2-25-1994

Study of existing information concerning water quality within Lake Mead

Vicki Scharnhorst

Southern Nevada Water Authority

MEMORANDUM

Date: February 25, 1994 **Job No.:** 3521.0101

To: Douglas A. Selby

From: Vicki Scharnhorst (MW/CH2M Hill)

RE: Study of Existing Information Concerning Water Quality Within Lake Mead
Southern Nevada Water Authority TTF - Activity 010A15M

INTRODUCTION

The purpose of Task 010A15M of the Southern Nevada Water Authority (SNWA) Treatment and Transmission Facility (TTF) contract is to conduct a study of existing information concerning water quality within Lake Mead and identify additional water quality studies that are needed to supplement existing data.

The objective of this task is not to discuss treatability of the raw water source; this is addressed by Task 010A18M, "Define Water Treatment Requirements". In addition, a narrative on the effect of pending Safe Drinking Water Act amendments and a determination of treated water quality goals is included in Task 010A16M, "Review Safe Drinking Water Act (SDWA) Regulatory Impacts".

Lake Mead has the largest surface area of any reservoir in the Northern Hemisphere. Bordered by Arizona and Nevada, the lake was created by the impoundment of the Colorado River behind Hoover Dam. The dam was constructed in 1935 to control flooding and provide a dependable water source, which now supplies about 20 million people in the desert Southwest and Los Angeles metropolitan area. The Bureau of Reclamation manages the water resources of the reservoir, and the National Park Service administers the recreation facilities at the reservoir.

SUMMARY

A considerable body of water quality data have been collected in Lake Mead at or near the alternative intake sites for the SNWA TTF. The sites include Callville Bay, Water Barge Cove, Black Island, Government Wash (Las Vegas Bay), Saddle Island (SNWS intake), Hemenway Wall (Promontory Point), and Hoover Dam. The major sources of Lake Mead water quality data include the Southern Nevada Water System (SNWS), the U.S. Bureau of Reclamation, the National Park Service, and the City of Las Vegas/Clark County Sanitation District joint Water Quality Study.

With respect to water quality data that would be used to evaluate and select treatment processes, data is available at most intake sites for turbidity, alkalinity, coliforms, dissolved oxygen, TDS, odor and temperature. However, there is little or no data on arsenic, total organic carbon, and trihalomethane formation potential. Several years of data is available at the SNWS intake (Saddle

Island site) and at the Colorado River below Hoover Dam. Minimal data was found for Water Barge Cove. There is a preponderance of data within the Las Vegas Bay from the confluence with the Las Vegas Wash to Black Island; however, the data was predominately collected to collaborate water quality standards set for the wastewater treatment plants (nitrogen: ammonia, nitrate, nitrite and dissolved oxygen, chlorophyll, coliforms).

This activity has focused on identifying additional tasks for data collection and analysis rather than evaluation. However, preliminary review of the data suggests:

- Las Vegas Bay, influenced by wastewater discharge and stormwater runoff conveyed through the Las Vegas Wash, has higher concentration of microorganisms than other sites. Because of this risk of contamination from pathogens in the wash discharge and because of the shallower depth, an intake in the Las Vegas Bay should be eliminated from further consideration by this initial screening.

- Based on depth sampling conducted by the SNWS and others, it appears that some water quality parameters vary with depth. This has been demonstrated in samples taken at the SNWS intake from 0 to 54 meters for dissolved oxygen, temperature and odor, occurring predominately during the summer months. Multiple intake depths should be considered.

A preliminary evaluation of data indicates that alternate intake sites (other than the Las Vegas Bay/Government Wash site) are similar in terms of water quality.

TASK SCOPE

The scope for Task 010A15M is as follows:

- Conduct a study of existing information concerning water quality within Lake Mead and at different elevations.
  - Identify relevant materials regarding water in Lake Mead to (1) assist in selecting alternative intake sites and depths and (2) assist in defining treatment requirements.
  - Obtain data from existing Southern Nevada Water System and U.S. Fish and Wildlife Service sources.
  - Review and summarize existing water quality data.
  - Determine relationships between water quality, treatment selection, and intake location.
- Identify additional water quality studies that are needed to supplement existing data.

ALTERNATIVE INTAKE LOCATIONS

Available Lake Mead water quality data was collected for seven alternate intake locations:

- Callville Bay
- Water Barge Cove
- Box Car Cove
- Government Wash
- Saddle Island
- Hemenway Wall
- Hoover Dam

These intake sites are shown on Figure 15-1. Intake elevations could vary from as low as elevation 895 MSL, the worst-case drought elevation, to as high as elevation 1050 MSL which is the minimum power pool at Hoover Dam. The existing SNWS intake is set at elevation 1013 MSL. The maximum gage height for Lake Mead was recorded at 1225.85 ft (July 24, 1983) and the minimum recorded gage height is 1083.21 ft (April 26, 1956).

WATER QUALITY FACTORS AFFECTING TREATMENT

The principal objective of a water treatment facility is to provide water to consumers which satisfies regulatory requirements and other water quality objectives such as color, odor, hardness, etc. Undesirable constituents in the source water must either be removed or rendered innocuous through appropriate physical and chemical processes.

Table 15-1 shows a list of constituents which affect water treatment process selection.

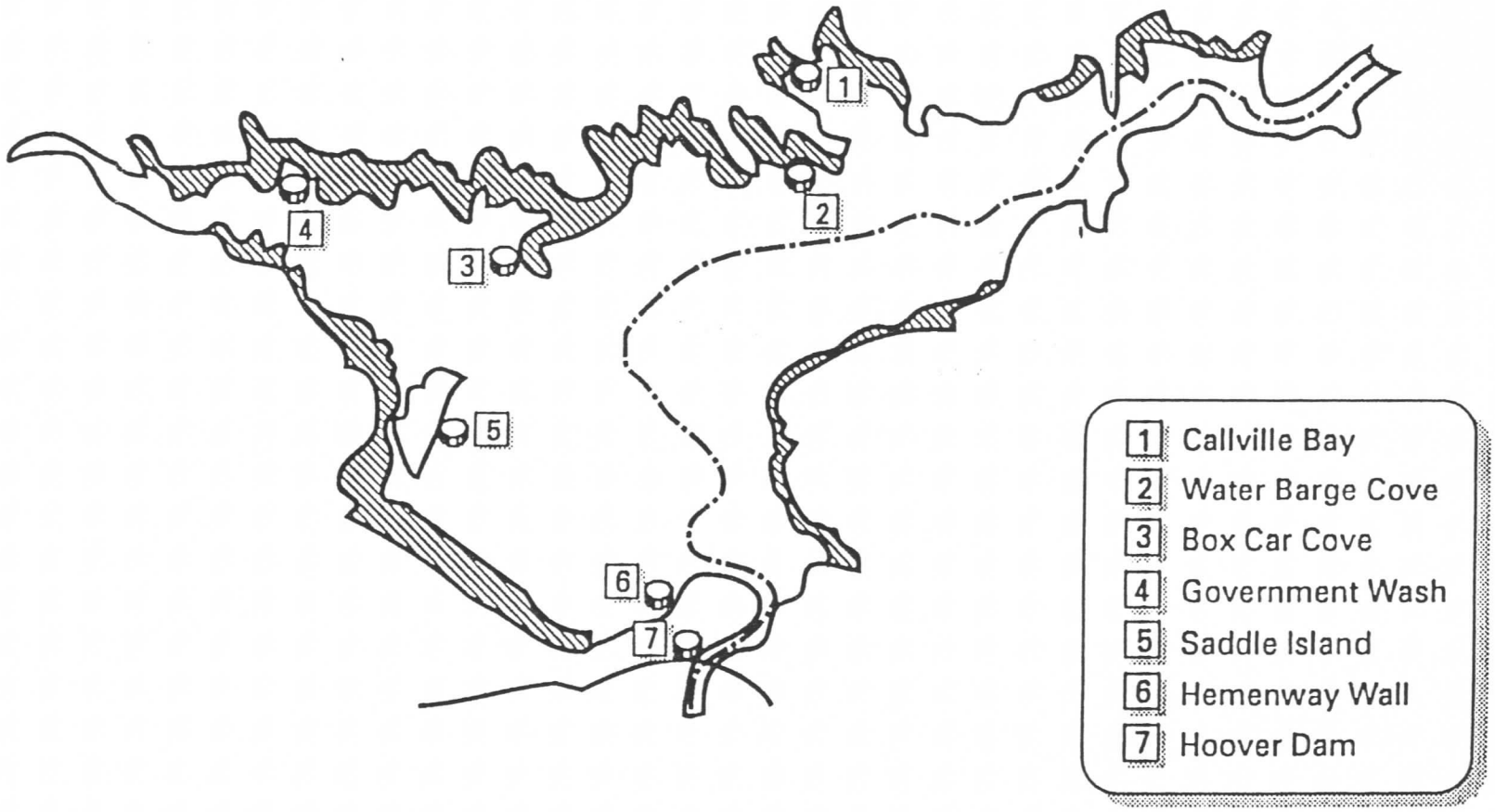

FIGURE 15-1
ALTERNATIVE INTAKE SITES

SOUTHERN NEVADA WATER AUTHORITY

Table 15-1

Source Water Quality Characteristics Impacting Treatment

Characteristic	Processes Impacted by Characteristic
Turbidity	Filtration technique (i.e., conventional, direct filtration)
Total Organic Carbon	Disinfection/DBP Rule (enhanced coagulation); DBP formation
Alkalinity	Disinfection Method/DBP Rule (enhanced coagulation)
Arsenic	Enhanced coagulation
Coliform Bacteria (Total & Fecal).	Disinfectant choice and required inactivation
DBP (or THM) Formation Potential	Disinfectant choice and organics removal technology
Dissolved Oxygen	Oxidation, iron and manganese removal
Hardness	Softening, membrane technology
Taste and Odor or Algae Counts/ Chlorophyll a	Oxidation, PAC, GAC, etc.
Total Dissolved Solids	Membrane/softening
Temperature	Flocculation/sedimentation; disinfection

Process engineering must select the appropriate technology to provide cost effective treatment to meet the water quality standards. In order to adequately evaluate individual units in the process train, and to find the best source water quality, a reconnaissance was performed for the availability of these data in numerous areas in Lake Mead.

EXISTING WATER QUALITY DATA AND STUDIES

Over one hundred studies have been prepared and published on water quality in Lake Mead. Appendix 15-1, entitled "Chronological Summary of Water Quality and Limnological Studies in Lake Mead During 1936 - 1993" includes the title, study period, stations sampled and constituents/measure-ments analyzed for each study.

Several agencies were contacted to discuss ongoing water sampling and monitoring programs being conducted in Lake Mead. The following briefly discusses current sampling locations and the constituents for which analyses are performed.

Southern Nevada Water System

The Southern Nevada Water System (SNWS) has been taking raw water samples in Lake Mead for over 10 years. The various sampling locations are shown in Figure 15-2. All samples are taken from a boat. Sample location and frequency are summarized below. Data is reported on forms by hand; at this time it is not stored in a database. Representative report forms are included in Appendix 15-2. Although the data discussed below does not include total organic carbon, the SNWS is purchasing a TOC analyzer and will begin this analysis by July 1994.

Form 105N - Routine Physical & Chemical Analysis.

Sampling Interval: Monthly

Locations Sampled:
- SNWS Intake (surface)
- SNWS Intake (24 m)
- LV Bay (surface)
- LV Bay (24 m)
- LV Wash (surface)
- Black Island (surface)
- Black Island (24 m)
- Callville Bay (surface)
- Callville Bay (24 m)
- Promontory Point (surface)
- Promontory Point (24 m)

Constituents Tested:
- Alkalinity (Carbonate and Bicarbonate)
- Ammonia, Nitrogen
- Color
- Conductivity
- Nitrate
- Odor
- Dissolved Oxygen
- pH
- Phosphate
- Temperature
- Turbidity
- Particle Count
- Secchi Disk Reading

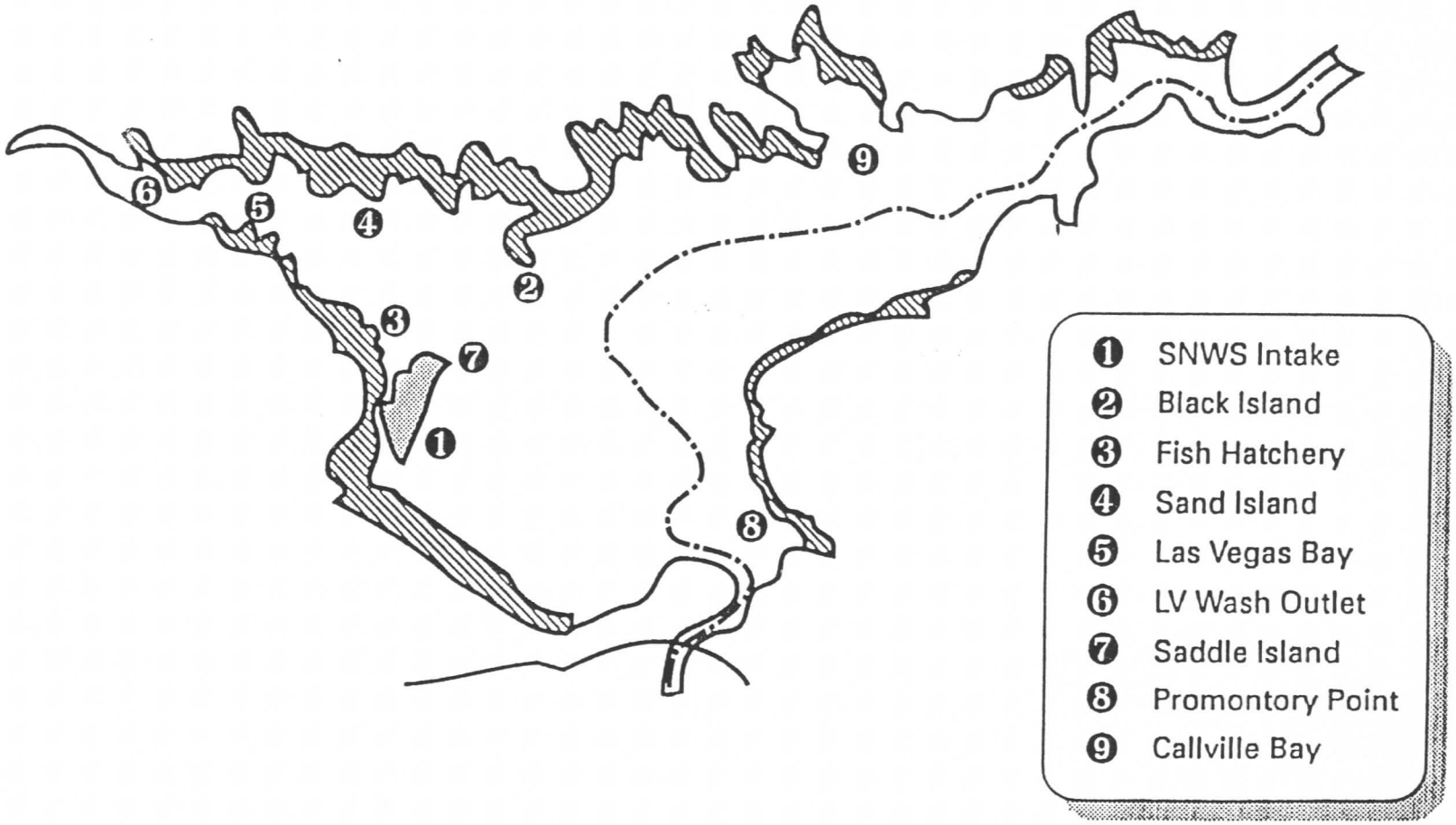

FIGURE 15-2
SOUTHERN NEVADA WATER SYSTEM
SAMPLING LOCATIONS

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Form 478F - Lake Chlorophyll.

Sampling Interval:	Monthly
Locations Sampled:	SNWS Intake (0-6 m) SNWS Intake (9 m) SNWS Intake (12 m) SNWS Intake (15 m) SNWS Intake (18 m) SNWS Intake (21 m) SNWS Intake (24 m) Saddle Island (0-6 m) Fish Hatchery (0-6 m) Sand Island (0-6 m) LV Bay (0-6 m) LV Wash Outlet (0-2 m)
Constituents Tested:	Temperature Transparency pH Dissolved Oxygen Conductivity Chlorophyll

Form 108L - Lake Profile.

Sampling Interval:	Weekly/Twice Weekly
Locations Sampled:	SNWS Intake (surface) SNWS Intake (3 m) SNWS Intake (6 m) SNWS Intake (12 m) SNWS Intake (18 m) SNWS Intake (24 m) SNWS Intake (30 m) SNWS Intake (36 m) SNWS Intake (42 m) SNWS Intake (48 m) SNWS Intake (54 m)
Constituents Tested:	Temperature Threshold Odor Number pH

Dissolved Oxygen
Orthophosphate
Nitrate
Nitrite
Ammonia
Particle Count
Turbidity
Conductivity
True Color

Form 101N - Phytoplankton Record.

Sampling Interval: Weekly

Locations Sampled:
SNWS Intake (0-6 m)
SNWS Intake (12 m)
SNWS Intake (24 m)
SNWS Intake (42 m)
Raw Water
Finished Water

Species Generally Present:
Oscillatoria (Filamentous blue-green alga)
Aphanotheca
Gamphosphaeria
Phormidium
Merismopedia
Sphaerocystis
Ochromonas
Chlamydomonas (Green alga)
Oocystis
Trachedlomonas
Quadrigula Lagerheimia
Scenesdesmus (Coccoid Nonmotile green alga)
Cyclotella (Centric Diatom)
Melosira (Centric Diatom)

Form 257B - Trihalomethanes. These data have only been collected for the last 18 months and is the result of pilot plant work conducted on raw water.

Sampling Interval: Daily/Weekly

Locations Sampled: SNWS Intake

THMs Tested:
Chloroform
Bromodichloromethane
Chlorodibromomethane
Bromoform
Total THMs

Microbiological Data.

Sampling Interval: Intermittent

Locations Sampled:
SNWS Intake
Callville Bay
Black Island
Saddle Island
Promontory Point
Fish Hatchery (0-6 m)
Sand Island (0-6 m)
LV Bay (0-6 m)
LV Wash Outlet (0-2 m)

Pathogens Tested:
Fecal Coliform
Fecal Streptococci
Vibrio sp.
Salmonella sp.
Shigella
Camphylobacter
Yersinia
Legionella
Listeria

National Park Service

The National Park Service (NPS) operates five water treatment plants in Nevada to serve visitors to the Lake Mead National Recreation Area. Intakes for the treatment plants are located at Overton Beach, Echo Bay, Callville Bay, Las Vegas Bay and Boulder Beach. Total coliform is tested twice per month and turbidity is measured daily at each of these sites.

Lake Mead National Recreation Area recently retained the University of Nevada Las Vegas (UNLV) to prepare a report on the "Determination of Fecal Coliform Levels and Heterotrophic Plate Counts in the Las Vegas Wash Waterway", October 1993. Sampling locations in Lake Mead included the delta, the beach outcrop below the campground, and the dropoff area (where the greatest depth occurs) at Las Vegas Bay (reference Figure 15-3).

Sampling Interval: Weekly from July 27 to September 24, 1993.

Constituents Tested:
pH
TDS
Conductivity
Temperature
Fecal Coliform
Heterotrophic Plate Count
Chemical Analyses (currently unpublished)

The NPS is currently conducting a Carrying Capacity Study on Lake Mead and Lake Mohave to determine public health risk at the most heavily used recreational sites and "background" sites to represent "pristine" lake conditions. There are 24 zones, two sample sites per zone. Sites 1 through 9 are on Lake Mohave; Sites 10 through 24 are on Lake Mead. The NPS is analyzing for the presence of pathogens in the water and the sediments of these zones.

Sampling Interval: Weekly to Bi-weekly from June 2 to September 29, 1993.

Constituents Tested:
Temperature
Fecal Coliform
Fecal Streptococci

U.S. Bureau of Reclamation

The Bureau of Reclamation (Reclamation) has prepared several reports and collected numerous data within Lake Mead and below Hoover Dam since 1941. The reports are listed in Appendix 15-1. Reclamation has recently completed a remote sensing study in Las Vegas Bay as part of the effort in preparing a report entitled "Monitoring Impacts on Inland Fisheries Using Hydroacoustics", which incudes landsat images for recording chlorophyll a concentrations in Las Vegas Bay and surface temperature in the lake. These images are presented in Figure 15-4 and Figure 15-5. Reclamation monitors water quality at Hoover and Davis Dams as well; this information is reported by the U.S. Geological Survey (USGS) in the annual publication "Water Resources Data for Arizona".

Water Resources Data for Arizona (USGS)

Sampling Interval: Varies by parameter

Locations Sampled:
Colorado River below Hoover Dam, Arizona-Nevada
Lake Mohave at Davis Dam, Arizona-Nevada

Constituents Tested:
Streamflow
Specific Conductance
pH
Temperature

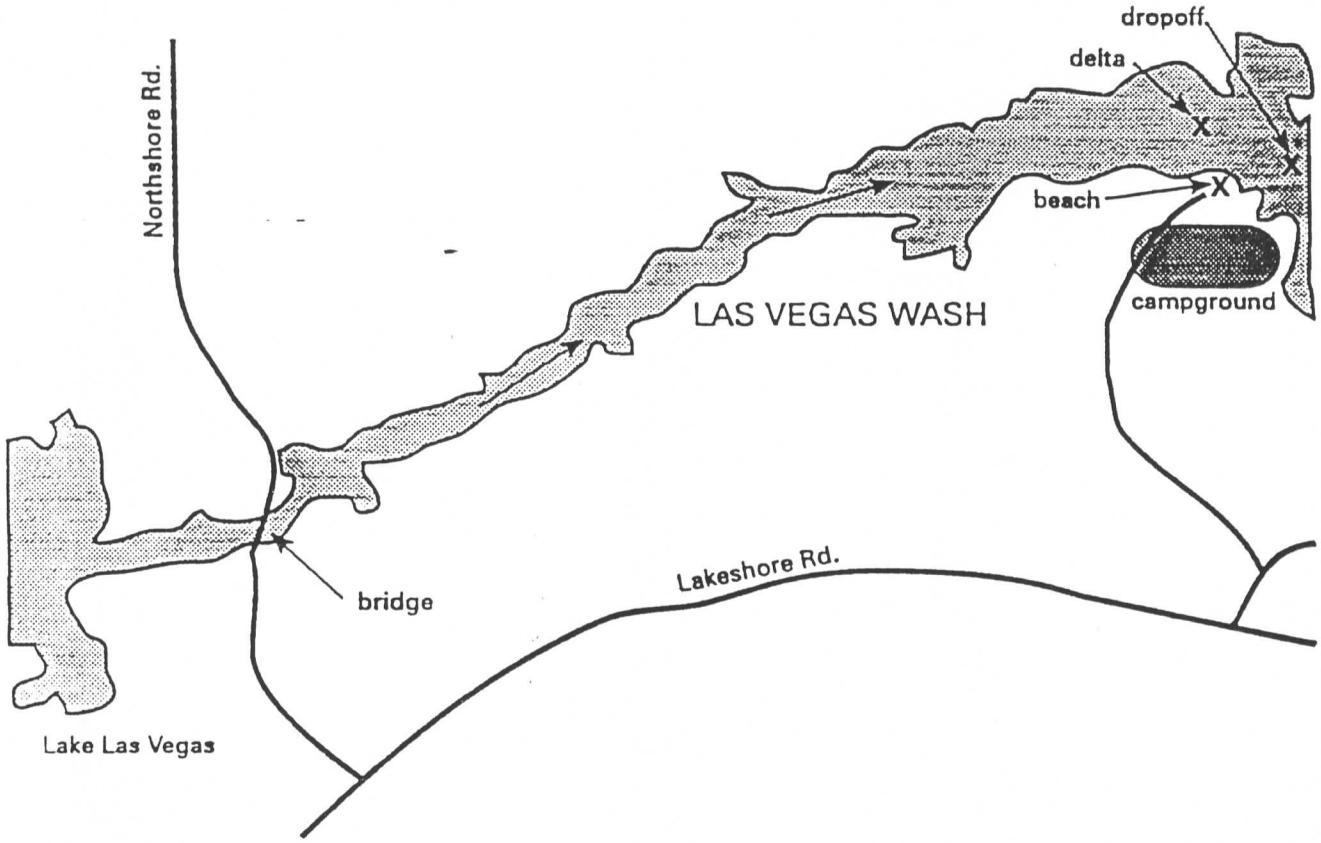

FIGURE 15-3
NATIONAL PARK SERVICE
BACTERIOLOGICAL SAMPLING SITES

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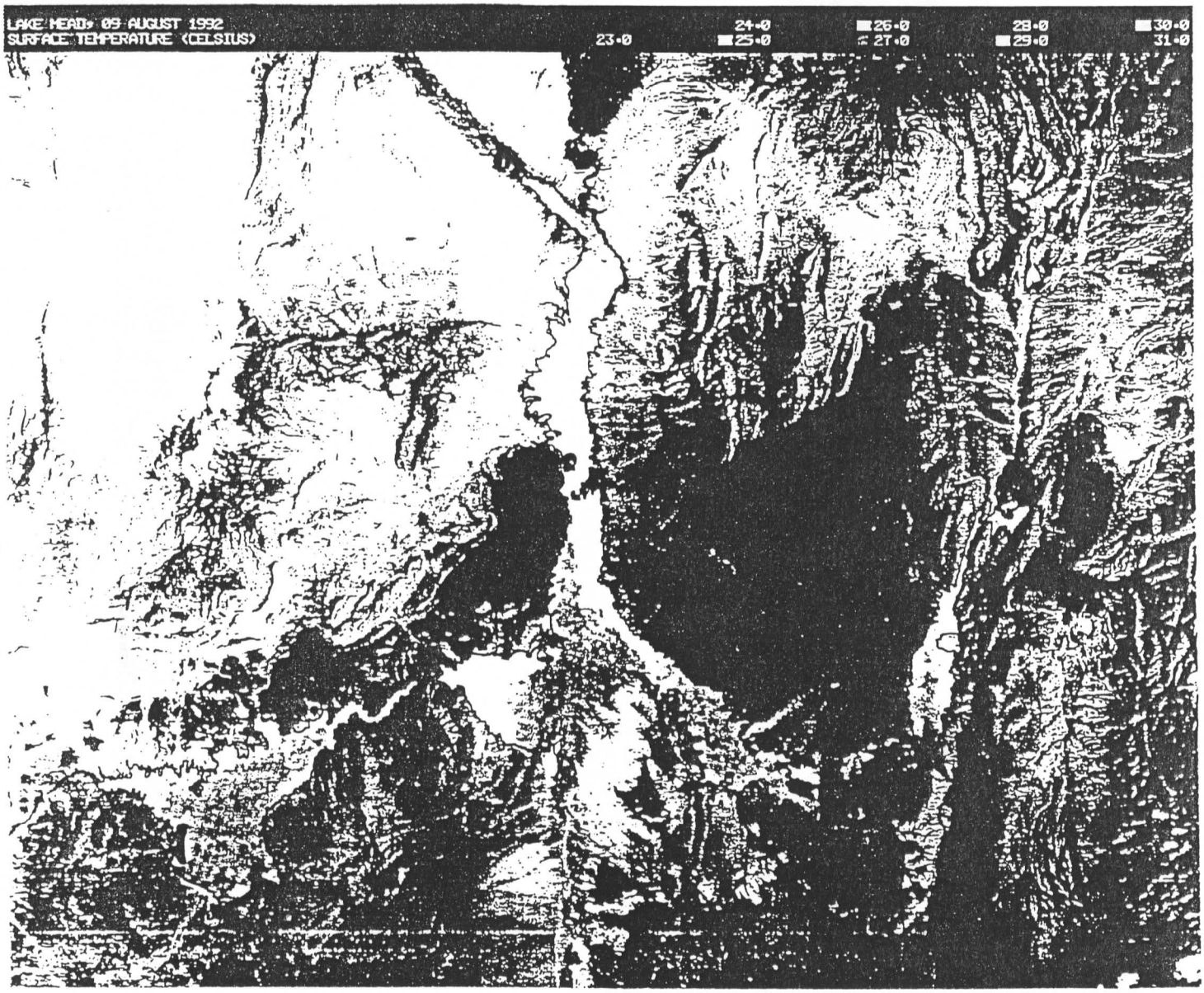

Figure 15-4 - Water surface temperatures measured by Landsat satellite imagery for Lake Mead, Nevada, August 9, 1992.

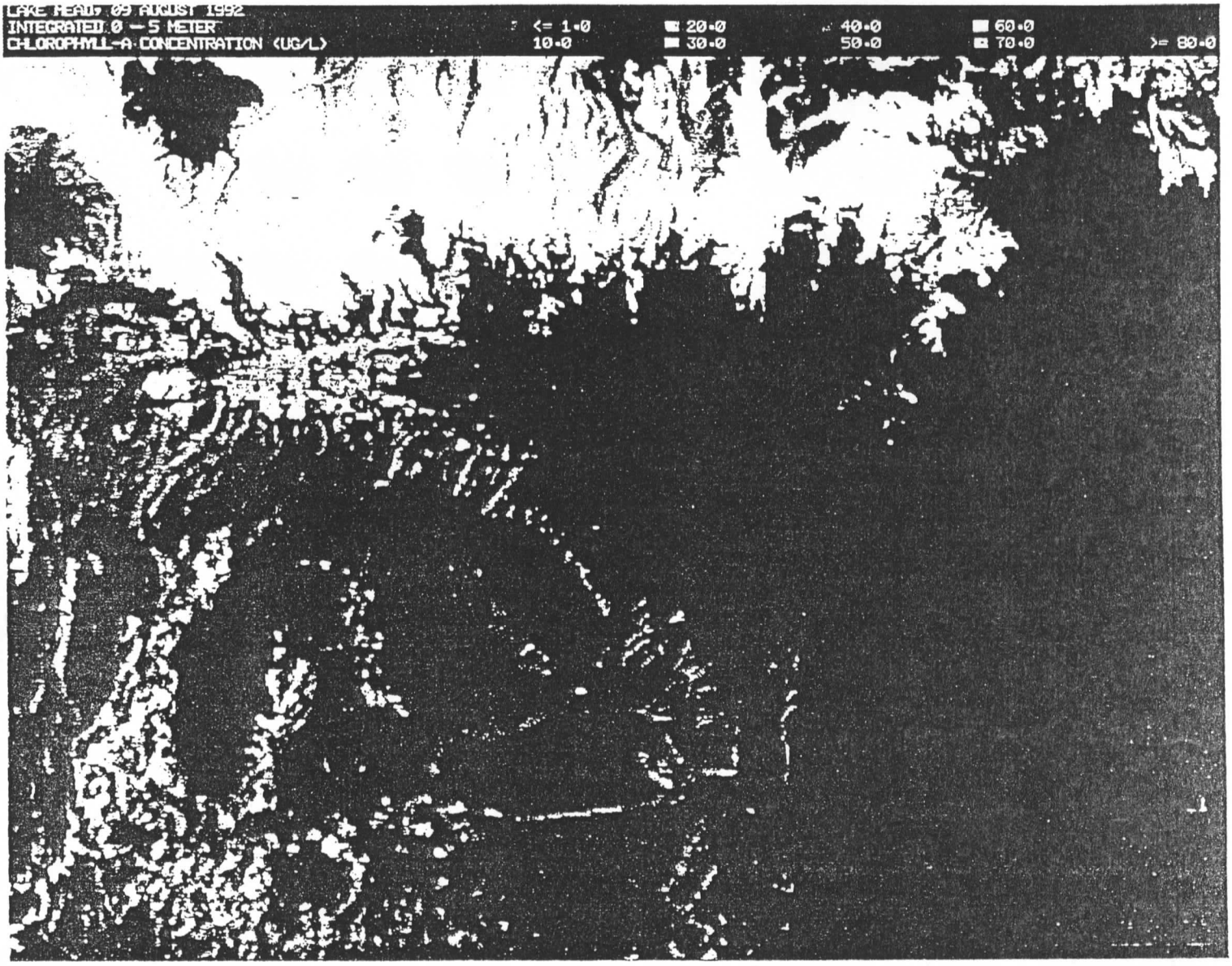

Figure 15-5 - Surface chlorophyll-a concentrations measured by Landsat satellite imagery of Las Vegas Bay, Lake Mead, Nevada, August 9, 1992.

Turbidity
Dissolved Oxygen
Fecal Coliform
Fecal Streptococci
Hardness
Calcium
Magnesium
Sodium Adsorption Ratio
Potassium
Bicarbonate
Alkalinity
Sulfate
Chloride
Flouride
Silica
Solids Residue @ 180° C., Dissolved (mg/l)
Solids, Sum of Constituents, Dissolved (mg/l)
Solids, Dissolved (tons per acre foot)
Nitrite
Nitrite + Nitrate
Ammonia
Nitrogen - Organic
Nitrogen - Organic + Ammonia
Total Nitrogen
Total Phosphate
Total Orthophosphate

Aluminum (Reported Quarterly)
Arsenic (Reported Quarterly)
Barium (Reported Quarterly)
Barylium (Reported Quarterly)
Cadmium (Reported Quarterly)
Chromium (Reported Quarterly)
Cobalt (Reported Quarterly)
Copper (Reported Quarterly)
Iron (Reported Quarterly)
Lead (Reported Quarterly)
Lithium (Reported Quarterly)
Manganese (Reported Quarterly)
Mercury (Reported Quarterly)
Molybdenum (Reported Quarterly)
Nickel (Reported Quarterly)
Selenium (Reported Quarterly)
Silver (Reported Quarterly)

Strontium (Reported Quarterly)
Vanadium (Reported Quarterly)
Zinc (Reported Quarterly)
Sediment Suspended (Report for 9 Months)
Sediment, Discharge, Suspended (Reported for 9 Months)
Sediment, Suspended (Reported Quarterly)
Sieve Dia.1 Finer than 0.062 MM

Las Vegas Bay Remote Sensing Study

Sampling Interval:	Almost monthly from January 1990 through 1992 and has continued intermittently since
Locations Sampled: from	14 stations and 6 coves beginning at LV Wash mouth of bay across Saddle Island following the buoyline
Constituents Tested:	Chlorophyll a (Surface) Temperature (Surface) Phosphate (0 m, 1 m, 3 m, and 0-5 m composite) Nitrate Zooplankton Dissolved Oxygen Specific Conductance pH

The Lower Colorado Region office of Reclamation began water quality monitoring from Temple Basin up to the Grand Wash Cliffs; which lies west and north of Boulder Basin.

Sampling Interval:	Quarterly since June 1993
Constituents Tested:	Ammonia Phosphate Nitrate Zooplankton Temperature Dissolved Oxygen Conductivity pH

City of Las Vegas/Clark County Sanitation District

The City of Las Vegas (CLV) Water Pollution Control Facility has been gathering water quality samples in Lake Mead for over 4 years. The Lake Mead sampling was conducted at a total of 10 stations: six locations in the inner Las Vegas Bay; two in the middle Las Vegas Bay (Stations 4 &

5); one in Boulder Basin (Station 8); and one at Hoover Dam (Station 9) (reference Figure 15-6). The Clark County Sanitation District laboratory analyzes the samples. Some zooplankton analyses is done by the CLV laboratory as well.

Sampling Interval:	Biweekly from March through October Monthly from November through February LM 9 bimonthly Total Organic Carbon (last 6 to 8 months)
Constituents Tested:	Chlorophyll-a Fecal Coliform Total Phosphorus Dissolved Orthophosphate Ammonia TKN Nitrate Nitrite Nitrate + Nitrite Temperature Dissolved Oxygen Conductance pH

Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California (MWD) has numerous years of Colorado River water quality data from Lake Havasu near the Whitsett Intake Pumping Plant. MWD diverts water for the Los Angeles Basin from Lake Havasu which is used to supply drinking water to millions of people in the Southern California area.

Location Tested:	Lake Havasu near Whitsett Intake
Constituents Tested:	Aluminium Arsenic Barium Cadmium Chromium Copper Iron Lead Lithium Manganese Mercury Molybdenum

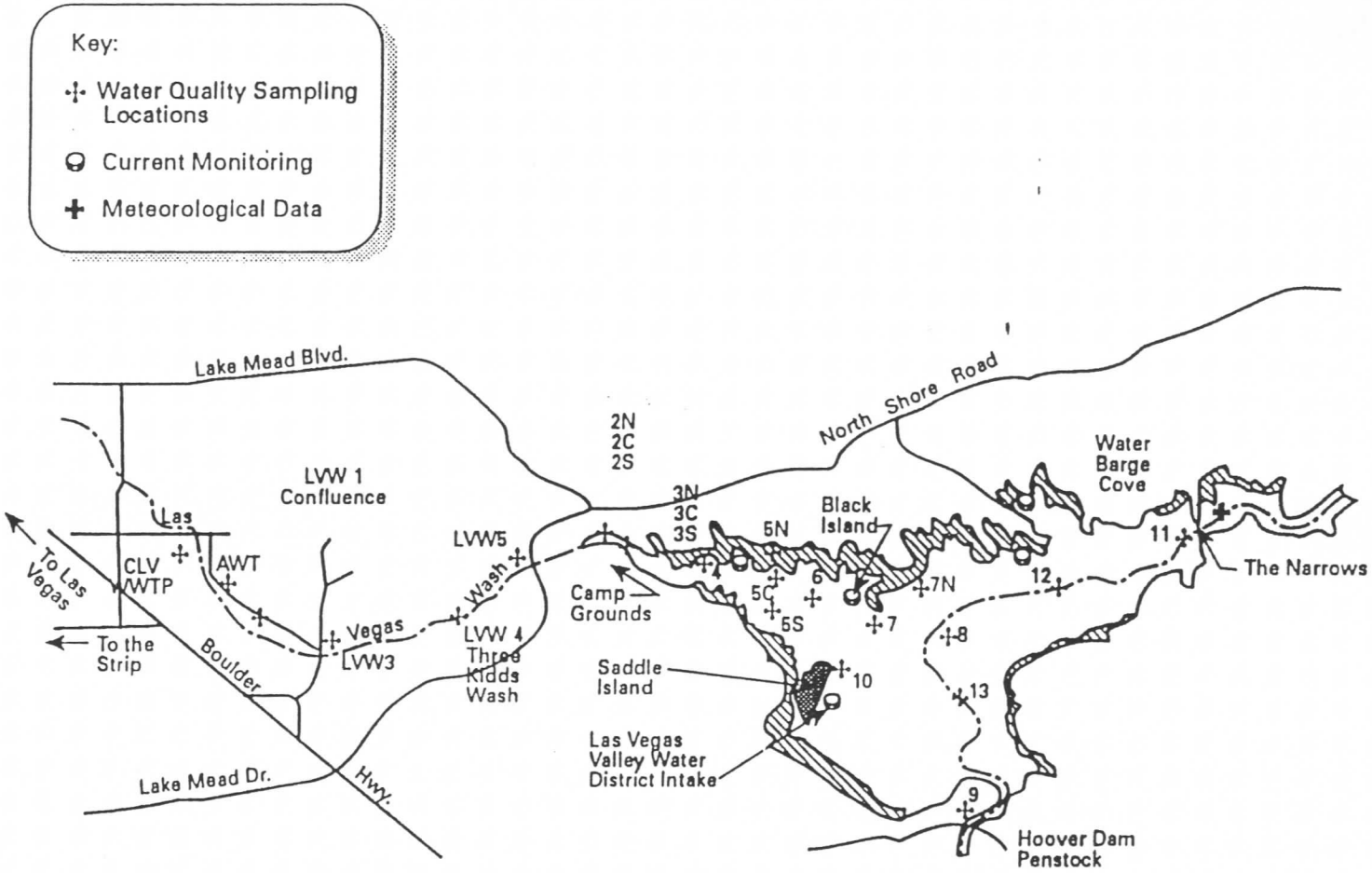

FIGURE 15-6
CITY OF LAS VEGAS/CLARK COUNTY SANITATION DISTRICT
WQS SAMPLING PROGRAM

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Selenium
Silver
Strontium
Zinc
Silica
Calcium
Magnesium
Sodium
Potassium
Carbonate
Bicarbonate
Sulfate
Chloride
Nitrate
Flouride
Boron
Total Dissolved Solids
Total Hardness as Ca Co3
Total Alkalinity as Ca Co3
Free Carbon Dioxide
H^+ Concentration
Specific Conductance
Turbidity
Temperature

EXISTING PHYSICAL DATA AND STUDIES

Lake Mead is a complex body of water which varies in structure throughout the year. An understanding of the hydrodynamics of the Lake will assist in selecting the intake location, depth and type. Measurements of the currents within Lake Mead are rather limited; however two studies have been conducted which include current profiles for the lake.

U.S. Bureau of Reclamation Study from 1971

A study entitled "Measurements of Currents in Lake Mead with the Deep Water Isotopic Current Analyzer (DWICA)" was performed in 1971 by J.J. Sartoris and D.A. Hoffman for the U.S. Bureau of Reclamation.

Study Period: November 10 - 17, 1967

Locations Monitored:

Station 1: Promontory Point about 1 mile above Hoover Dam at a depth of 410 feet.

Station 2:	Mouth of Las Vegas Bay about 1 mile north of Saddle Island at a depth of 285 feet.
Station 3:	Boulder Basin 0.6 miles southwest of Sentinel Island at a depth of 358 feet.

Summary of Findings:

Station 1. "A comparison of current profiles obtained at Station 1 indicates a strong current in the direction of Hoover Dam and approximately centered on the elevation of the outlet. Measurements obtained during the peaking cycle indicate that this current is closely related to discharges through the dam. ...Strong bottom currents in the direction of the dam were observed on the 11th and 16th [of November]. These may be density currents and could be caused by sediment load, salinity, and cold inflow."

Station 2. "The current profiles at this station agree rather closely in indicating a strong current at the surface flowing into Las Vegas Bay out of Boulder Basin. Below this current and centered at about the 100 foot depth is a slightly stronger current flowing in the opposite direction. This current, flowing out of Las Vegas Bay into Boulder Basin, coincides with the top of the thermocline. ... These profiles indicate a major component current in the direction of the water pipe [at Saddle Island] intake between depths of 50 and 110 feet."

Station 3. Data were inconclusive for this station.

City of Las Vegas/CCSD/ECO-Systems Study from 1989

A draft of a two volume study entitled "Physical/Chemical Measurements in Lake Mead, Nevada From August 1 to October 11, 1989" was prepared by ECO-Systems Management Associates for the City of Las Vegas and Clark County Sanitation District. This information was used in the Lake Mead Eutrophication Model, prepared to develop an understanding of the extent to which wastewater discharges affect water quality in Lake Mead. Although the focus of this study was Las Vegas Bay, several data collection sites were chosen in order to determine the characteristics and the correlation of currents in Lake Mead.

Study Period:	April 20 to May 22, 1989 August 1 to October 11, 1989
Locations Monitored:	Four sites within Las Vegas Bay Off Saddle Island near the SNWS intake The Narrows between Boulder and Virgin Basins

Figures 15-7 and 15-8 represent the flow distribution for the model. The report entitled "Development and Calibration of the Lake Mead Eutrophication Model", April 1991 states that "The 1988-89 model calibration and preliminary modeling of 1979-80 conditions found that the Lake stratifies rapidly during the end of March and mid-April. Recurring periods of high vertical mixing appear in June of the three years where the measurements have been studied. This event appears to bring large quantities of inorganic nutrients to the surface just as water temperatures begin to approach annual maximums, so it is an important influence on chlorophyll production."

In Las Vegas Bay, the ECO-Systems study reports the presence of currents moving in a southwesterly direction at a depth of 5 m and currents moving in a northerly direction at a depth of 25 m. Further, the study reports a current moving in a southwesterly direction at about 5 Km/month near Black Island. All currents in the vicinity of the SNWS Intake are reported to be moving parallel to the Saddle Island shoreline. The study noted that current velocities and directions were similar for both summer and fall monitoring periods.

SUMMARY OF WATER QUALITY DATA

In general, water quality in Lake Mead is very consistent as a result of the numerous dams on the Colorado River that regulate the flow and tend to equalize the water quality. The water quality parameters that can be most affected by local conditions are turbidity and biological parameters. Trace metals and minerals are not expected to change significantly in Lake Mead. Turbidity may change due to modification in operation of the reservoir and changing lake levels. Biological parameters (e.g., coliforms and HPCs) vary by proposed intake site due to discharges from wastewater treatment plants and stormwater discharge (i.e., nonpoint sources). This is particularly noticeable in the samples taken from the Las Vegas Bay which receives wastewater from the treatment plants discharging to the Las Vegas Wash as well as urban stormwater runoff. This observation is elaborated by Figure 15-10 and Figure 15-11.

Mineral, Physical and Biological Parameters

Table 15-2 presents mineral, physical and biological information collected from the SNWS, MWD and Reclamation. Of those constituents which are covered by a Primary Drinking Water Standard (i.e., MCL) only turbidity and coliforms are exceeded. Of those constituents covered by the Secondary Drinking Water Standards, only total dissolved solids (TDS) is exceeded.

TDS and Hardness. Figure 15-9 is a plot of Colorado River water TDS and hardness for a 15-year period. This information was prepared by MWD for Lake Havasu water. In addition, the annual summary of TDS for the Colorado River below Hoover Dam was analyzed from 1941 to the present. In general, raw water TDS can be expected to vary between 500 to 700 mg/l (an annual high TDS concentration of 833 mg/l was recorded in 1956, a drought year when the lake reached a record low level). However, TDS concentrations will increase if an extended drought occurs. Figure 15-12 is a plot of conductivity values for a two-year period (1992-1993) from the SNWS intake at depths from 0 to 54 meters. Based on the secondary standards, it would be

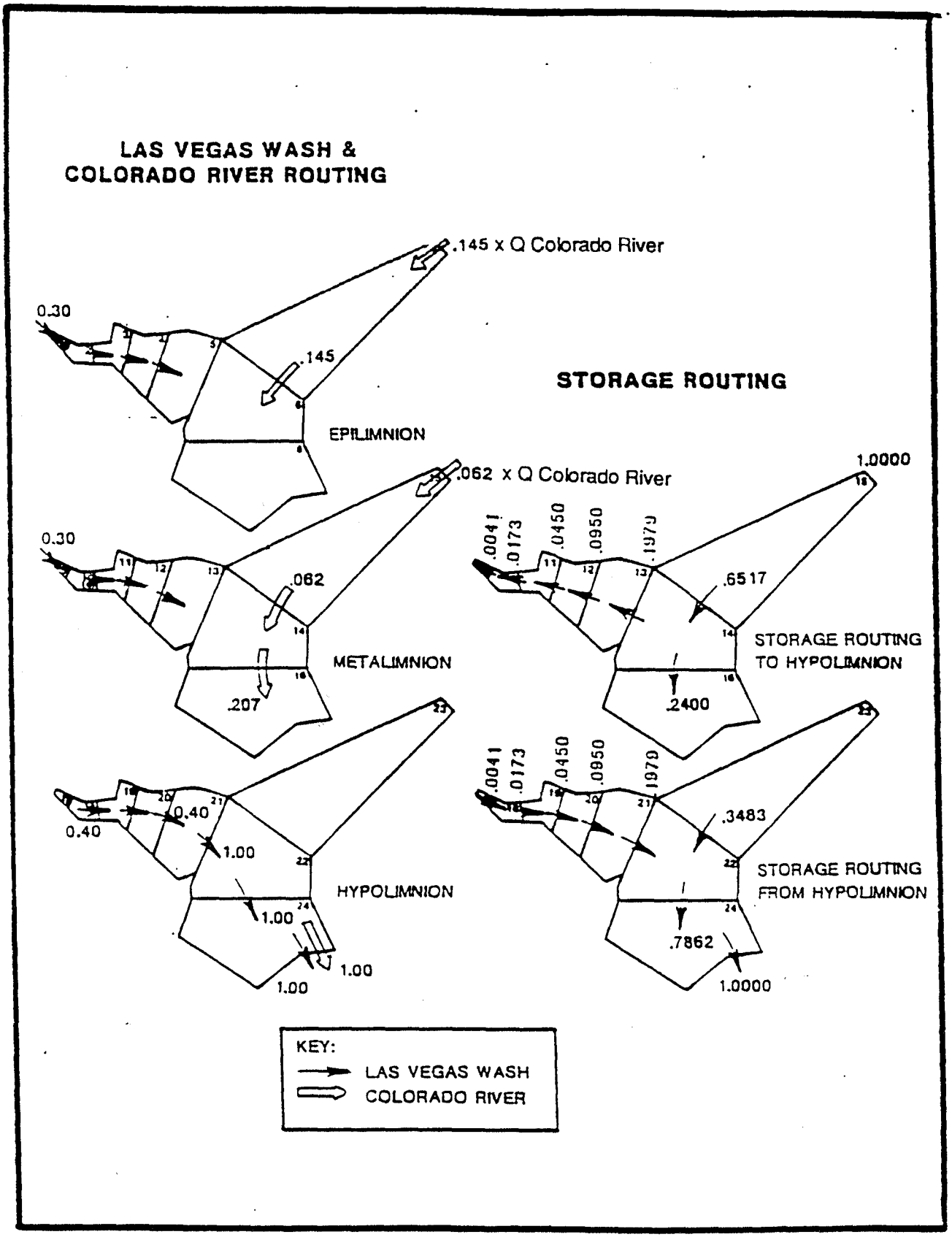


FIGURE 15-7

FLOW ROUTING IN LAS VEGAS BAY
AND BOULDER BASIN

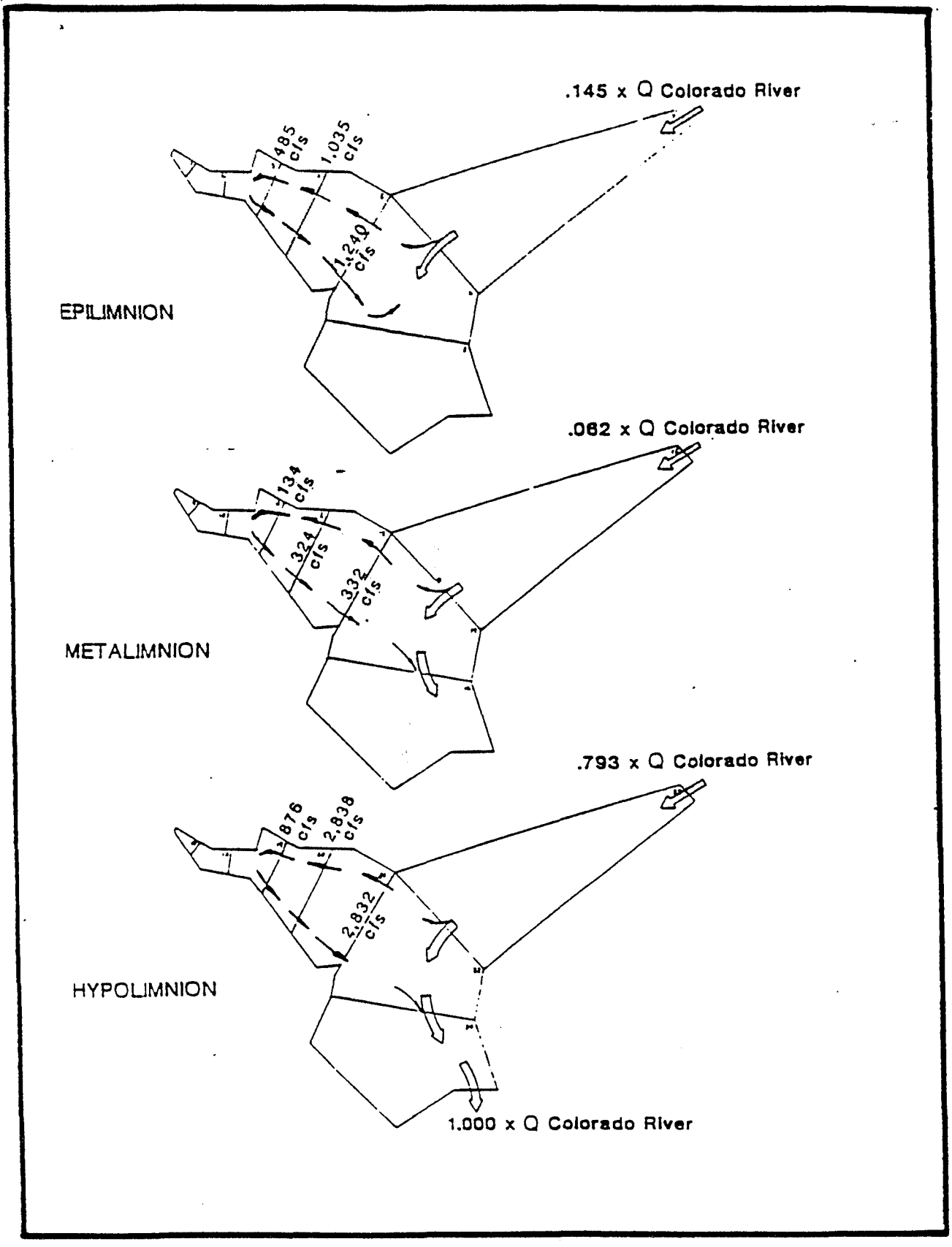


FIGURE 15-8

COLORADO RIVER FLOW ROUTING

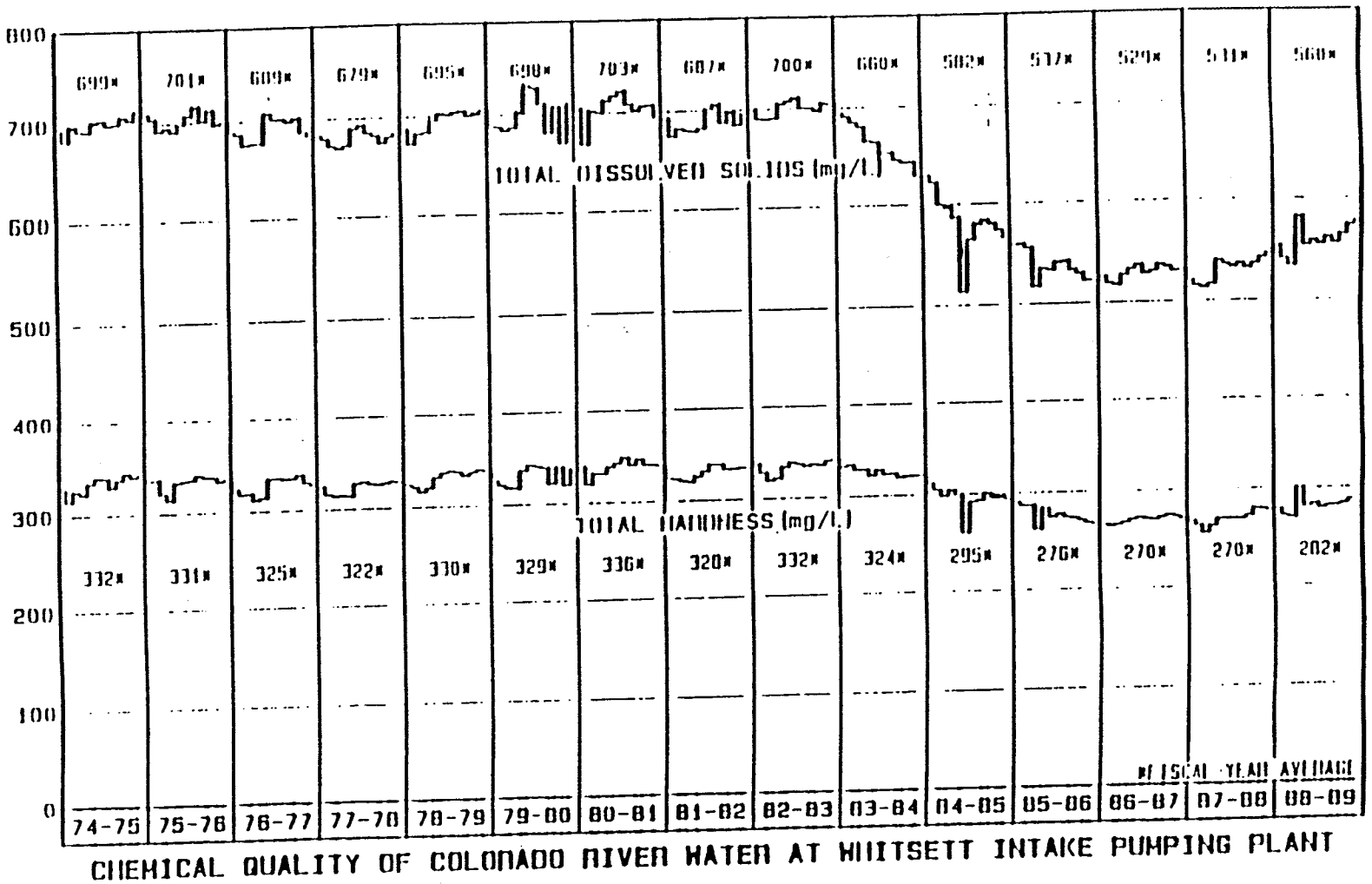


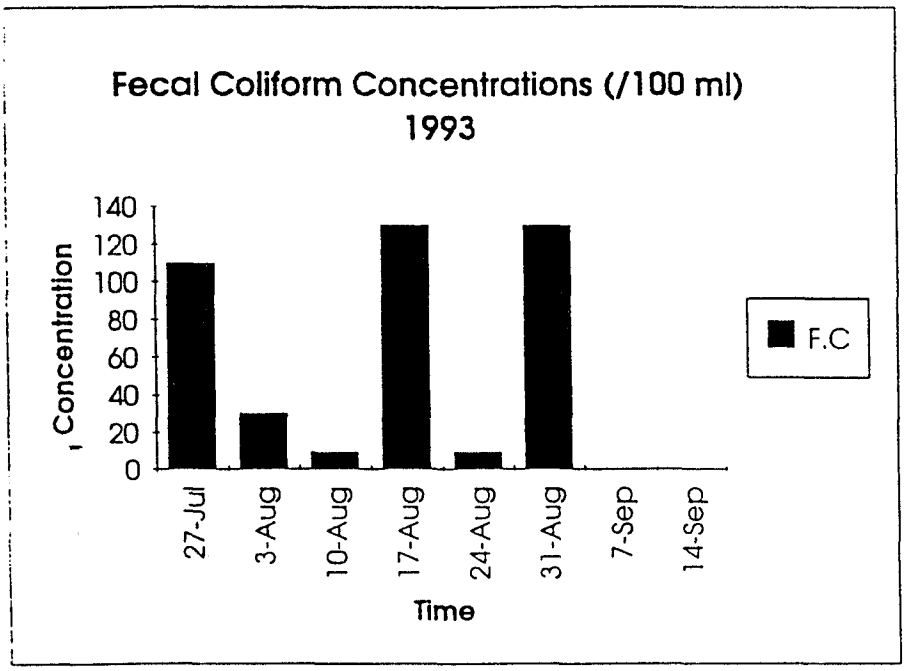
Figure 15-9

TDS AND HARDNESS DATA FROM MWDSC

UNLV Study of Las Vegas Wash

	F.C
27-Jul	110
3-Aug	30
10-Aug	9
17-Aug	130
24-Aug	9
31-Aug	130
7-Sep	<2 *
14-Sep	<2 *
Min	9
Max	130
Avg	69.5

* These values are not included in Min, Max, Avg calculations.



	H.P.C
27-Jul	7.20E+04
3-Aug	1.80E+05
10-Aug	
17-Aug	1.30E+05
24-Aug	2.40E+05
31-Aug	1.40E+05
7-Sep	6.00E+04
14-Sep	6.80E+04
Min	6.00E+04
Max	2.40E+05
Avg	1.34E+05

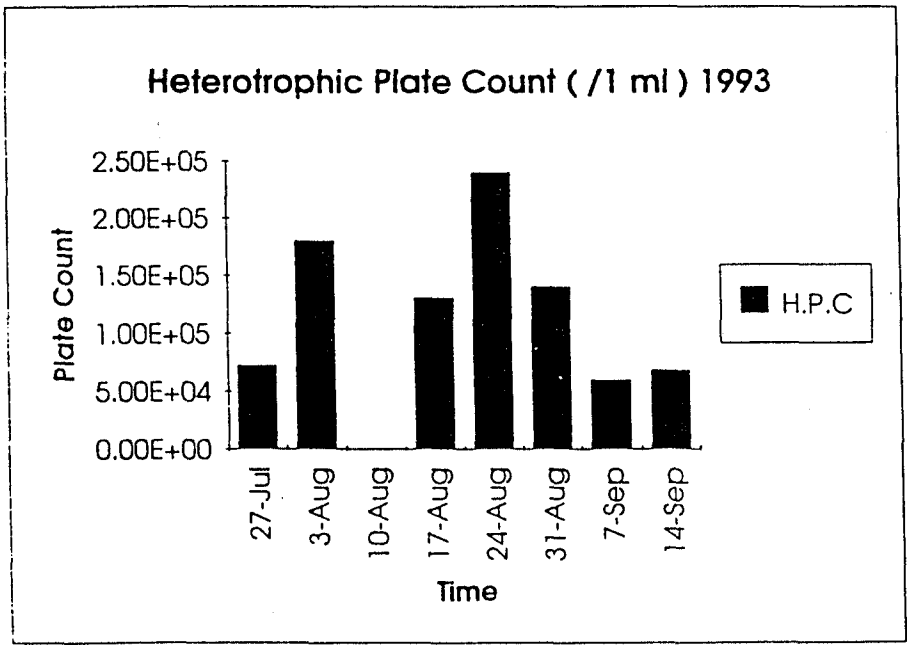
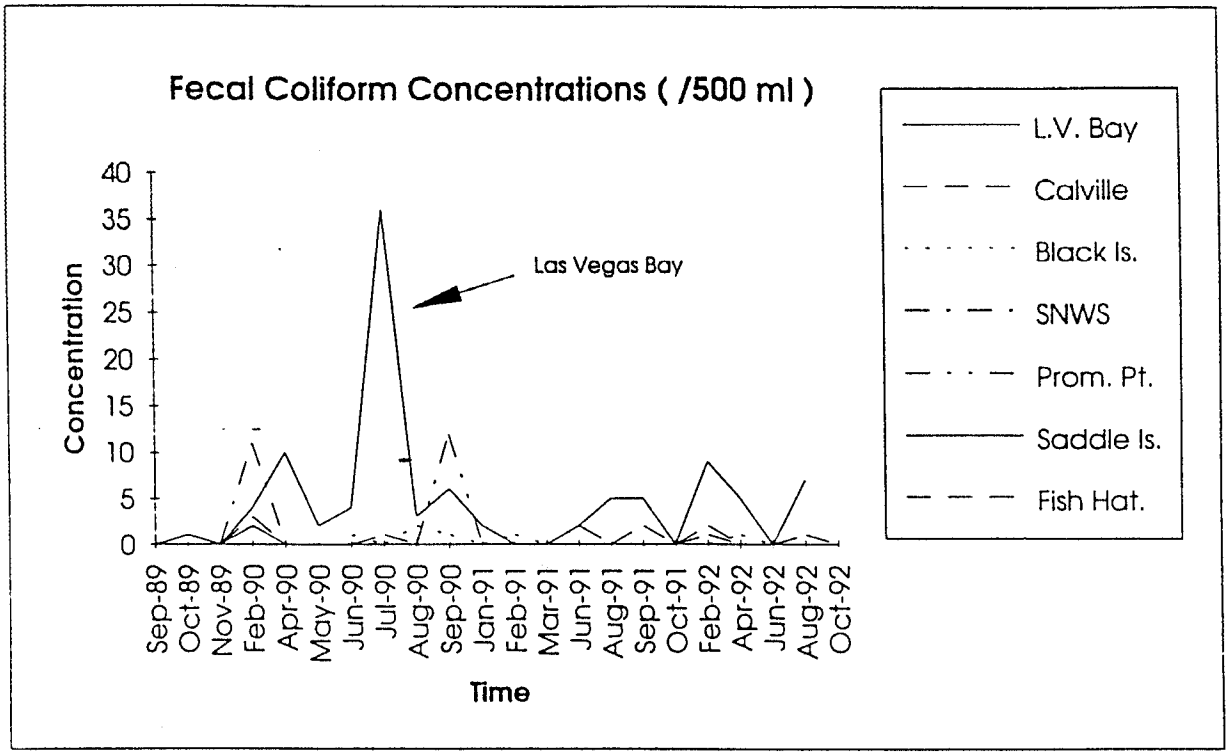


Figure 15-10

SNWS DATA



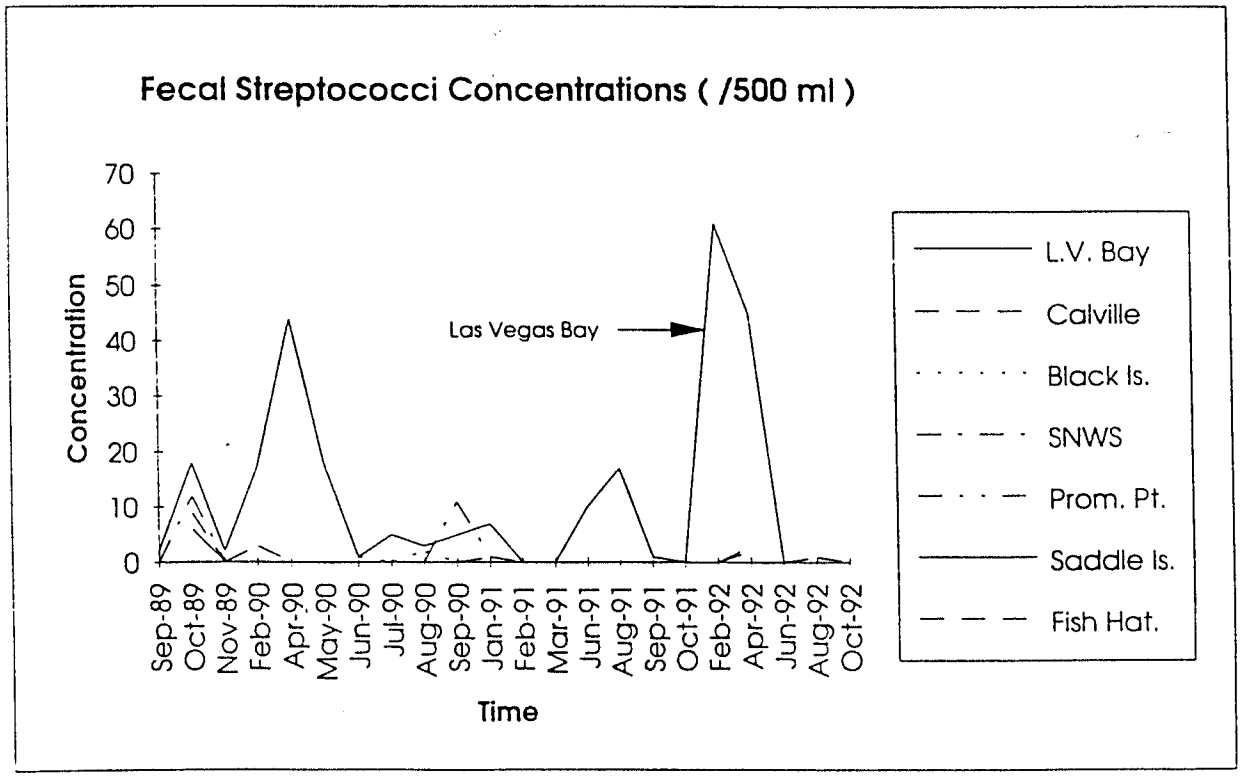


Figure 15-11

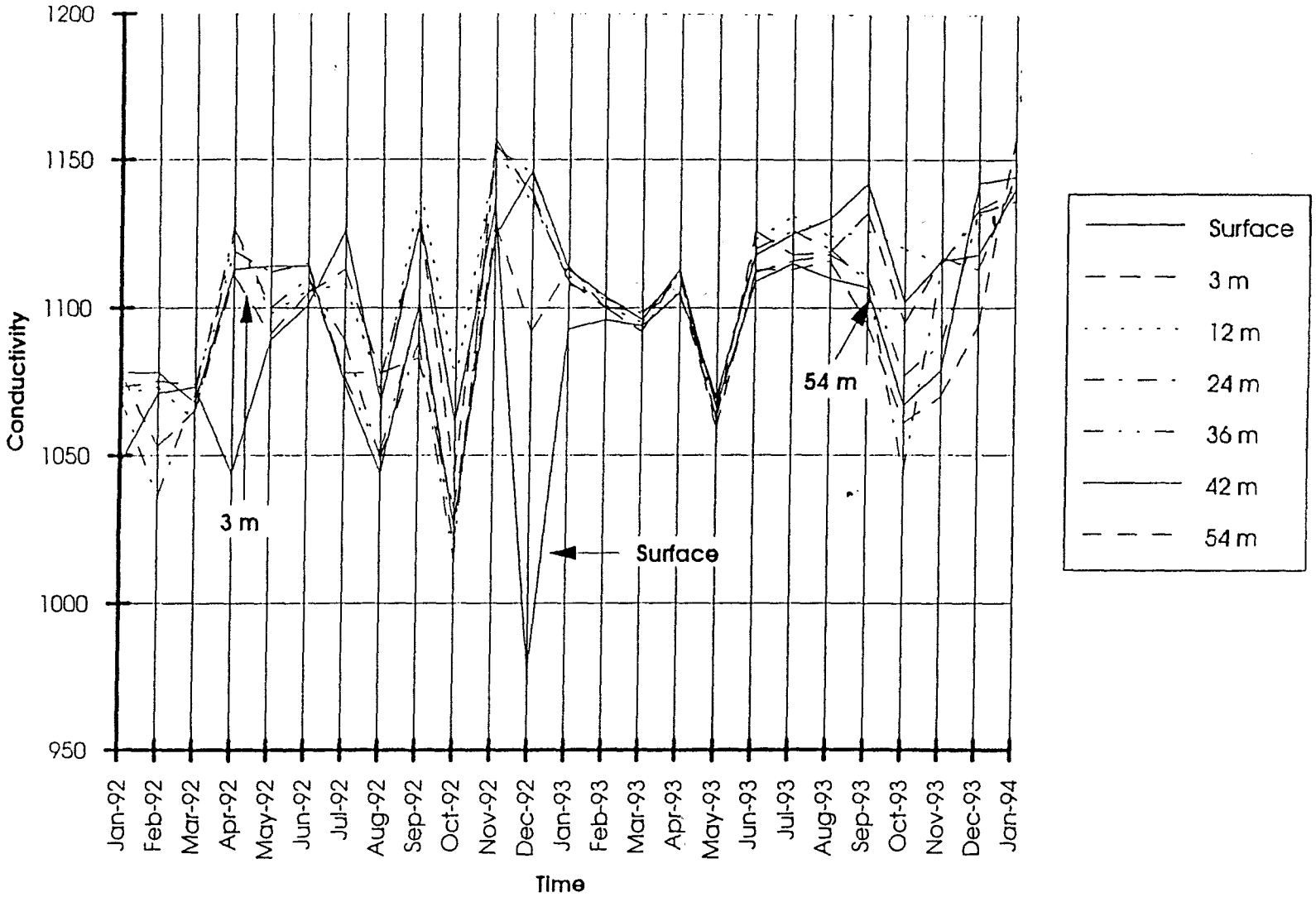
Table 15-2
Mineral, Physical, and Biological Analyses
(Results in mg/l, except where noted)

	SNWS Data for Lake Mead (1992/1993)		MWD Data for Lake Havasu Near the Whitsett Intake 1987 to 1989			Colorado River below Davis Dam Big Bend Water District			Proposed or Existing MCL
	Avg	Max	Min	Max	Avg	10/11/86	10/21/86	2/25/85	
Silica	9.14	9.50	8.6	10	9.2	9.1	8.8	8.5	
Calcium	77.15	77.90	61	73	69	65	65	74	
Magnesium	30.80	32.40	25	27	26	24	25	25	
Sodium	98.97	107.00	72	82	76	73	65	74	
Potassium	5.00	5.70	3.7	4.4	4	3.5	3.5	3.9	
Carbonate	--	--	0	2	1	--	--	--	
Bicarbonate	--	--	148	168	158	--	--	--	
Sulfate	281.28	310.00	208	235	221	219	219	240	250[a]
Chloride	87.38	95.00	55	72	62	219	219	240	250[a]
Nitrate	0.50	0.58	0.4	1.2	0.7	--	--	0.2	10[b]
Fluoride	0.34	0.38	0.26	0.38	0.3	--	--	0.3	2[a]
Total Dissolved Solids	--	--	513	582	546	530	530	560	500[a]
Total Hardness	329	344.00	255	300	276	259	269	--	
Total Alkalinity	124.7	132.00	119	138	130	129	129	--	
Free Carbon Dioxide	4.55	6.53	0.7	2.1	1.4	--	--	--	
pH (Standard Unit)	7.69	7.99	8.11	8.57	8.29	8.3	8.3	--	6.5 to 8.5[a]
Specific Conductivity (umho/cm)	1062	1107	808	913	865	820	825	--	
Turbidity (NTU)	0.28	0.78	0.34	3.5	1.1	--	--	--	0.5[b]
Temperature (°C)	18.87	20.50	9	30	20	17	19.5	--	
Color (cu)	4.17	5.00				--	--	5	15[a]
Total Coliform (C/100 ml)	--	--	<2	79	15	--	--	--	0[b]
HPC Bacteria (C/ml)	--	--	2	1,000	118	--	--	--	

[a]Secondary Drinking Water Standard.
[b]Primary Drinking Water Standard

Figure 15 - 12

Conductivity - SNWS Intake, 1992 - 93



desirable to have a water source with less TDS or possibly reduce TDS through advanced treatment processes; however, it is not mandatory.

Turbidity. As shown in Table 15-2, turbidity values from raw water at SNWS for a two-year period (1992 and 1993) averaged 0.28 NTU with a maximum of 0.78 NTU. SNWS turbidity lake profile data is plotted in Figure 15-13.

Dissolved Oxygen and Temperature. Dissolved oxygen concentrations in Lake Mead vary considerably with depth during periods of thermal stratification (Figure 15-14). As depicted in Figure 15-15, thermal stratification begins to develop by late-April and early-May. The reservoir is well stratified by early June, with the thermocline located at about 10 - 15 m. By late summer, the thermocline drops to 15 - 20 m. Thermal stratification persists well into the fall. The lake does not mix completely until late-November or early-December.

Lake Mead is characterized by a negative heterograde oxygen profile during periods of thermal stratification. A negative heterograde oxygen profile points to a decrease in Dissolved Oxygen (DO) concentrations with depth until a minimum DO concentration is reached. Beyond this depth the DO concentrations increase as a function of depth. In general, acute DO depletions in the metalimnion are attributed to this condition. A plausible explanation for this anomalous DO profile is reported by Paulson, L.J., Baker, J.R., Deacon, J.E. (1980) to be a metalimnetic biological and/or chemical oxygen demand. The thermocline is theorized to represent a sharp density gradient. This facilitates the agglomeration of settling organic matter in the metalimnion, which in turn creates an oxygen demand in this depth zone. Mineralization of this organic matter in the metalimnion reduces oxygen demand in the hypolimnion, thereby sustaining relatively higher DO concentrations in the hypolimnion. DO concentrations typically run about 8 ppm in the epilimnion during summer. Oxygen depletion occurs in the metalimnion between depths of 10 - 20 m. At the thermocline, DO often drops to less than 1 ppm in Las Vegas Bay and down to about 3 - 4 ppm in Boulder Basin. In the hypolimnion, DO concentrations rarely drop below 5 ppm in Boulder Basin. However, in Las Vegas Bay, hypolimnetic DO concentrations often drop to less than 1 ppm during late summer.

Oxygen concentrations are replenished in the metalimnion and hypolimnion during fall mixing. The lake is completely mixed during winter and early spring, and DO concentrations run about 10 ppm throughout the water column.

SNWS chlorophyll data were reviewed for the past two years at the six sampling locations. Figure 15-16 illustrates the temporal variation of chlorophyl a concentrations at the sampled locations. Chlorophyll a concentrations at the SNWS intake show that during summer months, when greater photosynthesis occurs, the chlorophyll a depth profile increases, peaking at depths of approximately 15 to 20 meters. Chlorophyll a concentrations increased dramatically at the SNWS intake between 1992 and 1993. Marked increases in chlorophyll a levels have occurred in the Las Vegas Bay over the last ten years. Data collected by Reclamation indicate that there are greater blooms in the Las Vegas Bay and that the temperature in the Bay has increased during this time.

Figure 15-13

Turbidity - SNWS Intake, 1992 -93

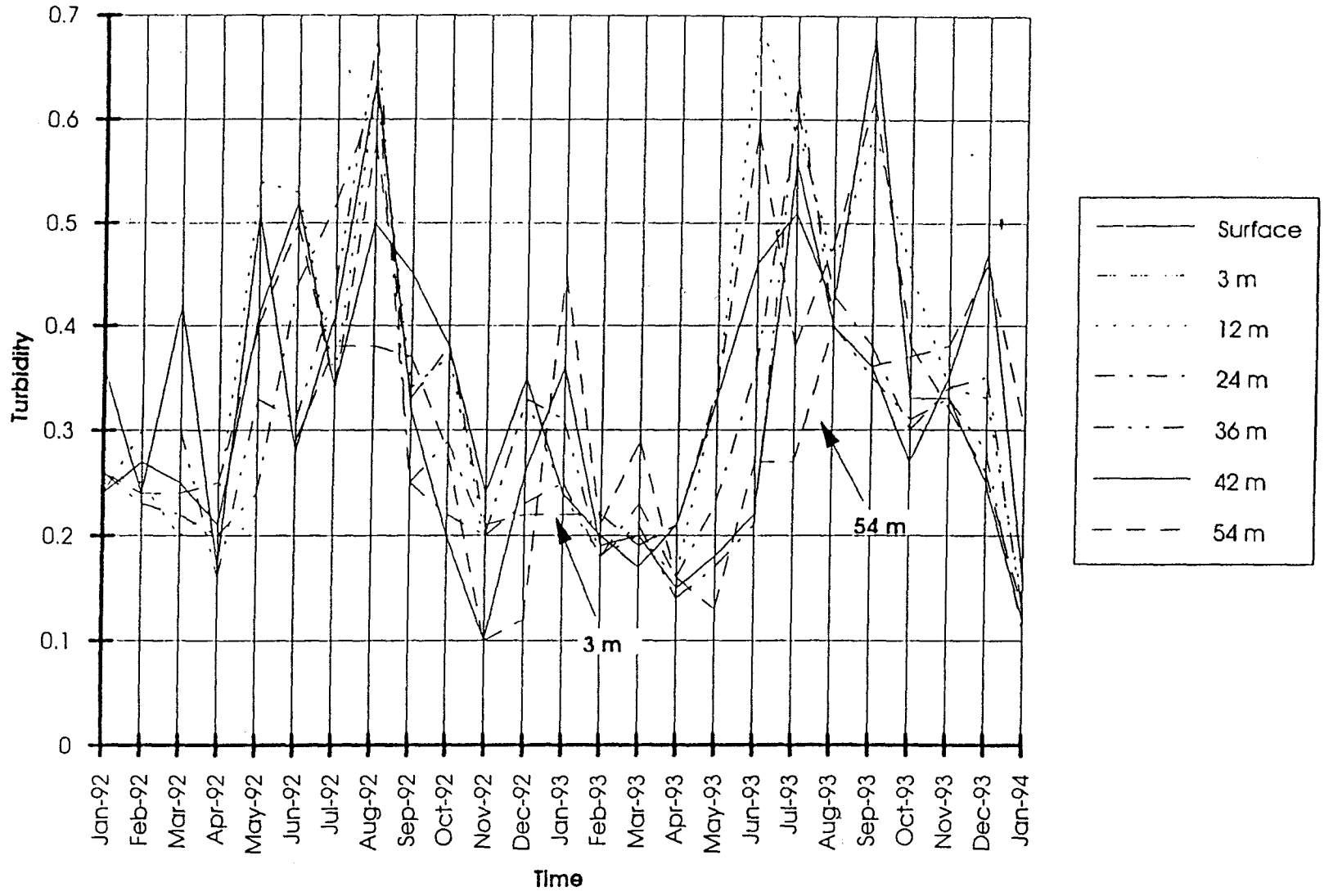


Figure 15-14

Dissolved Oxygen Concentrations - SNWS Intake, 1992-93

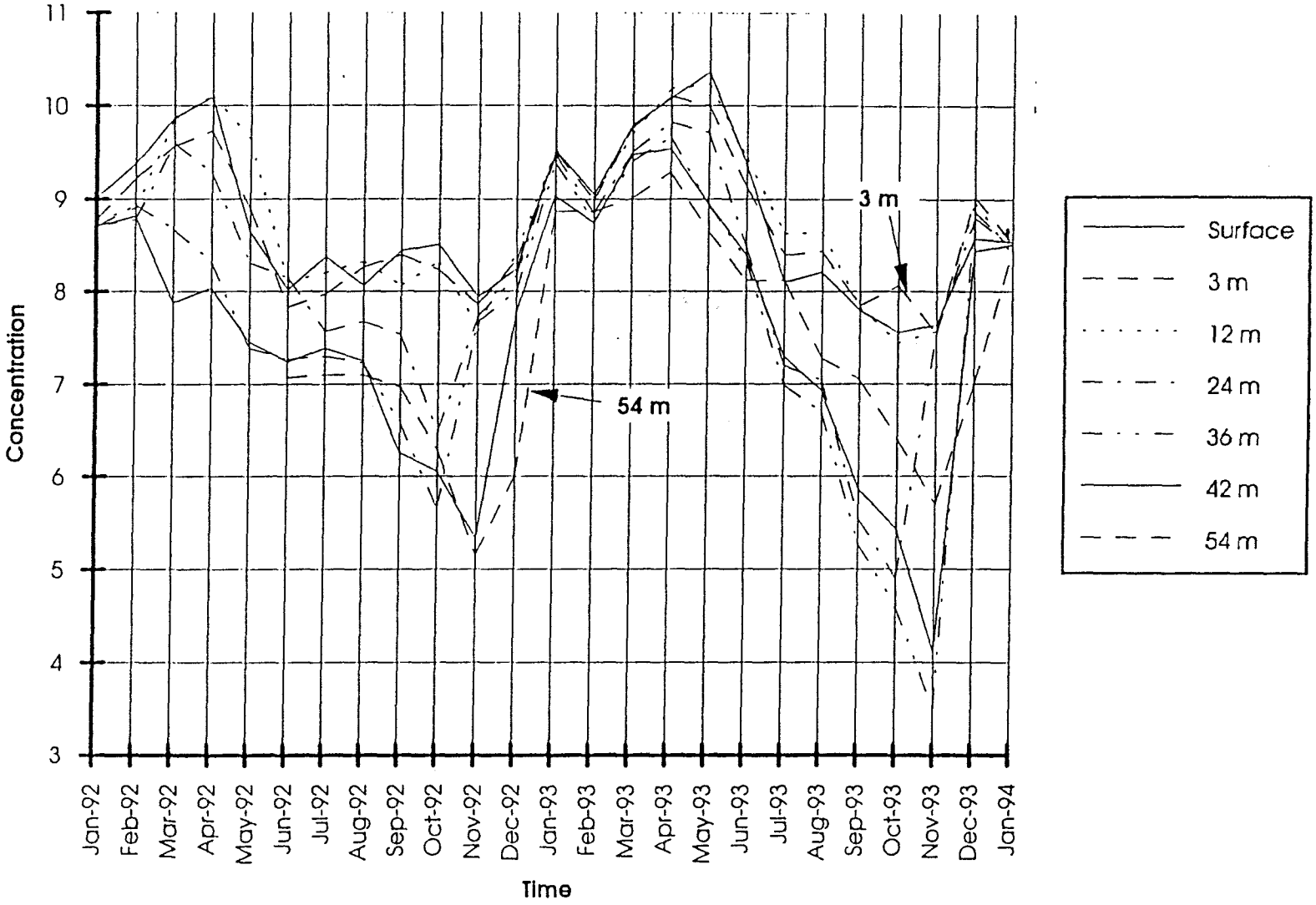


Figure 15 -15

Temperature - SNWS Intake, 1992 - 93

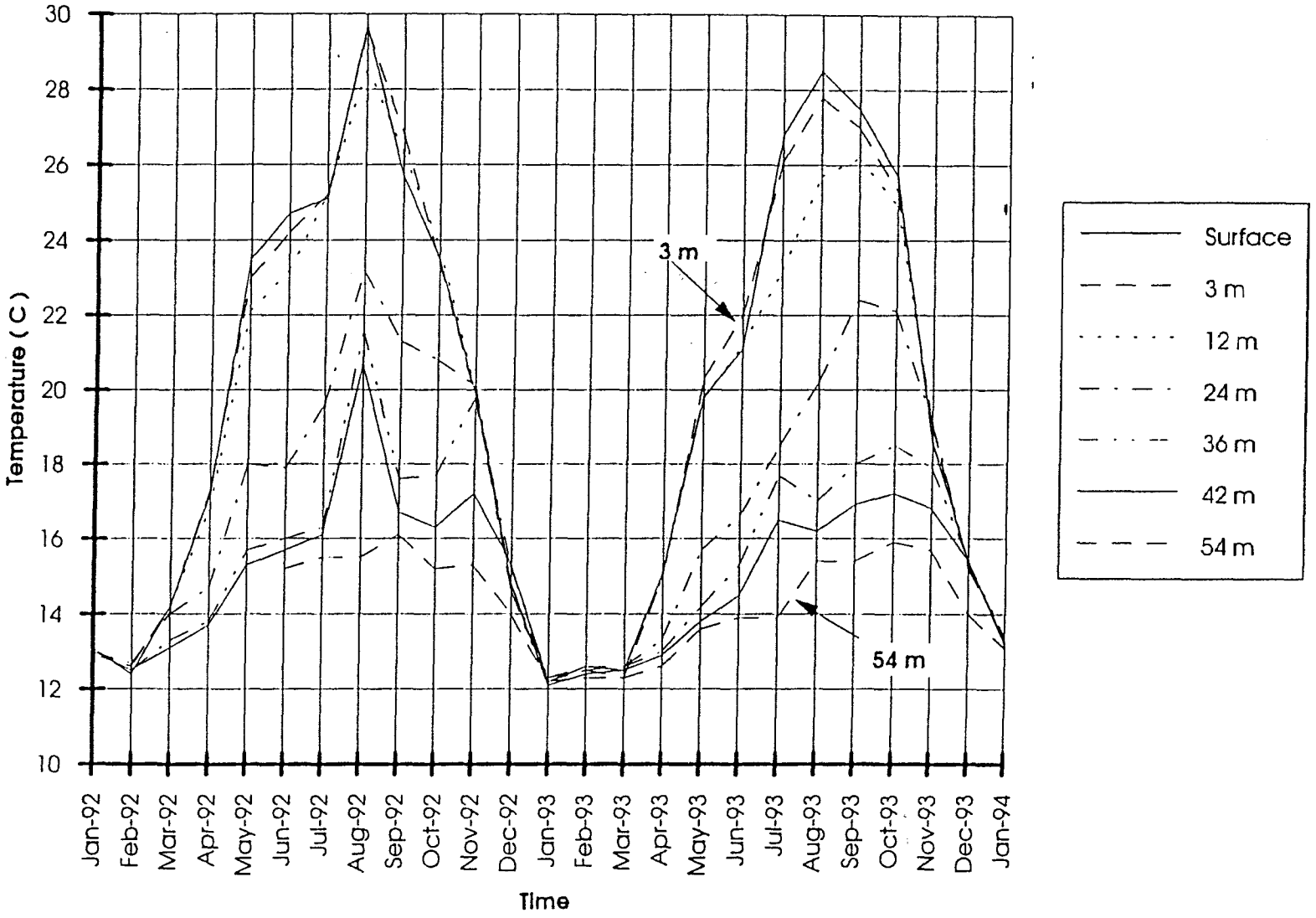
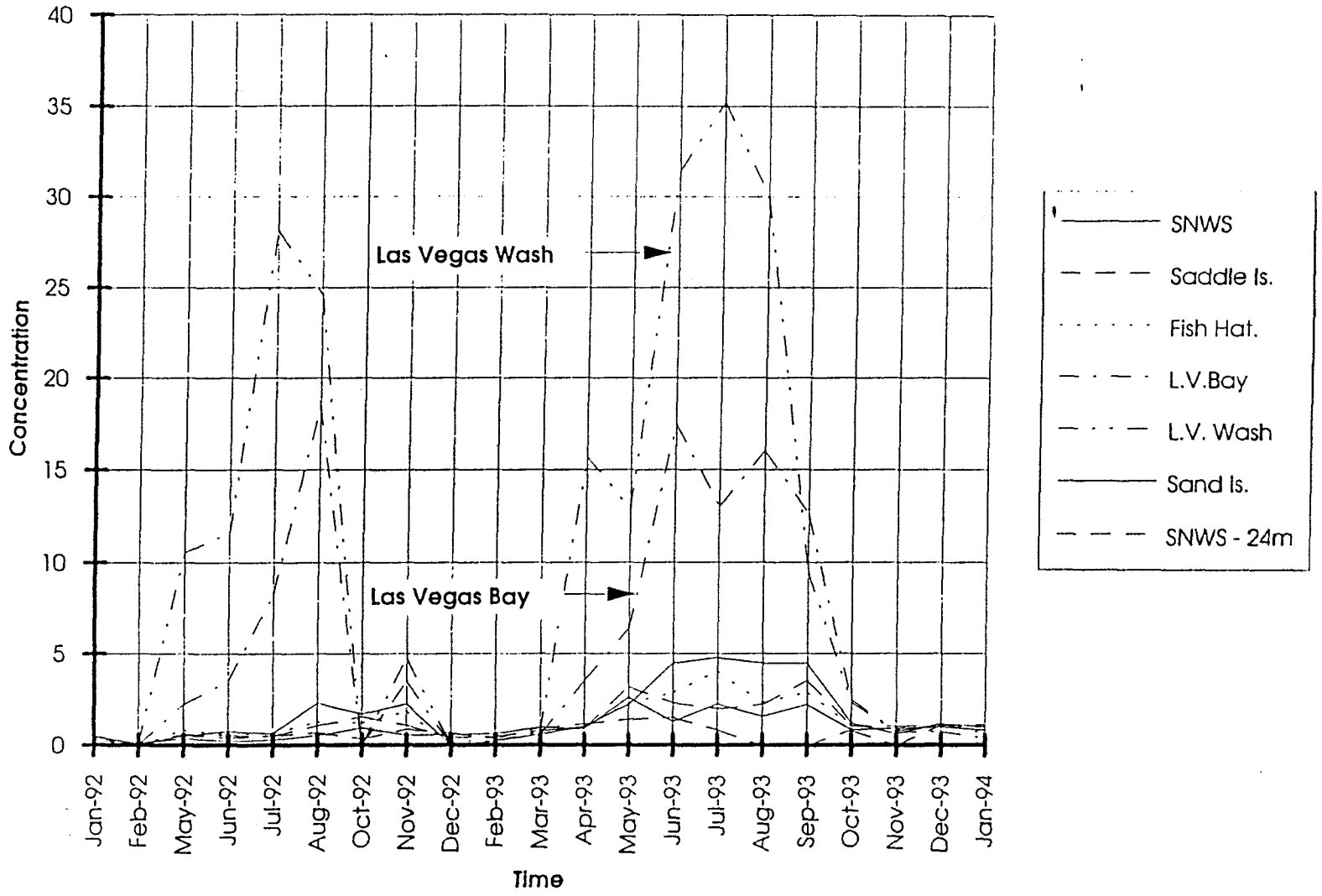


Figure 15-16

Chlorophyl "a" Concentrations



Trace Metals

Table 15-3 presents trace metals information collected from SNWS and MWD at Lake Havasu. As with the mineral, physical and biological data presented above, the water quality data at both locations is similar. All of the trace metals comply with the existing water quality standards (i.e., MCLs or secondary standards). However, there are questions regarding future standards for arsenic which will be addressed in Task 010A18M, Water Treatment.

The current MCL for arsenic is 50 ug/L (micrograms/liter); the proposed standard could be as low as 2 ug/L. Arsenic data received from MWD at Lake Havasu indicate arsenic levels ranging from 2 to 3 ug/L (in four samples taken in April and October of 1992 and 1993). SNWS data in two raw water samples indicate an arsenic level of 3 ug/L (samples taken in March and June 1993).

Trace Organics

Water quality data from the SNWS and BBWD indicate there are no trace organics present in treated Colorado River water except the THM compounds. Preliminary data from MWD shows concentrations of Haloacetic Acids (HAA) to be 40 to 60 percent of the total THMs in Colorado River water. Total organic carbon (TOC) analysis performed by the University of Arizona for Colorado River water show that TOC is between 1 and 3 mg/L. These results suggest that there is not a problem with either volatile organic compounds (VOCs) or synthetic organic compounds (SOCs) in the river water and that the TOC is relatively low.

The City of Las Vegas and Clark County Sanitation District have begun collecting TOC data at their Lake Mead stations 2 through 9 (reference Figure 15-6). The Clark County Sanitation District estimates that these data will be available for review by April 1994. These data should be reviewed for treatment impacts due to TOC concentration in the lake.

RECOMMENDATIONS FOR ADDITIONAL INFORMATION

Table 15-4 shows available water quality data at each alternative intake site. It is recommended that several years of data be reviewed at the specific intake sites including available data at depth to assist in intake siting and selection.

With respect to the water quality data used to evaluate treatment processes, the following is available at or in the general vicinity of most intake sites:

- Turbidity
- Alkalinity
- Coliform Bacteria
- DO
- TDS or Conductivity
- Odor
- Temperature

Table 15-3
Trace Metals Analyses
(Results in ug/l)

	Detection Limit	Proposed or Existing MCL	SNWS Data for Raw Lake Mead Water		MWD Data for Lake Havasu Near the Whitsett Intake	
			Maximum	Average	Maximum	Average
Aluminum	5	50[a]	--	--	250	102.75
Arsenic	1	50	3	3	5	2.8
Barium	5	1,000	220	190	157	103.6
Cadmium	0.5	5	1	1	0	0
Chromium	2	50	2	2	1	0.1
Copper	10	1,300	4	4	0	0.0
Iron	20	300	<10	<10	164	58.9
Lead	2	50	<1	<1	0	0.0
Manganese	2	50[a]	<1	<1	19	6.5
Mercury	0.2	2	<1	<1	0	0.0
Selenium	1	10	3	3	4	2.9
Silver	2	50	1	1	0	0.0
Strontium	20	--	1220	1205	1,060	776.3
Zinc	20	5,000[a]	<20	<20	14	2.0

[a]Secondary Drinking Water Standards

Table 15-4
Available Water Quality Data
at Alternative Intake Sites

	Turbidity	TOC	Alkalinity	Arsenic	Coliform Bacteria	THMFP	Dissolved Oxygen	Hardness	Odor	Algae	Conductivity or TDS	Temp
Callville Bay	SNWS NPS		SNWS (0 & 24M)		SNWS NPS		SNWS (0 & 24M)		SNWS (0 & 24M)		SNWS (0 & 24M)	SNWS (0 & 24M)
Water Barge Cove							UNLV			UNLV	UNLV	UNLV
Box Car Cove (Black Island)	SNWS (0 & 24M)	CCSD	SNWS (0 & 24M)		SNWS		UNLV SNWS (0 & 24M)		SNWS (0 & 24M)	UNLV	UNLV SNWS (0 & 24M)	UNLV SNWS (0 & 24M)
Government Wash (Las Vegas Bay)	SNWS (0 & 24M) NPS	CCSD	SNWS (0 & 24M)		SNWS CCSD NPS		SNWS (0 & 24M) USBR CCSD		SNWS (0 & 24M)	USBR CCSD	USBR NPS SNWS (0 & 24M)	USBR NPS CCSD SNWS (0 & 24M)
Saddle Island (SNWS Intake)	SNWS (0 & 54M)	CCSD	SNWS (0 & 54M)	SNWS	SNWS		UNLV SNWS (0 & 54M)	SNWS	SNWS (0 & 54M)	UNLV	SNWS (0 & 54M)	UNLV SNWS (0 & 54M)
Hemenway Wall (Promontory Point)	SNWS (0 & 24M)		SNWS (0 & 24M)		SNWS		UNLV SNWS (0 & 24M)		SNWS (0 & 24M)	UNLV	SNWS (0 & 24M)	UNLV SNWS (0 & 24M)
Hoover Dam	USBR	CCSD	USBR	USBR	USBR CCSD		UNLV USBR CCSD	USBR		UNLV CCSD	USBR CCSD	UNLV USBR CCSD

SNWS - Southern Nevada Water System
NPS - National Park Service
CCSD - City Las Vegas & Clark County Sanitation District WQS
USBR - U.S. Bureau of Reclamation
UNLV - University of Nevada, Las Vegas

There is little or no data on

- Arsenic
- TOC
- THM Formation Potential

In addition, there are several years worth of data at Saddle Island (SNWS intake), Colorado River below Hoover Dam (Reclamation) and Las Vegas Bay. Minimal data was found for Water Barge Cove.

Additional data would be useful in assessing disinfection by-product formation (TOC data), enhanced coagulation needs (low-level arsenic data). Task 010A18M addresses these issues in further detail along with recommendations for pilot- or bench-scale testing.

APPENDIX 15-1

CHRONOLOGICAL SUMMARY OF WATER QUALITY AND LIMNOLOGICAL STUDIES IN LAKE MEAD DURING 1936-1993

Chronological Summary of Water Quality and Limnological Studies in Lake Mead during 1936-1993

Prepared for:
Montgomery Watson Engineers

Compiled by:
Larry J. Paulson, Ph.D.
West Lakes

February 24, 1994

Longwell, C.R. 1936. ***Geology of the Boulder Reservoir Floor.*** Geological Society of America Bulletin. 47: 1393-1476.

U.S. Department of Interior, Bureau of Reclamation. 1941. ***Lake Mead Density Currents Investigations 1937-40, Vol. 1 and 2.*** 453 p.

Moffett, J.W. 1943. ***A Preliminary Report on the Fishery of Lake Mead.*** Transactions of the 8th North American Wildlife Conference. p. 179-186.

U.S. Department of Interior, Bureau of Reclamation. 1947. ***Lake Mead Density Currents Investigations 1941-46, Vol. 3.*** p. 454-904.

Anderson, E.R. and D.W. Pritchard. 1951. ***Physical Limnology of Lake Mead, Lake Mead Sedimentation Survey.*** U.S. Navy Electronics Laboratory, San Diego, California. Report No. 258. October 3, 1951. 153 p.

Study Period:	Twelve Survey Cruises from 25 February, 1948 to 11 February, 1949
Stations Sampled:	68 Stations Lake-wide
Constituents/ Measurements:	Temperature Salinity Secchi Depth

U.S. Department of Interior, Geological Survey. 1954. ***The First Fourteen Years of Lake Mead.*** Geological Survey Circular 346. 27 p.

Jonez, Al, Robert C. Sumner. 1954. ***Lakes Mead and Mohave Investigations - A Comparative Study of an Established Reservoir as Related to a Newly Created Impoundment.*** Nevada Fish and Game Commission. 186 p.

Harbeck, G.E., Jr., M.A. Kohler, G.E. Koberg, and others. 1958. ***Water-Loss Investigations: Lake Mead Studies.*** U.S. Geological Survey, Professional Paper No. 298. 100 p.

Smith, W.O., C.P. Vetter, G.B. Cummings, and others. 1960. ***Comprehensive Survey of Sedimentation in Lake Mead.*** U.S. Geological Survey, Professional Paper No. 295. 254 p.

U.S. Department of Interior, Bureau of Reclamation. 1965. ***Water Chemistry Survey of Boulder Basin Lake Mead.*** Chemical Engineering Branch, Division of Research, Report No. ChE-46, Denver, Colorado. 36 p.

Study Period: April-May 1964

Stations Sampled: 16 Stations in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:
- pH
- Dissolved Carbon Dioxide
- Dissolved Oxygen
- Conductance
- Temperature
- TDS (select stations)
- Anions/Cations (select stations)
- Nitrate (select stations)

U.S. Department of Health, Education, and Welfare, Public Health Service. 1965. ***Algal and Nutrient Survey of the Surface Waters of Lake Mead, June 4-8, 1965.*** Division of Water Supply and Pollution Control, Technical Services Branch, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. 8 p.

Study Period: June 4-8, 1965

Stations Sampled: 50 Stations in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:
- Total Phosphorus
- Soluble Phosphorus
- Nitrate-Nitrogen
- Ammonia-Nitrogen
- Organic Nitrogen
- Phytoplankton Species/Counts

U.S. Department of Interior, Federal Water Pollution Control Administration. 1967. ***Report on Pollution in Las Vegas Wash and Las Vegas Bay.*** Division of Technical Services, Cincinnati, Ohio and Colorado River Basin Water Quality Control Project, Denver, Colorado. 18 p., plus appendix with raw data.

Study Period: May 19-31, 1966

Stations Sampled:
- 14 Stations in Las Vegas Wash
- 8 Stations in Las Vegas Bay
- 7 Stations along Boulder Beach

Constituents/
Measurements:

Total Phosphorus
Nitrate-Nitrogen
Ammonia-Nitrogen
Organic Nitrogen
Total/Fecal Coliforms
Salmonella
Biological Oxygen Demand
Phytoplankton Species/Counts
Metals
Pesticides

U.S. Department of Interior, Bureau of Reclamation. 1967. ***Water Quality Study of Lake Mead.*** Chemical Engineering Branch, Division of Research, Report No. ChE-70, Denver, Colorado. 155 p.

Study Period:

April 23-May 8, 1964
May 11-24, 1965
November 1-11, 1965
April 14-20, 1966
November 1-9, 1966

Stations Sampled:

28 Stations Lake-wide
16 Stations in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:

pH
Dissolved Carbon Dioxide
Dissolved Oxygen
Conductance
Temperature
Secchi Depth
Alkalinity
TDS (select stations)
Anions/Cations (select stations)
Nitrate (select stations)

U.S. Department of Interior, Federal Water Pollution Control Administration. 1968. ***A Report on Biological Studies of Selected Reaches and Tributaries of the Colorado River.*** Technical Advisory and Investigations Branch, Cincinnati, Ohio and Colorado River Basin Water Quality Control Project, Denver, Colorado. 228 p.

Study Period:

April 1966

Stations Sampled:

Selected Reaches of the Colorado River.
One Station in Las Vegas Bay

Constituents/ Measurements:	Phytoplankton Species/Counts Invertebrate Identifications/Counts

Blackman, W.C., Jr. 1968. ***Pollution of Las Vegas Wash and Lake Mead and Recommendations for Necessary Studies.*** Memorandum to Director, SW Region, Federal Water Pollution Control Administration and Project Director, Colorado River Basin Water Quality Control Program. February 23, 1968. 16 p., plus appendices of raw data.

U.S. Department of Interior, Federal Water Quality Administration. 1970. ***Analysis of Algal Growth Potential and Possible Discharge Requirements for the Lower Colorado River.*** Pacific Southwest Region, San Francisco, California. May 1970.
46 p.

Study Period:	January 25-26, 1970 February 16-17, 1970 March 1-4, 1970
Stations Sampled:	7 Stations in Las Vegas Bay/ Boulder Basin 3 Stations Downstream of Hoover Dam 5 Ground Water Stations in Las Vegas Wash
Constituents/ Measurements:	Temperature Conductance Total Phosphorus Ortho Phosphorus Nitrate-Nitrogen Nitrite- Nitrogen Ammonia-Nitrogen Total Organic Nitrogen Total Kjeldahl Nitrogen Algal Bioassays Chlorophyll-a

Lara, J.M. and J.I. Sanders. 1970. ***The 1963-1964 Lake Mead Sediment Survey.*** U.S. Bureau of Reclamation, Report No. REC-OCE-70-21, Denver, Colorado. 172 p.

Summarizes results of lake wide sediment survey conducted to re-evaluate the 1948-49 area, capacity and sediment volume tables for the lake.

U.S. Department of Interior, Federal Water Quality Administration. 1970. ***Analysis of Water Quality and Proposed Water Quality Standards for Lake Mead and the Lower Colorado River.*** Pacific Southwest Region, San Francisco, California. October 1970. 63 p.

Study Period:	January 25-26, 1970 February 16-17, 1970 March 1-4, 1970 August 13-14, 1970
Stations Sampled:	7 Stations in Las Vegas Bay/ Boulder Basin 3 Stations Downstream of Hoover Dam 5 Ground Water Stations in Las Vegas Wash
Constituents/ Measurements:	Temperature Conductance Total Phosphorus Ortho Phosphorus Nitrate-Nitrogen Nitrite- Nitrogen Ammonia-Nitrogen Total Organic Nitrogen Total Kjeldahl Nitrogen Algal Bioassays Chlorophyll-a

Hoffman, D.A., P.R. Tramutt, and F.C. Heller. 1971. ***The Effects of Las Vegas Wash Effluent upon the Water Quality in Lake Mead.*** U.S. Bureau of Reclamation, Report No. REC-REC-71-11, Denver, Colorado. January 1971. 26 p.

Study Period:	March 2-11, 1968 May 22-27, 1968 August 21-27, 1968 November 15-19, 1968
Stations Sampled:	4 Stations in Las Vegas Bay/Boulder Basin 3 Stations in Las Vegas Wash
Constituents/ Measurements:	pH Dissolved Oxygen Conductance Temperature Secchi Depth

Dissolved Carbon Dioxide
Alkalinity
Chlorophyll-a
Total Phosphorus
Ortho Phosphorus
Nitrate-Nitrogen
Ammonia-Nitrogen
Organic-Nitrogen
TDS (wash stations)
Anions/Cations (wash stations)
Current Velocity (wash stations)

Sartoris, J.J. and D.A. Hoffman. 1971. ***Measurements of Currents in Lake Mead with the Deep Water Isotopic Current Analyzer (DWICA).*** U.S. Bureau of Reclamation, Report No. REC-REC-71-38, Denver, Colorado. October 1971. 17 p.

Study Period: November 10-17, 1967

Stations Sampled: 3 Stations in Boulder Basin

Constituents/ Measurements: Current Velocity and Direction

U.S. Environmental Protection Agency. 1971. ***Report on Water Pollution Problems in Las Vegas Wash and Las Vegas Bay.*** Region IX, San Francisco, California. November 1971. 20 p.

Study Period:
January 25-26, 1970
February 16-17, 1970
March 1-4, 1970
August 13-14, 1970

Stations Sampled:
9 Stations in Las Vegas Bay/Boulder Basin
3 Stations Downstream of Hoover Dam
5 Ground Water Stations in Las Vegas Wash
11 Surface Water Stations in Las Vegas Wash

Constituents/ Measurements:
Temperature
Conductance
Secchi Depth
Total Phosphorus
Ortho Phosphorus
Nitrate-Nitrogen
Nitrite-Nitrogen
Ammonia-Nitrogen
Total Organic Nitrogen

Total Kjeldahl Nitrogen
Algal Bioassays
Chlorophyll-a

U.S. Environmental Protection Agency. 1971. ***Report on Pollution Affecting Las Vegas Wash, Lake Mead & the Lower Colorado River, Nevada-Arizona-California.*** Division of Field Investigations, Denver, Colorado and Region IX, San Francisco, California. December 1971. 52 p., plus appendices of water quality standards.

Summarizes previous water quality studies in Las Vegas Wash and water quality standards for the Colorado River and Las Vegas Wash.

University of Arizona. 1971. ***Micronutrient and Biological Patterns in Lake Mead.*** Department of Hydrology and Water Resources, College of Earth Sciences and Department of Biological Sciences. Final Report to U.S. Bureau of Reclamation. 24 p., plus appendices of graphed data.

Study Period:
September 4-11, 1970
November 24-29, 1970
January 23-29, 1971
February 25-28, 1971
April 3-9, 1971
June 4-9, 1971

Stations Sampled: 8 Stations Lake-wide, 3 in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:
pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Alkalinity
Ortho Phosphorus
Nitrate-Nitrogen
TDS
Anions/Cations
Iron
Manganese
Zinc
Copper
Zooplankton Species/Counts
Primary Productivity (Carbon-14 Method)

Koenig, E.R. , R.W. Tew and J.E. Deacon. 1972. ***Phytoplankton Successions and Lake Dynamics in Las Vegas Bay, Lake Mead, Nevada.*** Arizona Academy of Sciences 7: 109-112.

Everett, L.G. 1972. ***A Mathematical Model of Primary Productivity and Limnological Patterns in Lake Mead.*** Technical Report No. 13, University of Arizona, Tucson, Arizona. 151 p.

Study Period:
September 4-11, 1970
November 24-29, 1970
January 23-29, 1971
February 25-28, 1971
April 3-9, 1971
June 4-9, 1971

Stations Sampled: 8 Stations Lake-wide, 3 in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:
pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Alkalinity
Ortho Phosphorus
Nitrate-Nitrogen
TDS
Anions/Cations
Iron
Manganese
Zinc
Copper
Zooplankton Species/Counts
Primary Productivity (Carbon-14 Method)

Deacon, J.E. and R.W. Tew. 1973. ***Interrelationships between Chemical, Physical, and Biological Conditions of the Waters of Las Vegas Bay of Lake Mead.*** Department of Biological Sciences, University of Nevada, Las Vegas. Final Report to Las Vegas Valley Water District. 186 p.

Study Period: January 1972 - November 1972

Stations Sampled: 15 Stations in Las Vegas Bay/Boulder Basin
1 Station in Las Vegas Wash

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Secchi Depth
Chlorophyll-a
Ortho Phosphorus
Nitrate+Nitrite-Nitrogen (select stations)
Alkalinity (select stations)
TDS (select stations)
Anions/Cations (select stations)
Silica (select stations)
Fecal Coliforms (select stations)
Phytoplankton Species/Counts
Fish Distribution

Staker, R.D. 1974. ***A diurnal zooplankton migration study in Lake Mead.*** Arizona Academy of Sciences. 9:85-88.

Staker, R.D., R.W. Hoshaw, and L.G. Everett. 1974. ***Phytoplankton distribution and water quality indices for Lake Mead (Colorado River).*** Journal of Phycology. 10: 323-331.

Deacon, J.E. 1975. ***Lake Mead Monitoring Program.*** Department of Biological Sciences, University of Nevada, Las Vegas. Final Report to Clark County Wastewater Management Agency. 207 p.

Study Period: February 1974 - December 1974

Stations Sampled: 7 Stations in Las Vegas Bay/Boulder Basin
1 Station in Las Vegas Wash

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Chlorophyll-a
Biological Oxygen Demand (wash station)
MBAS (wash station)
Chemical Oxygen Demand (wash station)
TSS (wash station)
Turbidity (wash station)
Total Phosphorus (select stations)

Dissolved Phosphorus (select stations)
Ammonia-Nitrogen (select stations)
Nitrate+Nitrite-Nitrogen (select stations)
Total Kjeldahl Nitrogen (select stations)
Alkalinity (select stations)
Fecal Coliform Bacteria (select stations)
Phytoplankton Species/Counts
Algal Bioassays
Fish Distribution

Aoki, I. 1975. ***Seasonal and Spatial Variation in Primary Productivity in Boulder Basin, Lake Mead, Clark County, Nevada.*** M.S. Thesis, University of Nevada, Las Vegas. 178 p.

Egdorf, S.S. 1976. ***The Nature and Distribution of Enteric Bacteria in Las Vegas Bay.*** M.S. Thesis, Department of Biological Sciences, University of Nevada, Las Vegas. 84 p.

Deacon, J.E. 1976. ***Lake Mead Monitoring Program.*** Department of Biological Sciences, University of Nevada, Las Vegas. Final Report to Clark County Sanitation District No. 1, Wastewater Treatment Physical Development Section. 182 p.

Study Period: April 1975 - February 1976

Stations Sampled: 6 Stations in Las Vegas Bay/Boulder Basin
1 Station in Las Vegas Wash

Constituents/
Measurements:
pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Chlorophyll-a
Biological Oxygen Demand (wash station)
MBAS (wash station)
Chemical Oxygen Demand (wash station)
TSS (wash station)
Turbidity (wash station)
Total Phosphorus (select stations)
Dissolved Phosphorus (select stations)
Ammonia-Nitrogen (select stations)
Nitrate+Nitrite-Nitrogen (select stations)
Total Kjeldahl Nitrogen (select stations)
Alkalinity (select stations)
Fecal Coliform Bacteria (select stations)

Phytoplankton Species/Counts
Primary Productivity (Carbon-14 Method)
Zooplankton Species/Counts

Goldman, C.R., A.D. Jassby, L.J. Paulson, B.L. Kimmel, and J.T. Rybock. 1976. ***A Review of the Limnology and Water Quality Standards for Lake Mead.*** Ecological Research Associates, Davis, California. Final Report to Clark County Sanitation Dist. No. 101 p.

Critical review of the Lake Mead Monitoring Program with recommendations for water quality standards and pollution abatement in Las Vegas Bay.

Sawyer, C.N. 1976. ***Report on Wastewater Disposal to the Board of County Commissioners, Clark County, Nevada.*** 69 p.

Review of controversy regarding water quality standards for Las Vegas Wash.

Tew, R.W. , S.S. Egdorf, and J.E. Deacon. 1976. ***Distribution of stream pollution in lake water.*** Journal of Water Pollution Control Federation. 48: 867-871.

Burke, T.A. 1977. ***The Limnetic Zooplankton Community of Boulder Basin, Lake Mead in Relation to the Metalimnetic Oxygen Minimum.*** M.S. Thesis, University of Nevada, Las Vegas. 95 p.

Deacon, J.E. 1977. ***Lake Mead Monitoring Program.*** Department of Biological Sciences, University of Nevada, Las Vegas. Final Report to Clark County Wastewater Management Agency. 207 p.

Deacon, J.E. 1977. ***Lake Mead Monitoring Program.*** Department of Biological Sciences, University of Nevada, Las Vegas. Final Report to Clark County Sanitation District No. 1, Wastewater Treatment Physical Development Section. 55 p.

Study Period:	August 1976 - June 1977
Stations Sampled:	6 Stations in Las Vegas Bay/Boulder Basin 1 Station in Las Vegas Wash
Constituents/ Measurements:	pH Dissolved Oxygen Conductance Temperature Light Intensity Chlorophyll-a

Biological Oxygen Demand (wash station)
MBAS (wash station)
Chemical Oxygen Demand (wash station)
TSS (wash station)
Turbidity (wash station)
Total Phosphorus (select stations)
Dissolved Phosphorus (select stations)
Ammonia-Nitrogen (select stations)
Nitrate+Nitrite-Nitrogen (select stations)
Total Kjeldahl Nitrogen (select stations)
Alkalinity (select stations)
Fecal Coliforms (select stations)
Phytoplankton Species/Counts
Primary Productivity (Carbon-14 Method) (select stations)
Zooplankton Species/Counts
Algal Bioassays (select stations)

Baker, J.R. , J.E. Deacon, T.A. Burke, S.S. Egdorf, L.J. Paulson, and R.W. Tew. 1977. ***Limnological Aspects of Lake Mead, Arizona-Nevada.*** U.S. Bureau of Reclamation Report No. REC-ERC-77-9, Engineering and Research Center, Denver, Colorado. 83 p.

Summarizes UNLV Lake Mead Monitoring Program results for 1975-1976.

U.S. Environmental Protection Agency. 1977. ***Report on Lake Mead Clark County, Nevada Mohave County, Arizona EPA Region IX.*** National Eutrophication Survey, Working Paper No. 808. Water and Land Quality Branch, Monitoring Operations Division, Environmental Monitoring & Support Laboratory, Las Vegas, NV. 28 p., plus appendices of raw data.

Study Period:
February 24, 1975
June 11, 1975
November 20, 1975
December 01, 1975

Stations Sampled:
15 NES Stations Lake-wide
22 Special Stations in Las Vegas Bay/Boulder Basin
4 Tributary Stations

Constituents/
Measurements:
pH
Dissolved Oxygen
Conductance
Temperature
Secchi Depth
Total Phosphorus
Dissolved Phosphorus
Ammonia-Nitrogen

Nitrate+Nitrite-Nitrogen
Total Kjeldahl Nitrogen
Alkalinity
Phytoplankton Species/Counts
Algal Bioassays

Goldman, C.R. and J.E. Deacon. 1978. ***Recommended Water Quality Standards for Las Vegas Bay and Las Vegas Wash.*** Special report prepared for City of Las Vegas and submitted to the Nevada Environmental Commission on August 10, 1978. 42 p.

Summarizes historical water quality data for Las Vegas Wash, Las Vegas Bay and Boulder Basin with recommended water quality standards for Las Vegas Wash.

Paulson, L.J., J.R. Baker, and J.E. Deacon. 1979. ***Potential Use of Hydroelectric Facilities for Manipulating the Fertility of Lake Mead.*** In: National Symposium on Mitigating Losses of Fish and Wildlife Habitats. Colorado State University, Fort Collins, Colorado, p. 296-302, July 16-20.

URS Company. 1979. ***Water Quality Problems in Las Vegas Bay and Boulder Basin of Lake Mead.*** Clark County 208 Water Quality Management Plan, Clark County, Nevada. 244 p.

Summarizes historical water quality data, evaluates water quality problems, and presents proposals for further studies.

Paulson, L.J., J.R. Baker, and J.E. Deacon. 1980. ***The Limnological Status of Lake Mead and Lake Mohave Under Present and Future Powerplant Operations at Hoover Dam.*** Lake Mead Limnological Research Center, Tech. Rept. No. 1, University of Nevada, Las Vegas. 229 p.

Study Period: October 1977 - September 1978

Stations Sampled:
13 Stations Lake-wide
5 Stations in Las Vegas Bay/Boulder Basin
4 Tributary Stations

Constituents/
Measurements:
pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Secchi Depth
Chlorophyll-a

Total Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Phytoplankton Species/Counts
Primary Productivity (Carbon-14 Method)
Zooplankton Species/Counts

Miller, T.G., L.J. Paulson, and J.R. Baker. 1980. ***The Influence of Dredging and High Discharge on the Ecology of Black Canyon.*** Lake Mead Limnological Research Center, Tech. Rept. No. 2, University of Nevada, Las Vegas. 59 p.

Baker, J.R., and L.J. Paulson. 1980. ***Evaluation of Possible Temperature Fluctuations from Proposed Power Modifications at Hoover Dam.*** Lake Mead Limnological Research Center, Tech. Rept, No. 3, University of Nevada, Las Vegas. 23 p.

Baker, J.R., and L.J. Paulson. 1980. ***Evaluation of Impacts Associated with Re-regulation of Water Levels in Lake Mohave.*** Lake Mead Limnological Research Center, Tech. Rept. No. 4, University of Nevada, Las Vegas. 28 p.

Kellar, P.E., S.A. Paulson, and L.J. Paulson. 1980. ***Methods for Biological and Chemical Analyses in Reservoirs.*** Lake Mead Limnological Research Center, Tech. Rept. No. 5, University of Nevada, Las Vegas. 234 p.

Prentki, R.T., L.J. Paulson, and J.R. Baker. 1980. ***Chemical and Biological Structure of Lake Mead Sediments.*** Lake Mead Limnological Research Center, Tech. Rept. No. 6, University of Nevada, Las Vegas. 89 p.

Study Period: October 1979

Stations Sampled: 6 Stations Lake-wide

Constituents/
Measurements:

Sediment Cesium-137
Sediment $CaCo_3$
Sediment Bulk Density
Sediment Organic Carbon
Sediment Organic Nitrogen
Sediment Total Phosphorus
Sediment Extractable Phosphorus
Sediment Organic Content
Sediment Water Of Hydration
Sediment Pore Water for Ammonia, Nitrate, Phosphate

Baker, J.R., and L.J. Paulson. 1980. ***Influence of the Las Vegas Wash Density Current on Nutrient Distribution and Phytoplankton Growth in Las Vegas Bay, Lake Mead.*** In: H.G. Stefan (ed.), Symposium on Surface Water Impoundments. American Society of Civil Engineers, p.1638-1646, Minneapolis, Minnesota, June 2-5.

Paulson, L.J., and J.R. Baker. 1980. ***Nutrient Interactions Among Reservoirs in the Colorado River System.*** In: H.G. Stefan (ed.), Symposium on Surface Water Impoundments, American Society of Civil Engineers, p. 1647-1656, Minneapolis, Minnesota, June 2-5.

Murray, J.W., C.J. Jones, K. Kuivila, and J. Sawlan. 1981. ***Diagenesis of Organic Matter in Las Vegas Bay and Bonelli Bay, Lake Mead.*** Department of Oceanography, University of Washington, Seattle, Washington, Special Report No. 96. 55 p.

Summarizes results of sediment study conducted for the Las Vegas Valley Water Quality Program, Water Quality Standards Study.

Paulson, L.J. 1981. ***Nutrient Management with Hydroelectric Dams in the Colorado River System.*** Lake Mead Limnological Research Center, Tech. Rept. No. 8, University of Nevada, Las Vegas. 37 p.

Paulson, L.J. 1981. ***Use of Hydroelectric Dams to Control Evaporation from Lake Mead.*** Lake Mead Limnological Research Center, Tech. Rept. No. 9, University of Nevada, Las Vegas. 28 p.

Edinger, J.E. and E.M Buchak. 1982. ***Development, Verification, and Use of Methods to Model Chemical and Thermal Processes for Lake Mead and Powell, Phase I, Model Evaluation and Data Analysis.*** J.E. Edinger Associates, Inc. Report to Bureau of Reclamation, Engineering and Research Center, Denver, Colorado. 71 p.

Edinger, J.E., E.M Buchak, and J.S. Norton. 1982. ***Development, Verification, and Use of Methods to Model Chemical and Thermal Processes for Lake Mead and Powell, Phase II, Analysis and Development of Carbonate-Bicarbonate Chemical Subroutine.*** J.E. Edinger Associates, Inc. Report to Bureau of Reclamation, Engineering and Research Center, Denver, Colorado. 44 p.

Brown and Caldwell and Culp/Wesner/Culp. 1982. ***Las Vegas Valley Water Quality Program, Water Quality Standards Study.*** Draft report submitted to the Las Vegas Valley Water Quality Study Board. Chapters 1-12.

Study Period: March 1979-December 1981

Stations Sampled:
8 Stations in Las Vegas Bay/Boulder Basin
1 Station in Virgin Basin
2 Stations in Bonelli Bay
5 Stations in Las Vegas Wash

Constituents/ Measurements:
pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Color
Secchi Depth
Chlorophyll-a
Biological Oxygen Demand (wash stations)
Carbonaceous BOD (wash stations)
Nitrogenous BOD (wash stations)
Total Coliforms (wash and select lake stations)
Fecal Coliforms (wash and select lake stations)
Fecal Streptococci (wash stations)
TSS
Volatile Suspended Solids
Total Phosphorus
Dissolved Phosphorus
Ortho Phosphorus
Extractable Phosphorus
Alkaline Phosphatase Activity
Nitrogen Fixation
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Nitrite-Nitrogen
Total Nitrogen
Total Kjeldahl Nitrogen
Alkalinity
Anions/Cations
Heavy Metals
Soluble Iron
Silica
Phytoplankton Species/Counts
Primary Productivity (Carbon-14 Method)
Periphyton Species/Biomass
Zooplankton Species/Counts
Algal Bioassays
Fish Distribution

Dye Tracing of Currents
Sediment Characteristics

Brown and Caldwell and Culp/Wesner/Culp. 1982. ***Appendices A, B, and C for Las Vegas Valley Water Quality Program, Water Quality Standards Study Report.*** Report submitted to the Las Vegas Valley Water Quality Study Board. March 8, 1982.

Appendix A. University of Nevada, Las Vegas Limnological Procedures Manual

Appendix B. Other University of Nevada, Las Vegas Technical Reports

Appendix C. Algal Bioassy Reports from Ecological Research Associates and EPA

Brown and Caldwell and Culp/Wesner/Culp. 1982. ***Appendices D, E, and F for Las Vegas Valley Water Quality Program, Water Quality Standards Study Report.*** Report submitted to the Las Vegas Valley Water Quality Study Board. March 8, 1982.

Appendix D. University of Washington Sediment Report

Appendix E. Supporting Limnological Data and Data Handling Procedures

Appendix F. Hydraulic Study Report

Hetzel, D.R. 1982. ***An Ecological Analysis of Relic Diatoms in Sediments of Las Vegas Bay, Lake Mead.*** M.S. Thesis, University of Nevada, Las Vegas. 41 p.

Morris, M.K. 1982. ***Effects of Wastewater Discharges on Periphyton Growth in Lake Mead, Nevada-Arizona.*** M.S. Thesis, University of Nevada, Las Vegas. 75 p.

Morris, F.A. 1983. ***Effects of a Desert Wetlands on Water Quality of Wastewater Effluent.*** M.S. Thesis, University of Nevada, Las Vegas, Nevada. 99 p.

Paulson, L.J., and J.R. Baker. 1983. ***Interrelationships Among Nutrients, Plankton and Striped Bass in Lake Mead.*** Lake Mead Limnological Research Center, Tech. Rept. No. 10, University of Nevada, Las Vegas. 94 p.

Study Period: January 1981 - December 1982

Stations Sampled:

17 Stations Lake-wide
7 Stations in Las Vegas Bay/Boulder Basin
4 Tributary Stations

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Secchi Depth
Chlorophyll-a
Total Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Total Nitrogen
Phytoplankton Species/Counts
Primary Productivity (Carbon-14 Method)
Zooplankton Species/Counts
Fish Distribution

Paulson L.J. and J.R. Baker. 1983. ***The Limnology in Reservoirs on the Colorado River.*** Lake Mead Limnological Research Center, Tech. Rept. No. 11, University of Nevada, Las Vegas. 276 p.

Study Period:

January 1981 - December 1982

Stations Sampled:

Lake Powell, Lake Mead, Lake Mohave, Lake Havasu
17 Stations Lake-wide in Lake Mead
7 Stations in Las Vegas Bay/Boulder Basin
4 Tributary Stations, and Hoover Dam outflow

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Secchi Depth
Chlorophyll-a
Total Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Total Nitrogen
Phytoplankton Species/Counts

Primary Productivity (Carbon-14 Method)
Zooplankton Species/Counts
Fish Distribution

Baker, J.R., and L.J. Paulson. 1983. ***The Effects of Limited Food Availability on Striped Bass Fishery in Lake Mead.*** In: V.D. Adams and V.A. Lamarra (eds.), Symposium on the Aquatic Resources Management of the Colorado River Ecosystem, Las Vegas, Nevada, p. 551-562, Ann Arbor Sciences Publ., November 16-19, 1981.

Evans, T.D., and L.J. Paulson. 1983. ***The Influence of Lake Powell on the Suspended Sediment-Phosphorus Dynamics of the Colorado River Inflow to Lake Mead.*** In: V.D. Adams and V.A. Lamarra (eds.), Symposium on the Aquatic Resources Management of the Colorado River Ecosystem, Las Vegas, Nevada, p. 57-70, Ann Arbor Science Publ., November 16-19, 1981.

Paulson, L.J. 1983. ***Scientific Perspectives on Integrated Aquatic Resources Management of the Colorado River.*** In: V.D. Adams and V.A. Lamarra (eds.), Symposium on the Aquatic Resources Management of the Colorado River Ecosystem, Las Vegas, Nevada, p. 685-688, Ann Arbor Science Publ., November 16-19, 1981.

Paulson, L.J., and J.R. Baker. 1983. ***The Effects of Impoundments on Salinity in the Colorado River.*** In: V.D. Adams and V.A. Lamarra (eds.), Symposium on the Aquatic Resources Management of the Colorado River Ecosystem, Las Vegas, Nevada, p. 457-474, Ann Arbor Science Publ., November 16-19, 1981.

Paulson, L.J. 1983. ***Use of Hydroelectric Dams to Reduce Evaporation and Salinity in the Colorado River System.*** In: V.D. Adams and V.A. Lamarra (eds.), Symposium on the Aquatic Resources Management of the Colorado River Ecosystem, Las Vegas, Nevada, p. 439-456, Ann Arbor Science Publ., November 16-19, 1981.

Prentki, R.T., and L.J. Paulson. 1983. ***Historical Patterns of Phytoplankton Productivity in Lake Mead.*** In: V.D. Adams and V.A. Lamarra (eds.), Symposium on the Aquatic Resources Management of the Colorado River Ecosystem, Las Vegas, Nevada, p. 105-124, Ann Arbor Science Publ., November 16-19, 1981.

Morris, F.A., and L.J. Paulson. 1983. ***Current Water Quality Trends in the Las Vegas Wash Wetlands.*** In: V.D. Adams and V.A. Lamarra (eds.), Symposium on

the Aquatic Resources Management of the Colorado River Ecosystem, Las Vegas, Nevada, p. 125-138, Ann Arbor Science Publ., November 16-19, 1981.

Bozek, M., L.J. Paulson, and J.E. Deacon. 1984. ***Factors Affecting Reproductive Success of Bonytail Chubs and Razorback Suckers in Lake Mohave.*** Lake Mead Limnological Research Center, Tech. Rept. No. 12, University of Nevada, Las Vegas, 136 p.

Janik, J.J. 1984. ***The Role of the Nannoplankton in the Phytoplankton Dynamics of Four Colorado River Reservoirs (Lakes Powell, Mead, Mohave, Havasu).*** M.S. Thesis, University of Nevada, Las Vegas. 133 p.

Paulson, L.J. 1984. ***Limnological Monitoring Data for Lake Mead During Summer and Fall 1983.*** Lake Mead Limnological Research Center, Tech. Rept. No. 13, University of Nevada, Las Vegas, 7 pp., plus appendices with raw data.

Study Period: February 1983 - December 1983

Stations Sampled: 5 Stations in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Secchi Depth
Chlorophyll-a
Total Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Total Nitrogen

Peterson, C.G. 1984. ***Benthic Diatom Community Dynamics in the Colorado River: Interactive Effects of Periodic Desiccation and Current Regime.*** M.S. Thesis, University of Nevada, Las Vegas. 140 p.

Wilde, G.R. 1984. ***Seasonal and Spatial Heterogeneity in the Limnetic Zooplankton Community of Lake Mead.*** M.S. Thesis, University of Nevada, Las Vegas. 95 p.

Paulson, L.J. 1986. ***Limnological Monitoring Data for Lake Mead During 1985.*** Lake Mead Limnological Research Center, Tech. Rept. No. 14, University of Nevada, Las Vegas, 9 pp., plus appendices with raw data.

Study Period: January 1985 - November 1985

Stations Sampled: 5 Stations in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Secchi Depth
Chlorophyll-a
Total Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Total Nitrogen

U.S. Bureau of Reclamation. 1986. ***Lower Colorado River Reservoir (Lakes Mead, Mohave, and Havasu) Water Quality Monitoring Program.*** Data collection program run by the Lake Mead Limnological Research Center, no formal report prepared for the project.

Study Period: April 1986 - December 1987

Stations Sampled: 15 Stations Lake-wide
5 Stations in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Secchi Depth
Chlorophyll-a
Total Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Total Nitrogen
TDS
Anions/Cations
Current Velocity

Zooplankton Species/Counts
Fish Distribution

Bartanen, T.M. 1987. ***Estimation of Food Limitation in Daphnia pulex from Boulder Basin, Lake Mead.*** M.S. Thesis, University of Nevada, Las Vegas. 92 p.

Nevada Division of Environmental Protection. 1987. ***Las Vegas Wash and Lake Mead Proposed Water Quality Standards Revisions and Rationale.*** 11 p., plus appendices.

City of Las Vegas. 1987. ***Analysis of the Water-Quality Standards Proposed by the Nevada Division of Environmental Protection.*** 154 p., plus appendices.

Paulson, L.J. 1987. ***Limnological Monitoring Data for Lake Mead During 1986.*** Lake Mead Limnological Research Center, Tech. Rept. No. 16, University of Nevada, Las Vegas. 8 pp., plus appendices with raw data.

Study Period:	March 1986 - December 1986
Stations Sampled:	5 Stations in Las Vegas Bay/Boulder Basin
Constituents/ Measurements:	pH Dissolved Oxygen Conductance Temperature Light Intensity Secchi Depth Chlorophyll-a Total Phosphorus Ortho Phosphorus Ammonia-Nitrogen Nitrate+Nitrite-Nitrogen Total Nitrogen

Haley, J.S., S. Leavitt, L.J. Paulson, and D.H. Baepler. 1987. ***Lake Mead Cover Enhancement Project.*** Lake Mead Limnological Research Center, Tech. Rept. No. 18. University of Nevada, Las Vegas, 117 p.

Axler, R.P., L.J. Paulson, P. Sollberger, and D.H. Baepler. 1987. ***Lake Mead Prefertilization Study, Preliminary Nutrient Enhancement Studies in Lake***

Mead. Lake Mead Limnological Research Center, Tech. Rept. No. 19, University of Nevada, Las Vegas, 113 p.

Peck, S.K., W. Pratt, J. Pollard, L.J. Paulson, and D.H. Baepler. 1987. ***Benthic Invertebrates and Crayfish in Lake Mead.*** Lake Mead Limnological Research Center, University of Nevada, Las Vegas. Final Report to National Oceanic and Atmospheric Administration, 84 p.

Paulson, L.J., S.A. Paulson, R.P. Axler, and J.S. Haley. 1987. ***The Lake Mead Fertilization Project - Program Magazine.*** Lake Mead Limnological Research Center, University of Nevada, Las Vegas, Special Publication. 46 p.

Sollberger, P.J. 1987. ***Comparison of Littoral and Limnetic Zooplankton Communities of Lake Mead.*** M.S. Thesis, University of Nevada, Las Vegas. 105 p.

Liston, C.R., Grabowski, S.J. 1988. ***Characterization of the Aquatic Environment in Lake Mead Near the Proposed Spring Canyon Pumped Storage project and Assessment of Potential Aquatic Impacts.*** Bureau of Reclamation. 225 p., plus appendices with raw data.

Axler, R.P., L. Paulson, P. Vaux, P. Sollberger, and D.H. Baepler. 1988. ***Fish AID: The Lake Mead Fertilization Project.*** Lake and Reservoir Management 4(2):1-12.

Paulson, L.J. 1988. ***Limnological Monitoring Data for Lake Mead During 1987.*** Lake Mead Limnological Research Center, Tech. Rept. No. 20, University of Nevada, Las Vegas. 12 pp., plus appendices with raw data.

Study Period:	April 1987 - December 1987
Stations Sampled:	5 Stations in Las Vegas Bay/Boulder Basin
Constituents/ Measurements:	pH Dissolved Oxygen Conductance Temperature Light Intensity Secchi Depth Chlorophyll-a Total Phosphorus Ortho Phosphorus

Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Total Nitrogen

Nevada Division of Environmental Protection. 1988. ***Rationale and Calculations for Total Maximum Daily Loads and Waste Load Allocations for Las Vegas Bay.*** 34 p., plus appendices.

Roline, R.A. Sartoris, J.J. 1988. ***Changes in the Morphometry of Las Vegas Wash and the Impact on Water Quality.*** U.S. Bureau of Reclamation, Published in Lake and Reservoir Management 4(1):135-142.

Clark County Sanitation District No. 1. 1988. ***Lake Mead Water Quality Standards Study.*** Data collection program run by the Lake Mead Limnological Research Center, no formal report prepared for the project. Data were used for development of water quality model by Dan Szumski and Richard French.

Study Period: August 1988 - November 1989

Stations Sampled: 13 Stations in Las Vegas Bay/Boulder Basin

Constituents/
Measurements:

pH
Dissolved Oxygen
Conductance
Temperature
Light Intensity
Secchi Depth
Chlorophyll-a
Total Phosphorus
Dissolved Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Total Kjeldahl Nitrogen
Primary Productivity (Carbon-14 Method)
Phytoplankton Species/Counts
Algal Bioassays
Zooplankton Species/Counts
Fish Distribution

Wilson, R.P., Garrett, W.B. 1989. ***Water Resources Data, Arizona, Water 1987.*** U.S. Geological Survey, Water Data Report AZ-87-1. 380 p.

Leavitt, S.L. and L.J. Paulson. 1989. ***Limnological Monitoring Data for Lake Mead During 1988.*** Lake Mead Limnological Research Center, Tech. Rept. No. 21, University of Nevada, Las Vegas. 11 pp., plus appendices with raw data.

Study Period:	April 1988 - December 1988
Stations Sampled:	5 Stations in Las Vegas Bay/Boulder Basin
Constituents/ Measurements:	pH Dissolved Oxygen Conductance Temperature Light Intensity Secchi Depth Chlorophyll-a Total Phosphorus Ortho Phosphorus Ammonia-Nitrogen Nitrate+Nitrite-Nitrogen Total Nitrogen

Haley, J.H., L.S. Croft, S.E. Leavitt, and L.J. Paulson. 1989. ***Introduction and Enhancement of Vegetation Cover at Lake Mead.*** Lake Mead Limnological Research Center, University of Nevada Las Vegas. Final Report to Nevada Department of Wildlife, 65 p., plus appendix of raw data.

Leavitt, S.E., J.H. Haley, M. Hager, and D.H. Baepler. 1989. ***Red Swamp Crayfish Ecology in Lake Mead.*** Lake Mead Limnological Research Center, University of Nevada Las Vegas. Final Report to Nevada Department of Wildlife, 49 p., plus appendix with annotated bibliography of crayfish ecology.

Pelle, B.L. 1989. ***Temporal and Spatial Patterns of Abundance of Age 0 Threadfin Shad (Dorosoma petenense) in the Overton Arm, Lake Mead.*** M.S. Thesis, University of Nevada, Las Vegas. 41 p.

Vaux, P. and L. J. Paulson. 1990. ***Lake Mead Nutrient Enhancement Project: Final Report.*** Lake Mead Limnological Research Center, University of Nevada, Las Vegas. Final Report to the Nevada Department of Wildlife and the National Oceanic and Atmospheric Administration. 160 p.

ECO-Systems Management Associates. 1989. ***Physical/Chemical Measurements in Lake Mead, Nevada, Vol 1.*** City of Las Vegas. 89 p. plus Appendices of instrument deployment data.

Sartoris, J.J., Roline, R.A. 1990. ***Present Conditions and Important Water Quality Trends in Las Vegas Wash, Nevada.*** Bureau of Reclamation - Internal Memorandum. 8 p., plus Appendices of Raw Data.

Bozek, M.A., L.J. Paulson, and G.R. Wilde. 1990. ***Effects of ambient Lake Mohave water temperatures on development, oxygen consumption, and hatching success of the razorback sucker.*** Environmental Biol. Fish. 27:255-263.

Hager, M.B. 1990. ***Enhancement and Monitoring of the Procambaris clarkii population in Lake Mead.*** M.S. Thesis, University of Nevada, Las Vegas. 71 p.

Paulson, L.J. 1990. ***Las Vegas Bay Sediment Study: Phase 1 Sediment Survey/Pilot Sediment Chamber Experiment.*** West Lakes, Las Vegas, Nevada. Final Report to City of Henderson. 6 p.

Study Period:	July 8, 1990
Stations Sampled:	27 Stations in Las Vegas Bay
Constituents/ Measurements:	Sediment Total Phosphorus Sediment Total Nitrogen Sediment Total Organic Carbon Sediment Organic Matter Sediment Texture

Paulson, L.J. 1990. ***NPDES Limnological Monitoring Program for Lake Mead.*** West Lakes, Las Vegas, Nevada. Monitoring program conducted for the City of Las Vegas, Water Pollution Control Facility. Data reported by CLV in 1992 annual report.

Study Period:	October 1990 - December 1990
Stations Sampled:	10 Stations in Las Vegas Bay/Boulder Basin 3 Stations in Las Vegas Wash
Constituents/ Measurements:	pH Dissolved Oxygen Conductance Temperature Light Intensity

Secchi Depth
Chlorophyll-a
Chloride
TSS (wash stations)
TDS (wash stations)
Total Phosphorus
Ortho Phosphorus
Ammonia-Nitrogen
Nitrate+Nitrite-Nitrogen
Nitrite-Nitrogen
Total Kjeldahl Nitrogen
Zooplankton Species/Counts

Wilde, G.R., and L.J. Paulson. 1990. ***Temporal and spatial variation in pelagic fish abundance in Lake Mead determined from echograms.*** Calif. Fish Game: 75:218-223.

Szumski, Dan & Associates. 1991. ***Lake Mead Eutrophication Model, Development and Provisional Calibration.*** Clark County Sanitation District. 137 p. plus Appendices of Data, Computer Code and associated documentation.

Sartoris, J.J., Roline, R.A. 1991. ***Las Vegas Wash Water Quality Monitoring Program - 1990 Report of Findings.*** Bureau of Reclamation - Internal Memorandum. 8 p. plus Appendices of raw data.

Paulson, L.J. 1991. ***Las Vegas Bay Sediment Study: Phase 2 Nutrient Release Experiments.*** West Lakes, Las Vegas, Nevada. Final Report to City of Henderson.
11 p.

Study Period: December 9 - December 30, 1990

Stations Sampled: 6 Stations in Las Vegas Bay

Constituents/
Measurements:

<u>Measurements on Sediments</u>
Total Phosphorus
Total Nitrogen
Total Organic Carbon
Organic Matter
Texture

<u>Measurements on Sediment Water</u>
Temperature
pH
Dissolved Oxygen

Alkalinity
Nitrate+Nitrite-Nitrogen
Nitrite-Nitrogen
Ammonia-Nitrogen
Total Phosphorus
Ortho Phosphorus

Sollberger, P.S. and L.J. Paulson. 1991. ***Littoral and limnetic zooplankton communities in Lake Mead, Arizona-Nevada, USA.*** Hydrobiologia 0:1-11.

Bureau of Reclamation - Quality of Water. ***Colorado River Basin, Progress Report No. 15.*** January 1991. United States Department of the Interior. 87 p. plus appendices of raw water data.

Roline, R.A., Sartoris, J.J. 1992. ***Las Vegas Wash Water Quality Monitoring Program - 1991 Report of Findings.*** Bureau of Reclamation - Internal Memorandum. 8 p. plus Appendices of raw data.

Mueller, G. 1993. ***Monitoring Impacts on Inland Fisheries Using Hydroacoustics.*** Bureau of Reclamation - Las Vegas Bay Remote Sensing Study (IV)1-17.

Roline, R.A. 1993. ***Las Vegas Wash Water Quality Monitoring Program - 1992 Report of Findings (Water Quality).*** Bureau of Reclamation - Internal Memorandum. 7 p. plus Appendices of raw data.

APPENDIX 15-2

SNWA DATA REPRESENTATIVE FORMS

Certification:
Lab I.D. #5

SOUTHERN NEVADA WATER SYSTEM

ROUTINE PHYSICAL & CHEMICAL ANALYSIS

LAKE

Date Collected: 10-28-93
Collected by: MJD, KRB, DXN

Date Received: 10-28-93
Time Received: 1215
Received by: MJD

Date Analyzed:
Date Reported: 11-2-93

Characteristic		Sample, Sample #, Time Collected 1: SNWS INTAKE SURF. #24-23-Q 0850		Sample, Sample #, Time Collected 2: SNWS INTAKE 24' #24-24-Q 0900		Date, Time, Analyst
Alkalinity:	Hydroxide		mg/L		mg/L	
	Carbonate	5	mg/L	8	mg/L	10/28 1330 NRB
	Bicarbonate	111	mg/L	110	mg/L	10/28 1330 NRB
Ammonia, Nitrogen		<0.05	mg/L	<0.05	mg/L	10/28 1220 BKA
Ammonia, Unionized			mg/L		mg/L	
BOD			mg/L		mg/L	
Calcium			mg/L		mg/L	
Carbon Dioxide			mg/L		mg/L	
Chloride			mg/L		mg/L	
Coliform, Total			/100mL		/100mL	
Coliform, Fecal			/100mL		/100mL	
Color		2	units	3	units	10/28, 0900, DXN
Conductivity		1141	us/cm	1135	us/cm	10/28, 0900, MJD
Fecal Streptococcal			/100mL		/100mL	
Fluoride			mg/L		mg/L	
Hardness			mg/L		mg/L	
Iron			mg/L		mg/L	
Magnesium			mg/L		mg/L	
Manganese			mg/L		mg/L	
Nitrate		0.22	mg/L	0.22	mg/L	10/28 1230 PNW
Odor		N/A	TON	N/A	TON	10/28,
Oxygen Dissolved		7.57	mg/L	7.68	mg/L	10/28, 0900, MJD
pH		8.28		8.27		10/28, 0900, MJD
Phosphate		<0.01	mg/L	<0.01	mg/L	10/28, 1300 ARS
Residue (filtrable)			mg/L		mg/L	
Sulfate			mg/L		mg/L	
Suspended Solids			mg/L		mg/L	
Temperature		21.1	deg-C	21.1	deg-C	10/28, 0900, MJD
Turbidity		.45	NTU	.46	NTU	10/28, 0900, MJD
Particle Count		674	/mL	844	/mL	10/28, 1220, DXN
Plankton Biomass			mg/L		mg/L	
Secci Disk Reading		11.0	m		m	10/28, 1900, DXN

Remarks: Cloudy, Light Breeze from East, 62° - NO Color-free H2O

Lab Mgr.: [signature] Date: 11-10-93
Treat.Mgr.: [signature] Date: 11/10
Director: [signature] Date: 11/18/93

Lab Supt.Supr.: RAM Date: 11-9-93
Chem. Supr.: SK Date: 11/2/93
Microbio. Supr.: DAL Date: 11-10-93

Certification:
Lab I.D. #5

SOUTHERN NEVADA WATER SYSTEM

ROUTINE PHYSICAL & CHEMICAL ANALYSIS

LAKE

Date Collected: 10-28-93
Collected by: MJD, CKD, DXN

Date Received: 10-28-93
Time Received: 1215
Received by: MJD

Date Analyzed:
Date Reported: 11-2-93

Characteristic		Sample, Sample #, Time Collected: LV BAY SURF. #24-25-Q 0935	LV BAY 24m #24-26-Q 0945	LV WASH OUT SURF. #24-27-Q 0955	Date, Time, Analyst
Alkalinity:	Hydroxide	mg/L	mg/L	mg/L	
	Carbonate	0 mg/L	0 mg/L	0 mg/L	10/28 1330 NRB ~~PNV~~
	Bicarbonate	111 mg/L	111 mg/L	110 mg/L	10/28 1330 NRB
Ammonia, Nitrogen		0.35 mg/L	0.35 mg/L	0.44 mg/L	10/28 1220 BKS
Ammonia, Unionized		mg/L	mg/L	mg/L	
BOD		mg/L	mg/L	mg/L	
Calcium		mg/L	mg/L	mg/L	
Carbon Dioxide		mg/L	mg/L	mg/L	
Chloride		mg/L	mg/L	mg/L	
Coliform, Total		/100mL	/100mL	/100mL	
Coliform, Fecal		/100mL	/100mL	/100mL	
Color		7 units	11 units	8 units	10/28, 0940, DXN
Conductivity		1217 us/cm	1271 us/cm	1232 us/cm	10/28, 0940, MJD
Fecal Streptococcal		/100mL	/100mL	/100mL	
Fluoride		mg/L	mg/L	mg/L	
Hardness		mg/L	mg/L	mg/L	
Iron		mg/L	mg/L	mg/L	
Magnesium		mg/L	mg/L	mg/L	
Manganese		mg/L	mg/L	mg/L	
Nitrate		0.40 mg/L	0.35 mg/L	0.39 mg/L	10/28 1280 PNV
Odor		N/A TON	N/A TON	— TON	10/28,
Oxygen Dissolved		7.66 mg/L	7.80 mg/L	7.65 mg/L	10/28, 0940, MJD
pH		8.25	8.22	8.20	10/28, 0940, MJD
Phosphate		0.01 mg/L	0.01 mg/L	0.01 mg/L	10/28 1300 BKS
Residue (filtrable)		mg/L	mg/L	mg/L	
Sulfate		mg/L	mg/L	mg/L	
Suspended Solids		mg/L	mg/L	mg/L	
Temperature		20.0 deg-C	20.3 deg-C	20.5 deg-C	10/28, 0940, MJD
Turbidity		.74 NTU	1.10 NTU	1.13 NTU	10/28, 0940, MJD
Particle Count		2365 /mL	2961 /mL	/mL	10/28, 1235 DXN
Plankton Biomass		mg/L	mg/L	mg/L	
Secci Disk Reading		5.0 m	m	4.5 m	10/28, 0940, CKD

Remarks: PARTLY CLOUDY, LIGHT BREEZE FROM WEST, 64° — NO ODOR free H2O

Lab Mgr.: DAR Date: 11-10-93
Treat.Mgr.: SK Date: 11/10
Director: [signature] Date: 11/10/93
Lab Supt.Supr.: DAR Date: 11-9-93
Chem. Supr.: SK Date: 11/2/93
Microbio. Supr.: DAR Date: 11-10-93

form 105N - rev93

Certification:
Lab I.D. #5

SOUTHERN NEVADA WATER SYSTEM

ROUTINE PHYSICAL & CHEMICAL ANALYSIS

LAKE

Date Collected: 10-28-93
Collected by: MJD, CKO, DXN

Date Received: 10-28-93
Time Received: 1215
Received by: MJD

Date Analyzed:
Date Reported: 11-2-93

Characteristic		Sample, Sample #, Time Collected: BLK. ISLAND Surf. #24-28-Q 1020		BLK. ISLAND 24' #24-29-Q 1030	Date, Time, Analyst
Alkalinity:	Hydroxide	mg/L	mg/L	mg/L	
	Carbonate	7 mg/L	mg/L	6 mg/L	10/28 1330 NRB
	Bicarbonate	111 mg/L	mg/L	112 mg/L	10/28 1330 NRB
Ammonia, Nitrogen		<0.05 mg/L	mg/L	<0.05 mg/L	10/28 1220 BKS
Ammonia, Unionized		mg/L	mg/L	mg/L	
BOD		mg/L	mg/L	mg/L	
Calcium		mg/L	mg/L	mg/L	
Carbon Dioxide		mg/L	mg/L	mg/L	
Chloride		mg/L	mg/L	mg/L	
Coliform, Total		/100mL	/100mL	/100mL	
Coliform, Fecal		/100mL	/100mL	/100mL	
Color		4 units	units	8 units	10/28, 1025, DXN
Conductivity		1122 us/cm	us/cm	1134 us/cm	10/28, 1025, MJD
Fecal Streptococcal		/100mL	/100mL	/100mL	
Fluoride		mg/L	mg/L	mg/L	
Hardness		mg/L	mg/L	mg/L	
Iron		mg/L	mg/L	mg/L	
Magnesium		mg/L	mg/L	mg/L	
Manganese		mg/L	mg/L	mg/L	
Nitrate		0.23 mg/L	mg/L	0.24 mg/L	10/28 1230 PKWY
Odor		N/A TON	TON	N/A TON	10/28,
Oxygen Dissolved		7.67 mg/L	mg/L	7.54 mg/L	10/28, 1025, MJD
pH		8.25		8.26	10/28, 1025, MJD
Phosphate		<0.01 mg/L	mg/L	<0.01 mg/L	10/28, 1300 NRB
Residue (filtrable)		mg/L	mg/L	mg/L	
Sulfate		mg/L	mg/L	mg/L	
Suspended Solids		mg/L	mg/L	mg/L	
Temperature		21.2 deg-C	deg-C	21.0 deg-C	10/28, 1025, MJD
Turbidity		.29 NTU	NTU	.32 NTU	10/28, 1025, MJD
Particle Count		735 /mL	/mL	779 /mL	10/28, 1945 DXN
Plankton Biomass		mg/L	mg/L	mg/L	
Secci Disk Reading		10.5 m	m	m	10/28, 1025, DXN

Remarks: Mostly Sunny, Light Breeze From West, 65° - No odor free H2O

Lab Mgr.: PAR Date: 11-10-93
Treat.Mgr.: [signature] Date: 11/10
Director: [signature] Date: 11/18/93

Lab Supt.Supr.: PAR Date: 11-9-93
Chem. Supr.: SK Date: 11/2/93
Microbio. Supr.: PAR Date: 11-10-93

form 105N – snws

Certification:
Lab I.D. #5

SOUTHERN NEVADA WATER SYSTEM

ROUTINE PHYSICAL & CHEMICAL ANALYSIS

LAKE

Date Collected: 10-28-93
Collected by: MJD, CKD, DKN

Date Received: 10-28-93
Time Received: 1215
Received by: MJD

Date Analyzed:
Date Reported: 11-2-93

Characteristic	Sample, Sample #, Time Collected: Callville Bay Surf. #24-30-Q 1055		Callville Bay 24m #24-31-Q 1105	Date, Time, Analyst
Alkalinity: Hydroxide	mg/L	mg/L	mg/L	
Carbonate	10 mg/L	mg/L	6 mg/L	10/28 1330 NRB
Bicarbonate	114 mg/L	mg/L	115 mg/L	10/28 1330 NRB
Ammonia, Nitrogen	<0.05 mg/L	mg/L	<0.05 mg/L	10/28 1220 BKA
Ammonia, Unionized	mg/L	mg/L	mg/L	
BOD	mg/L	mg/L	mg/L	
Calcium	mg/L	mg/L	mg/L	
Carbon Dioxide	mg/L	mg/L	mg/L	
Chloride	mg/L	mg/L	mg/L	
Coliform, Total	/100mL	/100mL	/100mL	
Coliform, Fecal	/100mL	/100mL	/100mL	
Color	8 units	units	9 units	10/28, 1100, MJD
Conductivity	1120 us/cm	us/cm	1119 us/cm	10/28, 1100, MJD
Fecal Streptococcal	/100mL	/100mL	/100mL	
Fluoride	mg/L	mg/L	mg/L	
Hardness	mg/L	mg/L	mg/L	
Iron	mg/L	mg/L	mg/L	
Magnesium	mg/L	mg/L	mg/L	
Manganese	mg/L	mg/L	mg/L	
Nitrate	0.21 mg/L	mg/L	0.20 mg/L	10/28 1230 PNW
Odor	N/A TON	TON	N/A TON	10/28,
Oxygen Dissolved	7.68 mg/L	mg/L	7.61 mg/L	10/28, 1100, MJD
pH	8.32		8.27	10/28, 1100, MJD
Phosphate	<0.01 mg/L	mg/L	<0.01 mg/L	10/28 1300 HRB
Residue (filtrable)	mg/L	mg/L	mg/L	
Sulfate	mg/L	mg/L	mg/L	
Suspended Solids	mg/L	mg/L	mg/L	
Temperature	21.1 deg-C	deg-C	21.1 deg-C	10/28, 1100, MJD
Turbidity	.31 NTU	NTU	.66 NTU	10/28, 1100, MJD
Particle Count	699 /mL	/mL	1245 /mL	10/28, 1255 DKN
Plankton Biomass	mg/L	mg/L	mg/L	
Secci Disk Reading	11.0 m	m	m	10/28, 1100, MJD

Remarks: Partly Sunny, Calm, 66° - No odor free water

Lab Mgr.: DAZ Date: 11-10-93
Treat.Mgr.: Date: 11/10
Director: Date: 11/18/93

Lab Supt.Supr.: DAZ Date: 11-9-93
Chem. Supr.: SK Date: 11/2/93
Microbio. Supr.: DAZ Date: 11-10-93

Certification:
Lab I.D. #5

SOUTHERN NEVADA WATER SYSTEM

ROUTINE PHYSICAL & CHEMICAL ANALYSIS

LAKE

Date Collected: 10-28-93
Collected by: MJD, CKN, DXN

Date Received: 10-28-93
Time Received: 1215
Received by: MJD

Date Analyzed:
Date Reported: 11-2-93

Characteristic		Sample, Sample #, Time Collected: Plemmons Pt. South #24-32-Q 1130		Plemmons Pt. 24 #24-33-Q 1140	Date, Time, Analyst
Alkalinity:	Hydroxide	mg/L	mg/L	mg/L	
	Carbonate	4 mg/L	mg/L	0 mg/L	10/28 1330 NRB
	Bicarbonate	113 mg/L	mg/L	116 mg/L	10/28 1330 NRB
Ammonia, Nitrogen		<0.05 mg/L	mg/L	<0.05 mg/L	10/28 1220 BKA
Ammonia, Unionized		mg/L	mg/L	mg/L	
BOD		mg/L	mg/L	mg/L	
Calcium		mg/L	mg/L	mg/L	
Carbon Dioxide		mg/L	mg/L	mg/L	
Chloride		mg/L	mg/L	mg/L	
Coliform, Total		/100mL	/100mL	/100mL	
Coliform, Fecal		/100mL	/100mL	/100mL	
Color		11 units	units	9 units	10/28, 1140, DXN
Conductivity		1143 us/cm	us/cm	1136 us/cm	10/28, 1140, MJD
Fecal Streptococcal		/100mL	/100mL	/100mL	
Fluoride		mg/L	mg/L	mg/L	
Hardness		mg/L	mg/L	mg/L	
Iron		mg/L	mg/L	mg/L	
Magnesium		mg/L	mg/L	mg/L	
Manganese		mg/L	mg/L	mg/L	
Nitrate		0.23 mg/L	mg/L	0.23 mg/L	10/28 1230 PTN
Odor		N/A TON	TON	N/A TON	10/28 —
Oxygen Dissolved		7.51 mg/L	mg/L	7.59 mg/L	10/28, 1140, MJD
pH		8.31		8.25	10/28, 1140, MJD
Phosphate		<0.01 mg/L	mg/L	<0.01 mg/L	10/28 1300 ARB
Residue (filtrable)		mg/L	mg/L	mg/L	
Sulfate		mg/L	mg/L	mg/L	
Suspended Solids		mg/L	mg/L	mg/L	
Temperature		21.3 deg-C	deg-C	21.2 deg-C	10/28, 1140, MJD
Turbidity		.31 NTU	NTU	.32 NTU	10/28, 1140, MJD
Particle Count		456 /mL	/mL	770 /mL	10/28, 1300 DXN
Plankton Biomass		mg/L	mg/L	mg/L	
Secci Disk Reading		11.5 m	m	m	10/28, 1140, MJD

Remarks: Partly Sunny, Calm, 69° — No odor Free H2O

Lab Mgr.: [signature] Date: 11-10-93
Treat.Mgr.: [signature] Date: 11/10
Director: [signature] Date: 11/10/93

Lab Supt.Supr.: KAN Date: 11-9-93
Chem. Supr.: SK Date: 11/2/93
Microbio. Supr.: DAL Date: 11-10-93

SOUTHERN NEVADA WATER SYSTEM

Date 12/27/91

MONTHLY LAKE CHLOROPHYLL

Lake Mead 1173.0Ft

Elevation (M) 357.5m

LOCATION	Field Analyst	Time Collectd	Temp. (°C)	Trans-parency (m)	pH (Units)	Dissolv. Oxygen (mg/L)	Conduc-tivity (us/cm)	Sample Volume (mL)	Chloro-phyll ug/L *	Date Analyzd /By
#1 SNWS INTAKE 0-6m	GLD/CKD	0900	14.6	15.0	8.27	8.52	1065	750	0	1-24-92 PSS
#1A SNWS INTAKE 9m		0915	14.6		8.27	8.64	1051	750	0	
#1B SNWS INTAKE 12m		0930	14.8		8.26	8.39	1064	750	0	
#1C SNWS INTAKE 15m		0945	14.9		8.26	8.36	1062	756	0	
#1D SNWS INTAKE 18m		1030	14.5		8 33	8.65	1058	750	0	
#1E SNWS INTAKE 21m		1045	14.5		8.27	8.89	1064	756	0	
#1F SNWS INTAKE 24m		1100	14.5	↓	8.27	8.78	1059	750	0	
#2 SADDLE ISLAND 0-6m		1120	14.8	12.0	8.29	8.83	1052	750	0	
#3 FISH HATCHERY 0-6m		1140	14.9	10.5	8.31	8.95	1052	750	0.119	
#4 SAND ISLAND 0-6m		1200	14.3	10.0	8.31	9.04	1066	750	0	
#5 LAS VEGAS BAY 0-6m		1220	14.0	10.0	8.32	9.35	1060	750	0.059	
#6 LV WASH OUTLET 0-2m	↓	1240	14.1	7.5	8.27	9.16	1067	500	0	↓

COMMENTS: * Calculated using monochromatic equation

Lab Supt. Supv. _____ Lab Manager _____

Microbio. Supv. _____ Director _____

SOUTHERN NEVADA WATER SYSTEM

LAKE PROFILE

Source Lake Mead Location SNWS Intake Surface Date Collected 1-21-94 Time Collected 0830 1100

Dept'h (Meters)	Dissolved Oxygen (mg/L)	Temp. (°C)	Threshold Odor Number	pH (value)	Ortho-phosphate (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	Particle Count (#/ML)	Turbidity (NTU's)	Conduc-tivity (us/cm)	True Color (units)
Intake Surface	8.53	13.2	1.4	8.03	<0.01		0.023	<0.05	934	.12	1140	5
3m	8.51	13.4	1.4	8.07	<0.01		0.023	<0.05	951	.13	1145	13
6m	8.50	13.3	1.4	8.09	<0.01		0.023	<0.05	948	.13	1143	8
12m	8.39	13.3	1.0	8.05	<0.01		0.024	<0.05	730	.14	1138	11
18m	8.43	13.4	1	8.06	<0.01		0.024	<0.05	744	.13	1139	12
24m	8.47	13.3	1	8.07	<0.01		0.024	<0.05	747	.13	1140	11
30m	8.48	13.5	1	8.07	<0.01		0.024	<0.05	750	.14	1142	12
36m	8.45	13.4	1	8.07	<0.01		0.029	<0.05	632	.11	1136	9
42m	8.50	13.3	1	8.06	<0.01		0.038	0.06	829	.16	1144	8
48m	8.57	13.2	1.4	8.07	<0.01		0.036	0.08	1038	.20	1154	6
54m	8.44	13.1	1.4	8.07	<0.01		0.036	0.10	1670	.30	1157	10
Date	1-21-94	1-21-94	1-21-94	1-21-94	1-21-94		1-21-94	1-21-94	1-21-94	1-21-94	1-21-94	1-21-94
Time	0830-1100	0830-1100	1315-1410	0830-1100	1230		1315	1200	1200-1230	1200 1230	0830-1100	1000-1100
Analyst	RAH	RAH	RAH	RAH	ARB		BKA ARB	BKA	OxN	RAH	RAH	RAH

REMARKS: Turbid meter wasn't working right took back to Lab. for NTU

1- Secchi Disk Reading (m) 14.5
2- Lake Mead Elevation (m) 362.7
3- SNWS Intake (Elev. 318 m) (m) 44.7 * "Pioneer still down"
4- Instantaneous Cl2 surface TON
5- 4-Hour Cl2 Surface TON

Lab Supt. Supv.: Date: 1-27-94
Chemistry Supv.: Date: 1/24/94
Microbio. Supv.: Date: 1/31/94
Lab Manager.: Date: 1/27/94
Treat. Supv.: Date: 1-27-94
Treat. Manager.: Date: 1/28
Director: Date: 1/31/94

form 108L – snws

SOUTHERN NEVADA WATER SYSTEM

PHYTOPLANKTON RECORD

Analyst: E.L. Putnam

Sheet 1 of 3

Collection Date: 9-7-93

Species	Size (µm)	Counts B. Strip 1	Counts C. Strip 2	D. Total (B + C)	E. Cells/mL (DxA)	G. Biomass mg/m3 (ExFx10-3)
Oscillatoria	1.2	93.6	151.2	244.8	272	0.31
	2.4	27.6	20.4	48	53	0.38
Aphanothece	2.4 x 3.6	5	6	11	12	0.13
Gomphosphaeria	2.4	10	0	10	11	0.08
Phormidium	2.4 x 22	4	4	8	9	0.20
Merismopedia	1.2	116	188	304	337	0.30
					(694)	(1.40)
Sphaerocystis	4.8	0	1	1	1	0.06
	6	0	1	1	1	0.11
	10.8	1	0	1	1	0.66
Ochromonas	4.8 x 6	22	15	37	41	2.97
	6 x 7.2	4	7	11	12	1.63
	7.2 x 8.4	1	0	1	1	0.23
Chlamydomonas	3.6	7	5	12	13	0.32
	4.8	15	12	27	30	1.74
	6	13	14	27	30	3.39
	3.6 x 4.8	4	4	8	9	0.29
	7.2	1	0	1	1	0.20
Oocystis *	4.8 - 9	2	0	2	2	0.22
	7.2 x 9.6	0	1	1	1	0.26
	7.2 x 12	1	1	2	2	0.65
Trachelomonas	9.6 x 13.2	1	0	1	1	0.64
	10.8 x 12	0	1	1	1	0.73
	12 x 14.4	0	1	1	1	1.09
Quadrigula	2.4 x 26.4	1	0	1	1	0.08

Sample Depth(m): Raw H2O

Location: Raw - Op's Tap

Source: Lake Mead

Date Collected: 9-7-93

Date Analyzed: 11-18-93

pH:

Temp °C:

Dissolved Oxygen:

Nitrite (NO2 - N):

Nitrate (NO3 - N):

Ammonia (NH3 - N):

Total Phosphate (as P):

Volume Settled (Vs): 50ml

Conversion Factor (a): 1.11

Magnification: 100x | 200x | (400x) | 1000x

Strip width (mm): 0.4 | 0.2 | (0.1) | 0.04

Strip length (mm): (25.5) | 10

Number of Strips: 1 | (2) | 3 | 4 | Entire

Total Cells/mL (ΣE): 978

Total Biomass mg/m3 (ΣG): 51.19

% Blue-Green Algae Biomass: 3.2%

Time Req'd for Anal.: 2.9h

Remarks:

*average size

Lab Sup.

Lab Mgr.

Treat. Sup.

Treat Mgr.

Director

form 101N – snwa

SOUTHERN NEVADA WATER SYSTEM

PHYTOPLANKTON RECORD

Analyst: E.L. Putnam

Sheet 2 of 3

Collection Date: 9-7-93

Species	Size (µm)	Counts B. Strip 1	Counts C. Strip 2	D. Total (B + C)	E. Cells/mL (DxA)	G. Biomass mg/m3 (ExFx10-3)
Tagetheimia	3.6x4.8	0	1	1	1	0.03
Scenedesmus	2.4x4.8	1	1	2	2	0.03
	3.6x12	0	8	8	9	0.73
elliptoid	2.4x6	7	5	12	13	0.24
	8.4x14.4*	1	4	5	6	3.19
	9.6x14.4	1	0	1	1	0.69
	10.8x25.2	0	1	1	1	1.54
	15.6x18	0	1	1	1	2.29
	20.4x55.2	0	1	1	1	12.03
½ LRGT	14.4	2	0	2	2	1.56
RGT	12	1	0	1	1	0.90
Cyclotilla	6.0	0	1	1	1	0.14
Melosira	9.6x3.2	0	2	2	2	3.46
					884	43.50

Sample Depth(m): Raw H2O

Location: Raw - Dp's Tap

Source: Lake Mead

Date Collected: 9-7-93

Date Analyzed: 11-18-93

pH:

Temp °C:

Dissolved Oxygen:

Nitrite (NO2 - N):

Nitrate (NO3 - N):

Ammonia (NH3 - N):

Total Phosphate (as P):

Volume Settled (Vs): 50 ml

Conversion Factor (a): 1.11

Magnification: 100x | 200x | (400x) | 1000x

Strip width (mm): 0.4 | 0.2 | (0.1) | 0.04

Strip length (mm): (25.5) | 10

Number of Strips: 1 | (2) | 3 | 4 | Entire

Total Cells/mL (ΣE): 928

Total Biomass mg/m3 (ΣG): 51.19

% Blue-Green Algae Biomass: 3.2 %

Time Req'd for Anal.: 2.9h

Remarks:

Lab Sup.

Lab Mgr.

Treat. Sup.

Treat Mgr.

Director

form 101N – anwre

SOUTHERN NEVADA WATER SYSTEM

PHYTOPLANKTON RECORD

Analyst: E.L. Putnam

Sheet 3 of 3

Collection Date: 9-7-93

Species	Size (µm)	Counts B. Strip 1	Counts C. Strip 2	D. Total (B + C)	E. Cells/mL (DxA)	G. Biomass mg/m3 (ExFx10-3)
Sphaerocystis	2.5	8	0	8	4	0.03
	5.0	5	52	57	30	1.96
	7.5	1	0	1	1	0.22
Quadrigula	25 x 35	1	0	1	1	0.11
Oocystis	7.5 x 10	0	1	1	1	0.29
	7.5 x 12.5	0	1	1	1	0.37
Elliptoidea	7.5 x 12.5	1	0	1	1	0.37
	10 x 12.5	1	0	1	1	0.65
	12.5 x 15	0	2	2	1	1.23
	12.5 x 25	0	1	1	1	2.05
Ochromonas	5 x 10	0	1	1	1	0.18
	5 x 12.5	2	0	2	1	0.23
					44	7.69

Sample Depth(m): Raw H_2O

Location: Raw H_2O Op's Tap

Source: Lake Mead

Date Collected: 9-7-93

Date Analyzed: 11-18-93

pH

Temp °C

Dissolved Oxygen

Nitrite (NO2 - N)

Nitrate (NO3 - N)

Ammonia (NH3 - N)

Total Phosphate (as P)

Volume Settled (Vs): 50 ml

Conversion Factor (a): 0.53

Magnification: 100x | (200x) | 400x | 1000x

Strip width (mm): 0.4 | (0.2) | 0.1 | 0.04

Strip length (mm): (25.5) | 10

Number of Strips: 1 | (2) | 3 | 4 | Entire

Total Cells/mL (ΣE): 978

Total Biomass mg/m3 (ΣG): 51.19

% Blue-Green Algae Biomass: 3.27.

Time Req'd for Anal. 2.9 h

Remarks:

Lab Sup.

Lab Mgr.

Treat. Sup.

Treat Mgr.

Director

form 101N – anwa

...TE & TIME COLLECTED	SAMPLE LOG #	CHLORO-FORM CHCl3 ug/L	BROMO-DICHLORO-METHANE CHCl2Br (ug/L)	CHLORO-DIBROMO-METHANE CHBr2Cl (ug/L)	BROMO-FORM CHBr3 ug/L	TOTAL ug/L	DIFFER-ENCE	PERC... REMO...
FLD Ø 12/7	60:12Q	2.5	<1.0	<1.0	<1.0	2.5		
FIN 12/7	60:14Q	19.9	18.9	12.0	<1.0	50.8	88.4	63.5
RAW 12/7	60:13Q	72.5	37.7	22.6	6.4	139.2		
FLD Ø 12/8	60:23Q	3.2	<1.0	<1.0	<1.0	3.2		
FIN 12/8	60:24Q	20.8	18.4	11.5	<1.0	50.7	90.4	64.1%
RAW 12/8	60:22Q	74.4	38.6	21.7	6.4	141.1		
FLD Ø 12/9	62:23Q	4.0	<1.0	<1.0	<1.0	4.0		
FIN 12/9	62:22Q	33.3	26.8	16.4	5.9	82.4	69.1	45.6%
RAW 12/9	62:21Q	78.1	41.8	25.0	6.6	151.5		
FLD Ø 12/10	64:28Q	3.1	<1.0	<1.0	<1.0	3.1		
FIN 12/10	64:27Q	21.9	19.3	12.6	5.8	59.6	89.4	60.0%
RAW 12/10	64:26Q	79.5	39.8	23.3	6.4	149.0		

(3.) Test: 7 / 8

Remarks:

$\bar{x}$ = 56.8
s = 8.8

Form 257B - snws

Analyst:
Chem Supv.:
Lab Mgr.:
Treat. Mgr.:

Date: 12-23-92
Dat...
D...
D...

Lauryl... # 31-26

Brilliant Green Bile # 31-2	0.1		3						
EC Medium # 31-16	0.01		1		1	2			
	0.001	✓	0	✓	0	0	0	0	0

Certification

Lab I.D. #5

Month: Dec. 1993

SOUTHERN NEVADA WATER SYSTEM

ENTEROCOCCUS WORK SHEET

WEEKLY

DATE	SAMPLE DATA: Sample Location	Taken By	Rec'd By	Sample No.	BACTERIOLOGICAL DATA: Time Date Taken	Time Date Rec'd	Setup Time Date	Setup By	Time Date Cnt'd	Counted By	Re-frig.	Free Cl2 mg/L	mL Used	Membrane Technique: Total Fecal Count	Membrane Technique: Strep /100mL
12-27	Raw	SH	SH	Q 77-17	1330 12-27	1335 12-27	1500 12-27	SH	1630 12-29	MS	✓	—	100	0	0
↓	L.V. Wash	DXN	DXN	Q 77-15	1000 12-27	1300 12-27	↓	↓	↓	↓	✓	—	1.0 / 1.0	1 / 2	150
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	✓	—	10 / 10	8 / 10	90
	Control						1500 12-27	SH	1630 12-29	MS		—	—	0	—

Remarks:

Log10 - Log 8 = 1.0 - 0.90 = 0.1 < 0.156 ∴ Data Acceptable

Medium Batch # M Entero #33-3 Rinse #32-24

Samp. Supr.

Quality Control

Microbio Supv.: [signature] Date: 12-30-93

Lab Mgr.: [signature] Date: 12/30/93

form 176G - snws