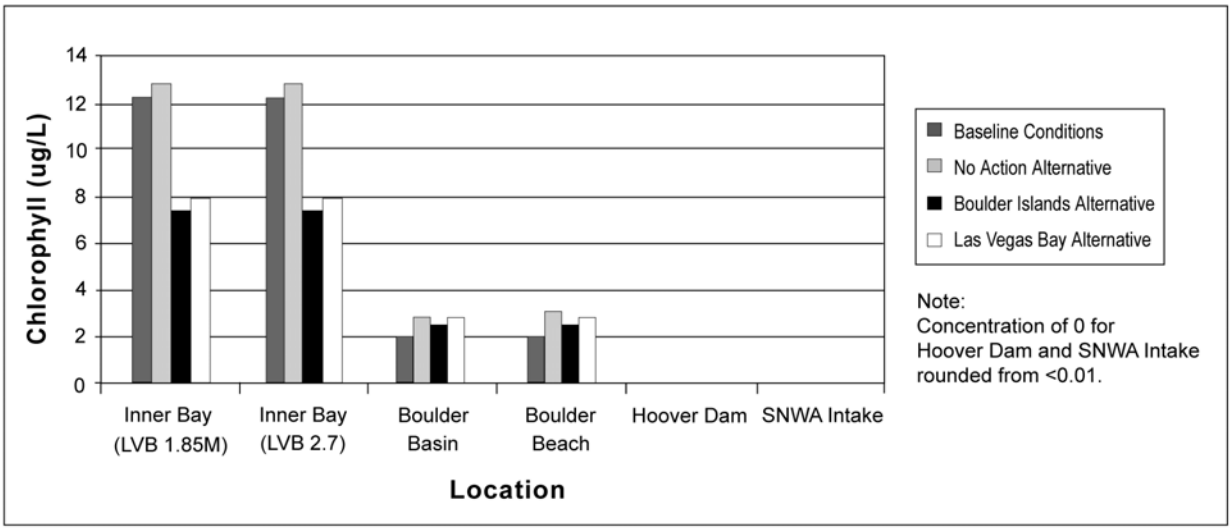

Figure D.2-6 Chlorophyll Concentrations under the No Action, Boulder Islands, and Las Vegas Bay Alternatives for year 2050 at a Lake Level of 1,178 ft (359 m).

D.2.3.2.2 Boulder Islands Alternatives at Lake Level of 1,000 ft (30 m)

Table D.2-11 presents the modeling results for the Boulder Islands Alternatives with flows of 300 mgd (462 cfs) at a Lake level of 1,000 ft (30 m). The data shows that the concentrations of all the parameters analyzed decrease in the inner Las Vegas Bay. The concentrations of most parameters increase in the vicinity of Hoover Dam and approximately half of the parameters increase in the vicinity of Boulder Basin (CR 346.4) and Boulder Beach. However, the increases are minimal and do not result in exceedances of water-quality standards (Table D.0-1).

Table D.2-12 and Figure D.2-4 show that the Boulder Islands Alternatives reduces chlorophyll concentrations in the inner Las Vegas Bay (Figure D.2-3). Chlorophyll concentrations in the Boulder Basin (CR 346.4), Boulder Beach, and Hoover Dam increase slightly, but remain well below water-quality standards.

Secchi depth would increase at all locations except Hoover Dam, which would only decrease by 0.2 m (0.7 ft). Secchi depth in the inner Las Vegas Bay would increase as much as 3.8 m (12.5 ft).

Total Phosphorus concentrations at Hoover Dam would increase by approximately 0.003 mg/L under the Boulder Islands Alternatives (Figure D.2-5).

Table D.2-13 presents the modeling results for the Boulder Islands Alternatives with flows of 400 mgd (616 cfs) at a Lake level of 1,000 ft (30 m). The data shows that the concentrations of all the parameters analyzed in the inner Las Vegas Bay decrease compared to baseline conditions, but increase compared to year 2030 concentrations. The increases do not result in exceedances of water-quality standards (Table D.0-1).

Table D.2-14 and Figure D.2-7 show that with flows of 400 mgd, the Boulder Islands Alternatives reduce chlorophyll concentrations in the inner Las Vegas Bay. Chlorophyll concentrations in the Boulder Basin (CR 346.4) and Boulder Beach increase slightly, but remain well below water-quality standards.

Secchi depth would increase in the inner Las Vegas Bay and Boulder Basin, but decrease approximately 2.2 m (7.2 ft) at Boulder Beach.

Total Phosphorus concentrations at Hoover Dam would increase by approximately 0.005 mg/L under the Boulder Islands Alternatives (Figure D.2-5).

Table D.2-11 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,000 ft [30 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	19.9 [67.8]	20.3 [68.5]	ND	19.6 [67.3]	19.5 [67.1]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	14.9 [58.8]	13.0 [55.4]	ND
Perchlorate (µg/L)	45.2	11.0	46.7	ND	12.9	3.4	13.9	4.0	6.6	1.6	5.8	ND
Conductivity (µS/cm)	1085	1,011	1094	ND	947	932	952	940	901	909	896	ND
Total Dissolved Solids (mg/L)[6]	687	640	693	ND	599	590	603	595	570	575	567	ND
vDissolved Oxygen (mg/L)	8.7	8.5	8.7	ND	8.3	8.3	8.3	8.2	7.7	7.5	7.5	ND
Chlorophyll (µg/L)	12.4	5.1	12.4	ND	2.0	2.2	2.1	2.4	≤ 0.01	0.1	≤ 0.01	ND
Secchi Depth (m)	3.2	7.0	3.2	ND	8.5	9.1	8.8	8.9	ND[7]	ND[7]	ND[7]	ND
Total Phosphorus (mg/L)	0.018	0.007	0.018	ND	0.005	0.005	0.005	0.005	0.005	0.008	0.004	ND
Soluble Phosphorus (mg/L)	0.009	0.005	0.009	ND	0.003	0.004	0.003	0.004	0.004	0.007	0.004	ND
Total Nitrogen (mg/L)	1.61	0.87	1.68	ND	0.42	0.59	0.44	0.62	0.34	0.79	0.36	ND
Total Inorganic Nitrogen (mg/L)[8]	1.57	0.84	1.64	ND	0.40	0.57	0.43	0.60	0.32	0.75	0.33	ND
Nitrate (mg/L)	1.56	0.82	1.63	ND	0.39	0.55	0.42	0.58	0.31	0.72	0.31	ND
Total Ammonia Nitrogen (mg/L)	0.012	0.019	0.013	ND	0.010	0.017	0.011	0.018	0.014	0.029	0.019	ND

Table D.2-11 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,000 ft [30 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Un-ionized Ammonia (mg/L)	.0008	≤0.001	0.0008	ND	0.0002	≤0.001	0.0004	≤0.001	0.0002	≤0.001	0.0003	ND
Bromide (mg/L)	0.106	0.095	0.107	ND	0.086	0.085	0.087	0.085	0.080	0.082	0.080	ND
Sulfate (mg/L)	295	273	297	ND	257	252	259	254	243	243	242	ND
Chloride (mg/L)	107	98	108	ND	85	86	85	87	79	83	78	ND
Fecal Coliform (MPN/dL)[9]	1.0	0.5	1.1	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND
Ph	8.1	8.0	8.1	ND	8.0	7.9	8.0	7.9	7.7	7.7	7.7	ND

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the mean seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

4 Hoover Dam discharge data is from the lower intake only.

5 No data exists for the SNWA 1,000-ft (30-m) intake.

6 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

7 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

8 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

9 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-12 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Boulder Islands Alternative[1] (1,000 ft [30 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day).

Location[3]	Chlorophyll (µg/L)[2]	
	Baseline Conditions	**Boulder Islands Alternative**
Inner Bay (LVB 1.85M)[4]	12.4	5.1
Inner Bay (LVB 2.7)[5]	12.4	ND
Boulder Basin (CR 346.4)	2.0	2.2
Boulder Beach	2.1	2.4
Hoover Dam[6]	0	0.1
SNWA Intake[7]	0	ND

Notes:

[1] This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

[2] Samples for chlorophyll taken within over the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

[3] Sampling/monitoring locations are shown on Figure D.2-1.

[4] M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1,178 ft (359m) is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

[5] ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

[6] Hoover Dam discharge data is from the lower intake only.

[7] No data exists for the SNWA 1,000-ft (30-m) intake.

Source: Black and Veatch 2004d.

Table D.2-13 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,000 ft [30 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	19.8 [67.7]	20.3 [68.5]	ND	19.6 [67.3]	19.5 [67.1]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	14. [57.5]	13.0 [55.4]	ND
Perchlorate (µg/L)	45.2	10.8	46.7	ND	12.9	3.2	13.9	3.8	6.6	1.3	5.8	ND
Conductivity (µS/cm)	1085	1010	1094	ND	947	934	952	941	901	907	896	ND
Total Dissolved Solids (mg/L)[6]	687	640	693	ND	599	591	603	596	570	574	567	ND
Dissolved Oxygen (mg/L)	8.7	8.5	8.7	ND	8.3	8.3	8.3	8.3	7.7	7.4	7.5	ND
Chlorophyll (µg/L)	12.4	6.1	12.4	ND	2.0	2.6	2.1	2.8	≤ 0.01	≤ 0.01	≤ 0.01	ND
Secchi Depth (m)	3.2	6.3	3.2	ND	8.5	10.3	8.8	6.6	ND[7]	ND[7]	ND[7]	ND[7]
Total Phosphorus (mg/L)	0.018	0.008	0.018	ND	0.005	0.006	0.005	0.006	0.005	0.010	0.004	ND
Soluble Phosphorus (mg/L)	0.009	0.006	0.009	ND	0.003	0.004	0.003	0.004	0.004	0.008	0.004	ND
Total Nitrogen (mg/L)	1.61	0.89	1.68	ND	0.42	0.64	0.44	0.68	0.34	0.88	0.36	ND
Total Inorganic Nitrogen (mg/L)[8]	1.61	0.85	1.61	ND	0.41	0.62	0.41	0.65	0.31	0.83	0.32	ND
Nitrate (mg/L)	1.56	0.83	1.63	ND	0.39	0.60	0.42	0.63	0.31	0.79	0.31	ND
Total Ammonia Nitrogen (mg/L)	0.012	0.020	0.013	ND	0.010	0.019	0.011	0.019	0.014	0.032	0.019	ND

Table D.2-13 Lake Mead Modeling Results for the Boulder Islands Alternative[1] (1,000 ft [30 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Bromide (mg/L)	0.106	0.095	0.107	ND	0.086	0.085	0.087	0.086	0.080	0.082	0.080	ND
Sulfate (mg/L)	295	272	297	ND	257	252	259	253	243	242	242	ND
Chloride (mg/L)	107	98	108	ND	85	86	85	87	79	83	78	ND
Fecal Coliform (MPN/dL)[9]	1.0	0.5	1.1	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND
pH	8.1	8.0	8.1	ND	8.0	7.9	8.0	8.0	7.7	7.7	7.7	ND

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

4 Hoover Dam discharge data is from the lower intake only.

5 No data exists for the SNWA 1,000-ft (30-m) intake.

6 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

7 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property at the lake surface.

8 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

9 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-14 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Boulder Islands Alternative[1] (1,000 ft (30 m) Lake level for year 2050 with effluent flows of L00 mgd [616 cfs] and effluent TP = 592 lbs/day).

Location[3]	Chlorophyll (µg/L)[2]	
	Baseline Conditions	Boulder Islands Alternative
Inner Bay (LVB 1.85M)[4]	12.4	6.1
Inner Bay (LVB 2.7)[5]	12.4	ND
Boulder Basin (CR 346.4)	2.0	2.6
Boulder Beach	2.1	2.8
Hoover Dam[6]	0	0
SNWA Intake[7]	0	ND

Notes:

1 This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

2 Samples for chlorophyll taken within over the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

3 Sampling/monitoring locations are shown on Figure D.2-1.

4 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1,178 ft (359m) is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

5 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

6 Hoover Dam discharge data is from the lower intake only.

7 No data exists for the SNWA 1,000-ft (30-m) intake.

Source: Black and Veatch 2004d.

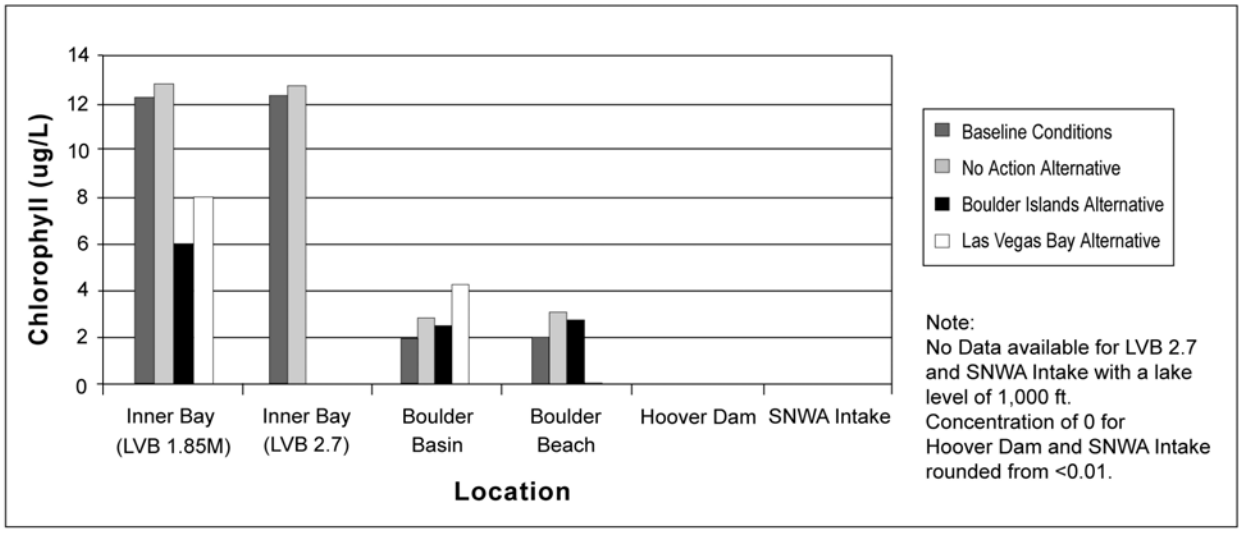

Figure D.2-7 Chlorophyll Concentrations under the No Action, Boulder Islands, and Las Vegas Bay Alternatives for year 2050 at a Lake Level of 1,000 ft (30 m).

D.2.3.3 Las Vegas Bay Alternative

This alternative would include a pipeline that would bypass the majority of the lower Las Vegas Wash via the EI. Highly treated effluent discharged from each of the CWC's treatment facilities would be collected in a pipeline and transported to an alternate receiving area in the Las Vegas Bay. Current, conventional treatment processes would continue to be used to meet the requirements set by the NDEP through the NPDES permitting program. Plant optimization would be implemented when current treatment processes alone could not treat wastewater to levels needed to meet water-quality objectives. The modeling results for the Las Vegas Bay Alternative with flows of 300 mgd (462 cfs) and 400 mgd (616 cfs) at Lake levels of 1,178 ft (359m) and 1,000 ft (30 m) are discussed in this section. The TP loading would be 467 lbs/day and 592 lbs/day, respectively, which is the achievable loading that would be attained using current, conventional treatment processes.

D.2.3.3.1 Las Vegas Bay Alternative at Lake Level of 1,178 ft (359m)

Table D.2-15 presents the modeling results for the Las Vegas Bay Alternative with flows of 300 mgd (462 cfs) at a Lake level of 1,178 ft (359m). The data shows that the concentrations of all the parameters analyzed in the inner Las Vegas Bay decrease under the Las Vegas Bay Alternative. Most of the parameter concentrations decrease at Boulder Basin (CR 346.4). The concentrations of most parameters increase in the vicinity of Boulder Beach, Hoover Dam Discharge, and SNWA Intake, but the increases are minimal and do not result in exceedances of water quality standards (Table D.0-1).

Table D.2-16 and Figure D.2-3 show that the Las Vegas Bay Alternative reduces chlorophyll concentrations in the inner Las Vegas Bay. Chlorophyll concentrations in the Boulder Basin (CR 346.4) increase slightly, but remain well below water quality standards.

Secchi depth would increase or remain the same as baseline at all locations except the Hoover Dam Discharge location. The Secchi depth would decrease by less than 0.2 m (less than 7 inches) at the Hoover Dam Discharge location. Secchi depth in the inner Las Vegas Bay would increase as much as 2.4 m (7.9 ft).

Total Phosphorus concentrations at Hoover Dam would increase minimally under the Las Vegas Bay Alternative (Figure D.2-5).

Table D.2-17 presents the modeling results for the Las Vegas Bay Alternative with flows of 400 mgd (616 cfs) at a Lake level of 1,178 ft (359m). The data shows that the concentrations of all the parameters analyzed in the inner Las Vegas Bay decrease compared to baseline conditions, but increase compared to year 2030 concentrations. The increases do not result in exceedances of water-quality standards (Table D.0-1).

Table D.2-18 and Figure D.2-6 show that the Las Vegas Bay Alternative reduces chlorophyll concentrations compared to baseline conditions in the inner Las Vegas Bay, but slightly increase chlorophyll concentrations compared to the 2030 flow concentrations. Chlorophyll concentrations in the Boulder Basin (CR 346.4) increase slightly compared to the 2030 flow concentrations, but remain well below water-quality standards.

Table D.2-15 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,178 ft [359] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	20.1 [68.2]	20.3 [68.5]	20.1 [68.2]	19.6 [67.3]	19.5 [67.1]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	13.3 [55.9]	13.0 [55.4]	13.0 [55.4]
Perchlorate (µg/L)	45.2	11.5	46.7	11.8	3.1	3.4	13.9	3.3	6.6	1.6	5.8	1.4
Conductivity (µS/cm)	1085	1,056	1094	1,060	959	932	952	964	901	914	896	906
Total Dissolved Solids (mg/L)[5]	687	669	693	671	607	590	603	610	570	579	567	574
Dissolved Oxygen (mg/L)	8.7	8.5	8.7	8.5	8.3	8.3	8.3	8.3	7.7	7.6	7.5	7.5
Chlorophyll (µg/L)	12.4	6.7	12.4	6.7	2.0	2.2	2.1	2.3	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01
Secchi Depth (m)	3.2	5.6	3.2	5.6	9.1	9.1	8.8	9.4	ND[6]	ND[6]	ND[6]	ND[6]
Total Phosphorus (mg/L)	0.018	0.010	0.018	0.011	0.007	0.005	0.005	0.007	0.005	0.007	0.004	0.006
Soluble Phosphorus (mg/L)	0.009	0.007	0.009	0.007	0.005	0.004	0.003	0.005	0.004	0.007	0.004	0.006
Total Nitrogen (mg/L)	1.61	1.02	1.68	1.03	0.42	0.57	0.44	0.60	0.34	0.50	0.36	0.48
Total Inorganic Nitrogen (mg/L)[7]	1.57	0.98	1.64	0.99	0.40	0.55	0.43	0.58	0.32	0.48	0.33	0.44
Nitrate (mg/L)	1.56	.097	1.63	0.98	0.39	0.54	0.42	0.56	0.31	0.46	0.31	0.42
Total Ammonia Nitrogen (mg/L)	0.012	0.016	0.013	0.016	0.010	0.012	0.011	0.013	0.014	0.017	0.019	0.021
Un-ionized Ammonia (mg/L)	0.0008	≤0.001	0.0008	≤0.001	≤0.001	≤0.001	0.0004	≤0.001	0.0002	≤0.001	0.0003	≤0.001

Table D.2-15 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,178 ft [359] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Bromide (mg/L)	0.106	0.100	0.107	0.100	0.086	0.087	0.087	0.087	0.080	0.081	0.080	0.080
Sulfate (mg/L)	295	280	297	281	255	252	259	256	243	244	242	242
Chloride (mg/L)	107	104	108	105	89	86	85	90	79	83	78	81
Fecal Coliform (MPN/dL)[8]	1.0	0.9	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ph	8.1	8.0	8.1	8.0	7.9	7.9	8.0	7.9	7.7	7.7	7.7	7.7

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the mean seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 Hoover Dam discharge data is from upper and lower intakes combined.

4 SNWA data is for intake located at 1,000 ft (30 m).

5 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

6 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

7 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

8 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-16 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Las Vegas Bay Alternative[1] (1,178 ft (359m) Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP=467 lbs/day).

Location[3]	**Chlorophyll (µg/L)[2]**	
	Baseline Conditions	**Las Vegas Bay Alternative**
Inner Bay (LVB 1.85M)[4]	12.4	6.7
Inner Bay (LVB 2.7)	12.4	6.7
Boulder Basin (CR 346.4)	2.0	2.2
Boulder Beach	2.1	2.3
Hoover Dam[5]	0	0
SNWA Intake[6]	0	0

Notes:

[1] This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table 3.1-5.

[2] Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

[3] Sampling/monitoring locations are shown on Figure D.2-1.

[4] M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1,178 ft (359 m) is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

[5] Hoover Dam discharge data is from upper and lower intakes combined.

[6] SNWA data is for intake located at 1,000 ft (30 m).

Source: Black and Veatch 2004d.

Table D.2-17 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,178 ft [359 m] Lake level for year 2030 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	20.1 [68.2]	20.3 [68.5]	20.0 [68.0]	19.6 [67.3]	19.6 [67.3]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	13.3 [55.9]	13.0 [55.4]	13.0 [55.4]
Perchlorate (µg/L)	45.2	11.4	46.7	11.6	3.1	3.0	13.9	3.2	6.6	1.6	5.8	1.4
Conductivity (µS/cm)	1085	1065	1094	1068	959	967	952	972	901	920	896	911
Total Dissolved Solids (mg/L)[5]	687	674	693	676	607	612	603	615	570	582	567	576
Dissolved Oxygen (mg/L)	8.7	8.5	8.7	8.5	8.3	8.3	8.3	8.2	7.7	7.5	7.5	7.4
Chlorophyll (µg/L)	12.4	7.9	12.4	7.9	2.0	3.0	2.1	2.9	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01
Secchi Depth (m)	3.2	5.1	3.2	5.1	9.1	7.8	8.8	7.9	ND[6]	ND[6]	ND[6]	ND[6]
Total Phosphorus (mg/L)	0.018	0.013	0.018	0.013	0.007	0.008	0.005	0.008	0.005	0.009	0.004	0.007
Soluble Phosphorus (mg/L)	0.009	0.009	0.009	0.009	0.005	0.006	0.003	0.006	0.004	0.008	0.004	0.007
Total Nitrogen (mg/L)	1.61	1.12	1.68	1.13	0.42	0.65	0.44	0.69	0.34	0.56	0.36	0.53
Total Inorganic Nitrogen (mg/L)[7]	1.61	1.08	1.61	1.09	0.55	0.63	0.41	0.66	0.31	0.54	0.32	0.49
Nitrate (mg/L)	1.56	1.06	1.63	1.07	0.39	0.61	0.42	0.65	0.31	0.52	0.31	0.47
Total Ammonia Nitrogen (mg/L)	0.012	0.018	0.013	0.018	0.010	0.014	0.011	0.015	0.014	0.018	0.019	0.023
Un-ionized Ammonia (mg/L)	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003

Table D.2-17 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,178 ft [359 m] Lake level for year 2030 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[3]		SNWA Intake[4]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Bromide (mg/L)	0.106	0.101	0.107	0.101	0.086	0.088	0.087	0.089	0.080	0.082	0.080	0.081
Sulfate (mg/L)	295	281	297	282	255	256	259	257	243	245	242	243
Chloride (mg/L)	107	106	108	107	89	91	85	92	79	84	78	82
Fecal Coliform (MPN/dL)[8]	1.0	0.9	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pH	8.1	8.1	8.1	8.1	7.9	8.0	8.0	8.0	7.7	7.7	7.7	7.7

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 Hoover Dam discharge data is from upper and lower intakes combined.

4 SNWA data is for intake located at 1,000 ft (30 m).

5 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

6 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property at the lake surface.

7 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

8 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-18 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Las Vegas Bay Alternative[1] (1,178 ft [359] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP=592 lbs/day).

Location[3]	Chlorophyll (µg/L)[2]	
	Baseline Conditions	Las Vegas Bay Alternative
Inner Bay (LVB 1.85M)[4]	12.4	7.9
Inner Bay (LVB 2.7)	12.4	7.9
Boulder Basin (CR 346.4)	2.0	3.0
Boulder Beach	2.1	2.9
Hoover Dam[5]	0	0
SNWA Intake[6]	0	0

Notes:
1 This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.
2 Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).
3 Sampling/monitoring locations are shown on Figure D.2-1.
4 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1,178 ft (359 m) is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.
5 Hoover Dam discharge data is from upper and lower intakes combined.
6 SNWA data is for intake located at 1,000 ft (30 m).

Source: Black and Veatch 2004d.

Secchi depth would increase in the inner Las Vegas Bay by approximately 1.9 m (6.2 ft) compared to baseline conditions. Secchi depth in the Boulder Basin (CR 346.4) and at Boulder Beach would decrease approximately 1.3 m (4.3 ft) and 0.9 m (3.0 ft), respectively.

Total Phosphorus concentrations at Hoover Dam would increase by approximately .004 mg/L under the Las Vegas Bay Alternative with 2050 flows (Figure D.2-5).

D.2.3.3. Las Vegas Bay Alternative at Lake Level of 1,000 ft (30 m)

Table D.2-19 presents the modeling results for the Las Vegas Bay Alternative with flows of 300 mgd (462 cfs) at a lake level of 1,000 ft (30 m). The data shows that the concentrations of all the parameters analyzed decrease in the inner Las Vegas Bay. The concentrations of approximately half of the parameters in the vicinity of Boulder Basin (CR 346.4) increase. The concentrations of most of the parameters in the vicinity of Boulder Beach, and Hoover Dam increase. However, the increases are minimal and do not result in exceedances of water-quality standards (Table D.0-1).

Table D.2-20 and Figure D.2-4 show that the Las Vegas Bay Alternative reduces chlorophyll concentrations in the inner Las Vegas Bay. Chlorophyll concentrations in the Boulder Basin (CR 346.4), Boulder Beach, and Hoover Dam increase slightly, but remain below water-quality standards.

Secchi depth in the inner Las Vegas Bay would increase approximately 2.6 m (8.5 ft). Decreases of up to 1.6 m (5.2 ft) at Boulder Basin (CR 346.4), Boulder Beach, and Hoover Dam would occur.

Table D.2-19 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,000 ft [30 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	20.1 [68.2]	20.3 [68.5]	ND	19.6 [67.3]	19.6 [67.3]	19.3 [66.7]	19.4 [66.9]	13.2 [55.8]	14.8 [58.6]	13.0 [55.4]	ND
Perchlorate (µg/L)	45.2	10.9	46.7	ND	3.1	3.4	13.9	3.9	6.6	1.7	5.8	ND
Conductivity (µS/cm)	1085	1,050	1094	ND	959	945	952	956	901	908	896	ND
Total Dissolved Solids (mg/L)[6]	687	664	693	ND	607	598	603	605	570	575	567	ND
Dissolved Oxygen (mg/L)	8.7	8.4	8.7	ND	8.3	8.2	8.3	8.2	7.7	7.4	7.5	ND
Chlorophyll (µg/L)	12.4	6.8	12.4	ND	2.0	3.6	2.1	3.7	≤ 0.01	0.1	≤ 0.01	ND
Secchi Depth (m)	3.2	5.8	3.2	ND	9.1	7.5	8.8	7.5	ND[7]	ND[7]	ND[7]	ND[7]
Total Phosphorus (mg/L)	0.018	0.014	0.018	ND	0.007	0.006	0.005	0.007	0.005	0.008	0.004	ND
Soluble Phosphorus (mg/L)	0.009	0.007	0.009	ND	0.005	0.004	0.003	0.005	0.004	0.007	0.004	ND
Total Nitrogen (mg/L)	1.61	1.54	1.68	ND	0.42	0.76	0.44	0.85	0.34	0.72	0.36	ND
Total Inorganic Nitrogen (mg/L)[8]	1.57	1.48	1.64	ND	0.40	0.73	0.43	0.82	0.32	0.69	0.33	ND
Nitrate (mg/L)	1.56	1.45	1.63	ND	0.39	0.71	0.42	0.79	0.31	0.66	0.31	ND

Table D.2-19 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,000 ft [30 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Total Ammonia Nitrogen (mg/L)	0.012	0.028	0.013	ND	0.010	0.020	0.011	0.021	0.014	0.029	0.019	ND
Total Ammonia Nitrogen (mg/L)	0.012	0.028	0.013	ND	0.010	0.020	0.011	0.021	0.014	0.029	0.019	ND
Un-ionized Ammonia (mg/L)	0.0008	≤ 0.001	0.0008	ND	≤0.001	≤ 0.001	0.0004	≤ 0.001	0.0002	≤ 0.001	0.0003	ND
Sulfate (mg/L)	295	277	297	ND	255	253	259	255	243	243	242	ND
Chloride (mg/L)	107	106	108	ND	89	88	85	90	79	83	78	ND
Fecal Coliform (MPN/dL)[9]	1.0	0.5	1.1	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND
Ph	8.1	8.0	8.1	ND	7.9	8.0	8.0	8.0	7.7	7.7	7.7	ND

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the mean seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

4 Hoover Dam discharge data is from the lower intake only.

5 No data exists for the SNWA 1,000-ft (30-m) intake.

6 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

7 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property of lake surface.

8 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

9 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-20 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Las Vegas Bay Alternative[1] (1,000 ft [30 m] Lake level for year 2030 with effluent flows of 300 mgd [462 cfs] and effluent TP = 467 lbs/day).

Location[3]	Chlorophyll (µg/L)[2]	
	Baseline Conditions	Las Vegas Bay Alternative
Inner Bay (LVB 1.85M)[4]	12.4	6.8
Inner Bay (LVB 2.7)[5]	12.4	ND
Boulder Basin (CR 346.4)	2.0	3.6
Boulder Beach	2.1	3.7
Hoover Dam[6]	0	0.1
SNWA Intake[7]	0	ND

Notes:

1 This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

2 Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

3 Sampling/monitoring locations are shown on Figure D.2-1.

4 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1,178 ft (359 m) is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

5 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

6 Hoover Dam discharge data is from the lower intake only.

7 No data exists for the SNWA 1,000-ft (30-m) intake.

Source: Black and Veatch 2004d.

Total Phosphorus concentrations at Hoover Dam would increase by approximately 0.003 mg/L under the Las Vegas Bay Alternative (Figure D.2-5).

Table D.2-21 presents the modeling results for the Las Vegas Bay Alternative with flows of 400 mgd (616 cfs) at a lake level of 1,000 ft (30 m). The data shows that concentrations of some parameters such as Total Nitrogen, TIN, and Total Ammonia Nitrogen increase in the inner Las Vegas Bay compared to baseline conditions. The increases do not result in exceedances of water-quality standards (Table D.0-1).

Table D.2-22 and Figure D.2-7 show that the Las Vegas Bay Alternative reduces chlorophyll concentrations compared to baseline conditions in the inner Las Vegas Bay, but increase chlorophyll concentrations compared to the 2030 flow concentrations. Chlorophyll concentrations in the Boulder Basin (CR 346.4) and at Boulder Beach increase compared to the 2030 flow concentrations, but remain well below water-quality standards.

Secchi depth would increase in the inner Las Vegas Bay by approximately 2.9 m (9.5 ft) compared to baseline conditions. Secchi depth in the Boulder Basin (CR 346.4) and at Boulder Beach would decrease approximately 0.9 m (3.0 ft) and 0.8 m (2.6 ft), respectively.

Total Phosphorus concentrations at Hoover Dam would increase by 0.004 mg/L under the Las Vegas Bay Alternative with 2050 flows (Figure D.2-5).

Table D.2-21 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,000 ft [30 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Temperature (°C[°F])	20.3 [68.5]	20.0 [68.0]	20.3 [68.5]	ND	19.6 [67.3]	19.5 [67.1]	19.3 [66.7]	19.3 [66.7]	13.2 [55.8]	14.1 [57.4]	13.0 [55.4]	ND
Perchlorate (µg/L)	45.2	10.7	46.7	ND	3.1	3.2	13.9	3.7	6.6	1.3	5.8	ND
Conductivity (µS/cm)	1085	1062	1094	ND	959	948	952	959	901	904	896	ND
Total Dissolved Solids (mg/L)[6]	687	672	693	ND	607	600	603	607	570	572	567	ND
Dissolved Oxygen (mg/L)	8.7	8.5	8.7	ND	8.3	8.2	8.3	8.3	7.7	7.4	7.5	ND
Chlorophyll (µg/L)	12.4	7.9	12.4	ND	2.0	4.2	2.1	4.3	≤ 0.01	0.1	≤ 0.01	ND
Secchi Depth (m)	3.2	6.1	3.2	ND	9.1	8.2	8.8	8.0	ND[7]	ND[7]	ND[7]	ND[7]
Total Phosphorus (mg/L)	0.018	0.018	0.018	ND	0.007	0.007	0.005	0.008	0.005	0.009	0.004	ND
Soluble Phosphorus (mg/L)	0.009	0.012	0.009	ND	0.005	0.005	0.003	0.006	0.004	0.008	0.004	ND
Total Nitrogen (mg/L)	1.61	1.76	1.68	ND	0.42	0.82	0.44	0.92	0.34	0.78	0.36	ND
Total Inorganic Nitrogen (mg/L)[8]	1.61	1.69	1.61	ND	0.55	0.79	0.41	0.88	0.31	0.73	0.32	ND
Nitrate (mg/L)	1.56	1.66	1.63	ND	0.39	0.77	0.42	0.86	0.31	0.70	0.31	ND
Total Ammonia Nitrogen (mg/L)	0.012	0.031	0.013	ND	0.010	0.021	0.011	0.022	0.014	0.031	0.019	ND

Table D.2-21 Lake Mead Modeling Results for the Las Vegas Bay Alternative[1] (1,000 ft [30 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day) (continued).

Parameter	Inner Bay (LVB1.85M)[2]		Inner Bay (LVB2.7)[3]		Boulder Basin (CR346.4)		Boulder Beach		Hoover Dam Discharge[4]		SNWA Intake[5]	
	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling	Baseline	Modeling
Un-ionized Ammonia (mg/L)	< 0.003	< 0.003	< 0.003	ND	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	ND
Bromide (mg/L)	0.106	0.102	0.107	ND	0.086	0.087	0.087	0.088	0.080	0.081	0.080	ND
Sulfate (mg/L)	295	278	297	ND	255	253	259	255	243	242	242	ND
Chloride (mg/L)	107	109	108	ND	89	89	85	91	79	82	78	ND
Fecal Coliform (MPN/dL)[9]	1.0	0.5	1.1	ND	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND
pH	8.1	8.1	8.1	ND	7.9	8.0	8.0	8.0	7.7	7.7	7.7	ND

Notes:

1 Sampling depth is surface to 1 m (3.3 ft) for locations other than SNWA and Hoover Dam, which were sampled at intake depths, and except chlorophyll, which was averaged over the top 5 m (16 ft) and except un-ionized ammonia, which is averaged over the entire depth. All data is the annual average, except for chlorophyll and Secchi depth, which includes the seasonal average (April 1 to September 30).

2 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary (See Figure D.2-1). The position of LVB1.85M for the initial Lake level of 1178 ft is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

3 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

4 Hoover Dam discharge data is from the lower intake only.

5 No data exists for the SNWA 1,000-ft (30-m) intake.

6 Total Dissolved Solids (TDS) is not simulated. It is computed from the correlation, TDS (mg/L) = 0.633 Conductivity (µS/cm).

7 ND = No Data. No Secchi depth data exists for Hoover Dam Discharge and SNWA Intake because Secchi depth is a property at the lake surface.

8 Total Inorganic Nitrogen is not simulated. It is computed as Nitrate + Total Ammonia Nitrogen. Nitrite is not simulated.

9 Most Probable Number per 100mL (1 deciliter).

Source: Black & Veatch 2004d.

Table D.2-22 Lake Mead Chlorophyll Concentrations for Baseline Conditions and the Las Vegas Bay Alternative[1] (1,000 ft [30 m] Lake level for year 2050 with effluent flows of 400 mgd [616 cfs] and effluent TP = 592 lbs/day).

Location[3]	Chlorophyll (µg/L)[2]	
	Baseline Conditions	Las Vegas Bay Alternative
Inner Bay (LVB 1.85M)[4]	12.4	7.9
Inner Bay (LVB 2.7)[5]	12.4	ND
Boulder Basin (CR 346.4)	2.0	4.3
Boulder Beach	2.1	4.3
Hoover Dam[6]	0	0.1
SNWA Intake[7]	0	ND

Notes:

1 This table is for comparison purposes. Other baseline parameters for Lake Mead are shown on Table D.2-2.

2 Samples for chlorophyll taken within the top 5 m (16 ft). Chlorophyll data is the mean seasonal average (April 1 to September 30).

3 Sampling/monitoring locations are shown on Figure D.2-1.

4 M = Mobile. LVB1.85M is mobile and located at a depth of 16 to 18 m (52 to 59 ft) near the confluence of Las Vegas Wash and Lake Mead. All other locations are stationary. The position of LVB1.85M for the initial Lake level of 1,178 ft (359 m) is the same as LVB2.7 for the entire growing season, but moves away from the Las Vegas Wash later in the year as the Lake level drops. Therefore the chlorophyll concentrations (which are averaged over the growing season) are the same at LVB1.85M and LVB2.7, while other parameters (averaged over the entire year) are slightly different.

5 ND = No Data. No data exists for LVB2.7 because it is located on dry land with a Lake level of 1,000 ft (30 m).

6 Hoover Dam discharge data is from the lower intake only.

7 No data exists for the SNWA 1,000-ft (30-m) intake.

Source: Black and Veatch 2004d.

D.3 Lake Mohave Model

The primary goal of the Lake Mohave modeling effort was to test the sensitivity of changing nutrient input to Lake Mohave on 1) the in-lake (Lake Mohave) water quality and 2) the nutrient discharged downstream of Davis Dam. CE-QUAL-W2, a time varying, longitudinal-vertical hydrodynamic and water quality model maintained by the Waterways Experiment Station of the USACE, was chosen for application to Lake Mohave. The information presented in this section is based on *Lake Mohave Water Quality Model Project Report: Validation* prepared by J.E. Edinger Associates, Inc (2003). Figure D.3-1 provides a general view of Lake Mohave.

It is important to note that the nutrient loading through Hoover Dam is dependent on several factors. These factors include, but are not limited to the quality of the effluent being discharged into Boulder Basin, and water quality from sources upstream of Boulder Basin such as water from the Overton Arm, water released from Lake Powell, and water from the tributaries of the Colorado River. In addition, the nutrient loading that goes through Hoover Dam is dependent upon how Reclamation operates Hoover Dam. For modeling purposes, it was assumed that Reclamation would not modify the operation of Hoover Dam. A description of the Hoover Dam operations that were taken into consideration during the water quality modeling efforts is provided in the Lake Mead Water Quality Modeling Report Black & Veatch 2005b), which is available upon request. However, Reclamation's operation of Hoover Dam is beyond the control and scope of this EIS.

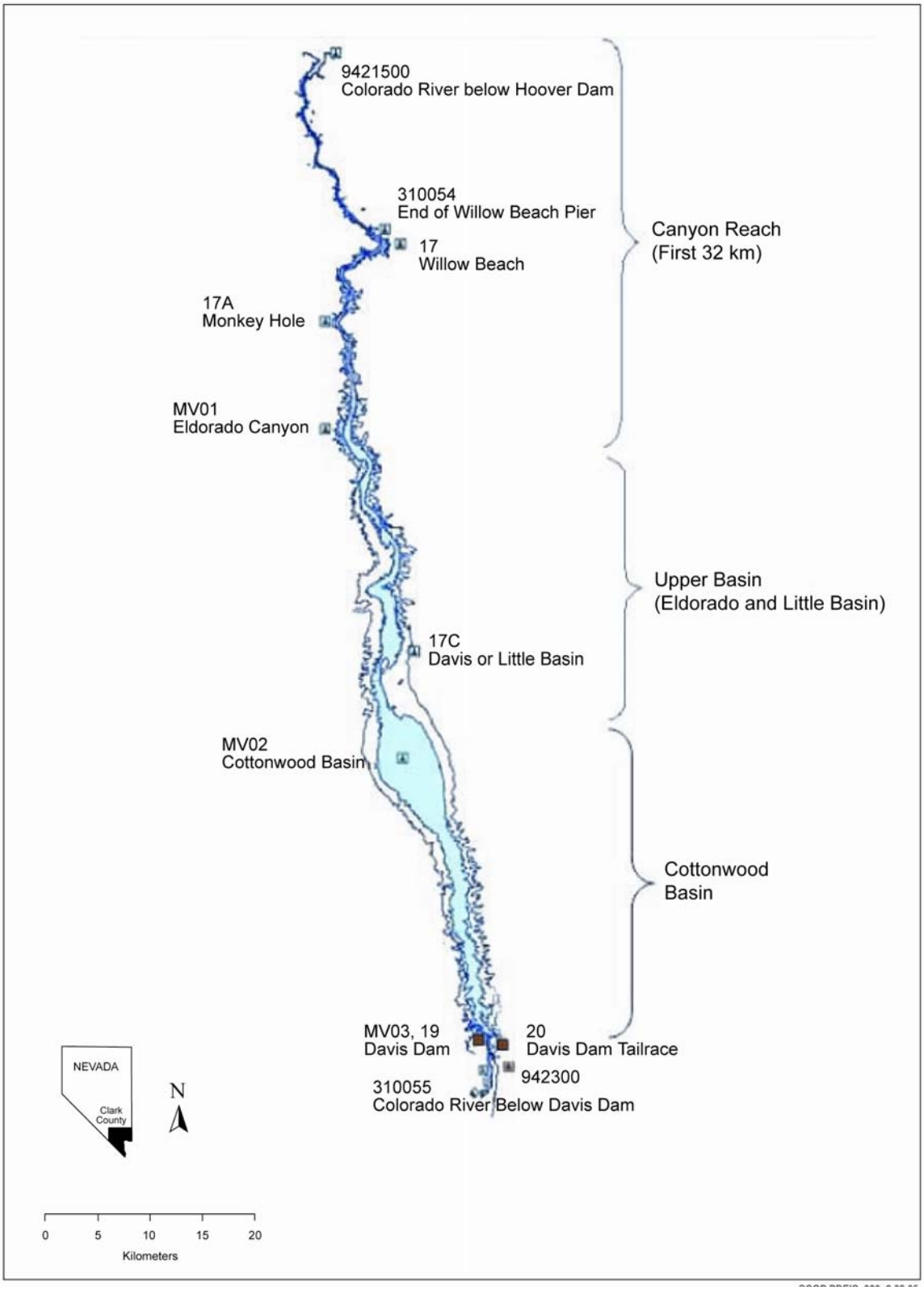

Figure D.3-1 General View of Lake Mohave.

D.3.1 Model Selection, Set-up, and Calibration

D.3.1.1 Model Selection

The Lake Mohave Model used CE-QUAL-W2, which is a longitudinal-vertical hydrodynamic and transport model built for long-term, time varying water quality simulations of lakes, reservoirs, and estuaries. CE-QUAL-W2 can accurately reproduce vertical and longitudinal water quality gradients when complete boundary condition data are available. CE-QUAL-W2 has been under development for the U.S. Army Corps of Engineers since 1974 and has had extensive review and testing.

Lake Mohave's dominant gradients are in the longitudinal and vertical directions, which is readily obvious by noting Lake Mohave's long and narrow outline (Figure D.3-1) or by considering Lake Mohave's basic dimensions: length of 108 kilometers (km) (67 miles [mi]), width of 6 km (4 mi), and maximum depth of 40 m (131 ft). Furthermore, the problem of phosphorus addition to Lake Mohave is one of simulating annual cycles. Both the longitudinal-vertical spatial domain and the long-term modeling needs fit well with CE-QUAL-W2's capabilities.

D.3.1.2 Model Set-up

Input data for the Lake Mohave Model had two main sources: Data included in reports prepared by UNLV and data downloaded from the USGS and STORET web sites. Researchers at UNLV designed, implemented, and interpreted the results of comprehensive field programs that measured physical, chemical, and biological variables for the periods 1977-1978 and 1981-1982. In addition, nutrient budget analyses were based on data downloaded from USGS and STORET web sites.

The Lake Mohave System characteristics most applicable to the Lake Mohave modeling effort are:

- The seasonally uniform, cold inflow from Lake Mead near-bottom releases (approximately 12ºC [54ºF] year round) transits the Canyon Reach (Figure D.3-1) with very little warming and enters the Upper Basins (Figure D.3-1) as an underflow through the spring, summer, and fall seasons. The location at which this inflow plunges varies with the density difference, flow rate, and water surface elevation. There is evidence that the inflow enters the Upper Basins as a surface flow in the winter due to insignificant density differences.
- Surface warming is important in the Upper Basins and especially in the Cottonwood Basin.
- Strong stratification develops in the Cottonwood Basin during the summer. Extension of the epilimnion all the way to Davis Dam is somewhat limited by upwelling in the vicinity of Davis Dam caused by the coldwater underflow. This underflow is larger than the inflow from Lake Mead due to entrainment of epilimnetic water at the plunge point. The upwelling can be strong enough to cause reverse currents on the surface.
- In contrast to the temperature differences between the Lake Mead outflow and the waters of Lake Mohave, there are no measurable differences in conductivity and TDS.

No seasonal pattern was apparent in the water quality characteristics of the inflow below Hoover Dam in the years for which seasonal data were available. Nitrate and dissolved phosphorus concentration averaged about 0.4 mg/L and 0.015 mg/L, respectively, while the ammonia concentration was usually less than 0.020 mg/L.

Water quality characteristics within Lake Mohave are strongly influenced by Lake Mohave's uniformly colder year-round inflow that becomes an underflow through most of the lake during the stratified period. This limits the availability of nutrients during the summer in the Cottonwood Basin, except for upwelling of entrained surface water near Davis Dam.

The concentration of nitrate varies seasonally in relation to thermal stratification, declining at the surface in the summer due to phytoplankton uptake, and rising due to mixing with river water upstream and upwelling of inflow at the downstream end. A horizontal nitrate gradient, ranging from 0.3 or 0.4 mg/L at Monkey Hole to less than 0.2 mg/L at Davis Dam, was sustained because of a net conversion of nitrate to organic nitrogen.

Dissolved phosphorus undergoes a similar seasonal change. Strong vertical or horizontal gradients were not discerned for phosphorus. Depletion of dissolved phosphorus by phytoplankton in the epilimnion was not as prominent as nitrate depletion. This feature is likely due to a lower stoichiometric requirement and faster turnover rate of phosphorus compared to nitrogen.

Dissolved oxygen concentration was reduced in the hypolimnion of Lake Mohave during thermal stratification (June-October). Typically, the DO would go as low as 4 mg/L during summer. The pH in the hypolimnion decreased consistent with biological respiration and mineralization of organic material. However, oxygen concentrations remained relatively high. There was a general decrease in oxygen concentration in the hypolimnion at the downstream stations. A metalimnetic oxygen minimum usually did not develop in Lake Mohave.

A key assumption in the Lake Mohave Model is that there are no sources of nutrients other than the inflow from Hoover Dam. There appear to be no point sources on Lake Mohave other than a fish hatchery at Willow Beach. Precipitation in the region is small.

Though the comparison should be conducted for input and output loads (the product of flow and concentration), the input and output concentrations are used for simplicity, because over the long-term, flows will balance out in the inflow and outflow records. Another reason for comparing concentrations is that computation of the loads as a product of flow and concentration requires interpolating the sporadic concentration measurements to the frequency of flow measurements, which is daily. There is no unique way to interpolate. Thus, computing the loads introduces additional assumptions in the analyses. Therefore, it is instructive to examine the time series of the concentration data prior to computing loads from these data.

Assuming there are no other sources of nutrients to Lake Mohave, the implications are that historically Lake Mohave has not served as a significant sink of total phosphorus delivered to it through Hoover Dam. Unless changes in lake "metabolism" due to additional phosphorus load alter this input-output relationship, the additional load from the wastewater effluent is likely to be passed relatively unchanged to the downstream reservoir.

In the analyses, nutrient loads were computed as a product of daily concentration estimates and daily flows.

The years 1977-1978 and 1981-1982 were selected for model calibration because large amounts of in-lake water quality data are available from the intensive studies by UNLV. All supporting inflow, outflow, and water surface elevation data were also available from various agency websites.

The two simulation periods were used for calibration of the model as follows. The temperature calibration was first carried out for the 1981-1982 period. The calibration was confirmed further by using the same coefficients in 1977 - 1978 simulations and comparing the model results to the detailed temperature profile data available for these two years. Water quality calibrations were similarly started with 1981-1982. The additional confirmation step for the water quality calibration, where the same kinetic coefficients would be applied to another set of years and then the calibration checked, was not done for this report.

Meteorological data sets for the two study periods were developed from hourly National Weather Service observations of air temperature, dew point temperature, wind speed and direction, and cloud cover at Las Vegas, NV.

Flow data were available as daily releases from Lake Mead for 1977-1978 and 1981-1982. Temperatures of the inflow to Lake Mohave from Lake Mead were developed from observations.

Inflow water quality constituent files were developed only for 1981-1982. Long-term data were examined for any seasonality to help determine the best interpolation approach for refining the model upstream boundary. No consistent seasonal pattern could be discerned in the TP data, except for a slight suggestion that December through January values may be slightly higher than those during the rest of the year.

Development of concentration input files for CE-QUAL-W2 also requires assumptions about how the measurements are related to the model representations of the water quality constituents. The following two guidelines, sometimes in conflict with one another, were used to develop the boundary concentration files.

- Total Phosphorus and total nitrogen (TN) estimates should be accurate as these reflect the nutrient budgets that are crucial to mass balance accuracy.
- The partitioning of nutrients and organic carbon should reflect the lability of these components at short and long time scales. Constant stoichiometry of organic matter and algae in the model is a constraint to achieving the best representation.

D.3.1.3 Model Calibration

Calibration was conducted in three phases: water balance, temperature calibration, and water quality calibration. Each phase depended on the successful completion of the prior phase.

Water balance is the process of using observation of lake elevations to account for missing flows or inaccuracies. It is a necessary first step because it affects all other calibration efforts. Temperature calibration was conducted using time-series observations rather than synoptic measurements (i.e., vertical

profiles at a particular time). This approach is consistent with the goal of modeling the seasonal behavior of the Lake Mohave system and also allows gross properties (e.g., seasonal temperature changes) to be examined prior to examining vertical profiles from the temperature and water quality observations.

Water quality calibration is a more involved exercise than temperature calibration because of fewer and less precise field data, a preponderance of non-linear and interaction terms in the underlying equations, and there are more constituents and parameters to consider. The water quality calibration isolated the key calibration features indicated by the field data in the aggregate, and then the model was calibrated to capture these key features. Key calibration target features were isolated from a review of the field data and prior reports. In no particular order of importance, these were:

- Approximately similar TP in Lake Mohave inflow and outflow,
- Approximate TN loss of about 10 percent during passage through Lake Mohave,
- Significant increase in Total Kjeldahl Nitrogen (TKN) in the outflow at Davis Dam,
- Significant (30 percent) decrease in NO3 in the outflow at Davis Dam,
- Surface depletion of NO3 to near detection limits,
- Nitrogen limitation may sometimes occur during the summer,
- High vertical gradient at the surface for primary production,
- DO vertical gradient not so high at the surface,
- No anoxia anywhere in any season,
- Slow longitudinal decline of DO towards the Davis Dam, down to about 4 mg/L,
- Primary production in the range of 500 to 3000 $mgC/m^2/day$,
- Secchi disk depth is highly variable, but in the range of 1 to 12 m (3 to 39 ft), and
- Chlorophyll *a* concentration ranges seasonally from 1 to 6 µg/L.

Given the relevance of nutrient retention for the problem being studied, model-based nutrient budget calculations formed a significant part of the calibration effort. Analyses of nutrient retention from long-term monitoring data, subject to the assumption of no phosphorus load besides Hoover Dam outflow, suggest a certain amount of "average" retention that may vary from year to year and is dependent on assumptions regarding outliers and below-detection values in the field data. For the calibration, the nutrient load corresponding to the distributed inflow was computed by estimating a reasonable runoff flow rate and reasonable runoff concentration separately.

D.3.3 Results

The Lake Mead Model simulated nutrient loads through the Hoover Dam for various scenarios of effluent discharge locations in Lake Mead. These nutrient loads were used as input to the Lake Mohave model.

Two scenarios were run in which the nutrient load estimated at Hoover Dam was increased by 25 percent and 100 percent. The same proportional increase was applied to all the nutrient species. These hypothetical and illustrative scenarios do not relate to any specific effluent or loading scenarios. Since all nutrient species were changed proportionally, it can be tempting to think of the two scenarios as indicative of loads under different hydrologic years, but it may be noted that higher flows will likely

change the system retention. Increase in loading due to a higher flow is a very different perturbation to a system compared to an increase in loading due to a higher inflow concentration.

The year 2000 was selected for running scenarios as a result of discussions within the SCOP Water Quality Modeling Subcommittee. Table D.3-1 shows the fate of the nutrient under loads estimated from field data for year 2000.

Tables D.3-2 and D.3-3 show the fate of the total and the additional nutrient loading through Hoover Dam under the two scenarios (25 percent increase in nutrient loading and 100 percent increase in nutrient loading).

The effects of scenarios on the in-lake water quality are summarized in Table D.3-4. A 25 percent increase in loads led to an in-lake water quality change that appeared minor compared to measurement and modeling uncertainty for these metrics. A 100 percent load increase led to more significant effects. Two-year average clarity was reduced by 25 percent. Primary productivity and average algal population density were both increased 40 percent with a doubling of nitrogen and phosphorus loads.

Table D.3-1 Daily Average Nutrient Budgets for the Calibrated Model for 2000.

	Hoover Dam Release	**Non-Hoover Load Assumed**	**Davis Dam Release**	**Percent Retention in Lake Mohave**
TP (lbs/day)	471	115	524	10.4 %
TN (lbs/day)	50,824	7	42,916	15.6 %

Table D.3-2 Fate of a 25 percent Increased Load at Hoover Dam for 2000.

	Additional In	**Additional Out**	**Percent Retention of Additional Load**	**Percent Retention of Total Load**
TP (lbs/day)	119	88	26.2%	13.0 %
TN (lbs/day)	13,518	9,663	28.5%	18.3 %

Table D.3-3 Fate of a 100 percent Increased Load at Hoover Dam for 2000.

	Additional In	**Additional Out**	**Percent Retention of Additional Load**	**Percent Retention of Total Load**
TP (lbs/day)	471	352	25.5%	17.1 %
TN (lbs/day)	52,095	36,967	29.0%	22.4 %

Table D.3-4 Model Predictions of In-lake Water Quality Metrics.

Metric	**2000 Load Estimated from Field Data**	**Scenario 1** **125 percent 2000 Load**	**Scenario 2** **200 percent 2000 Load**
Minimum Secchi Depth (ft)	16.0	16.0	14.7
Average Secchi Depth (ft)	25.1	23.0	19.1
Areal Primary Production (mgC/m^2/day)	296.0	343.0	449.0
Maximum Chlorophyll *a* (µg/L)	4.4	5.3	7.5
Average Chlorophyll *a* (µg/L)	2.7	3.1	3.9

The model results showed a net reduction of the additional phosphorus and nitrogen during passage through Lake Mohave. In the two scenarios examined that scaled up the phosphorus and nitrogen load through Hoover Dam, this reduction was about 25 percent for TP and 30 percent for TN. The additional phosphorus and nitrogen assumed in the scenarios was retained by a larger percentage than baseline load. If there are phosphorus sources other than Hoover Dam outflow, the overall nutrient retention will be higher.

Effects of the hypothetical load increases on the water quality of Lake Mohave were quantified into five metrics (Table D.3-4). The results showed significant effects in all chosen metrics with a 100 percent increase in nutrient loads, but the effects were much less with a 25 percent increase.