Report on water pollution problems in Las Vegas Wash and Las Vegas Bay

Environmental Protection Agency

REPORT ON WATER POLLUTION PROBLEMS
IN
LAS VEGAS WASH AND LAS VEGAS BAY

AN OPEN FILE REPORT

A Technical Assistance Report
to the State of Nevada,
Department of Health, Welfare, and Rehabilitation

Environmental Protection Agency
Region IX
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INTRODUCTION

This report was prepared by the Federal Water Quality Administration, Pacific Southwest Region, now the Environmental Protection Agency (EPA), Region IX, at the request of the State of Nevada, Department of Health, Welfare, and Rehabilitation. In a letter, dated December 5, 1969, this agency asked for technical assistance, as authorized by the Federal Water Pollution Control Act, in developing discharge standards appropriate for Las Vegas Bay, Lake Mead, and the Lower Colorado River. The subsequent study was performed by EPA from January through August, 1970. The establishment of Nevada State Water Quality Standards for these waters will enable responsible officials to develop solutions for water quality problems in Las Vegas Bay and Las Vegas Wash.

Water quality standards are needed in order to (1) abate present nuisance conditions in waters of Las Vegas Bay, Lake Mead, and the Lower Colorado River, and (2) to provide a basis for the evaluation of alternative waste disposal plans under consideration by local districts using Lake Mead and the Lower Colorado River for sewage disposal. For example, one recent proposal recommends the formation of a Las Vegas area-combined-metropolitan sewage collection and treatment system which would discharge into the Lower Colorado River below Hoover Dam, (Consultants' Report, Phase 1, 1969). The curtailment of Las Vegas Wash effluent discharge may provide some mitigation for present nuisance algal conditions found in the Las Vegas Bay arm of Lake Mead. However, under this plan, it is also possible that the nutrients discharged to the river could support nuisance algal growth in downstream impoundments. Standards based on ability to support algal growth, together with dilution calculations, would permit the evaluation of the effects of this plan.

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusion:

In areas on Lake Mead other than Las Vegas Bay, phosphorus appears to be the limiting nutrient. Phosphorus is a conservative nutrient.

Recommendation:

It is therefore recommended that an interim discharge standard be set limiting the acceptable concentration of total phosphate as phosphorus in the receiving water at 10 micrograms per liter. A previous study group (1966) suggested that the Lake Mead phosphorous standard be set at 5 micrograms per liter to limit growth to roughly 2000 algal cells per milliliter, a condition not considered a nuisance level by this group (4). This level is exceeded in the main body of the Lake at present. It is suggested that this upper limit concentration be reduced to 5 micrograms per liter when ambient conditions permit. Because the Colorado River passes through many impoundments where algal growths could cause substantial nuisance, it is recommended that the Lake Mead receiving water standard of 10 micrograms per liter be extended to the Colorado River.

Because phosphorus is a conservative nutrient, it may build up within impoundments and cease to be limiting in these areas. To prevent blooms in areas of substantial phosphorous buildup, it is recommended that a standard of 1 milligram per liter of total (all forms) nitrogen as nitrogen be set for Lake Mead and for the Colorado River. This standard is based on present ambient levels of nitrogen in these bodies of water.

2. Conclusion:

There are substantial nuisance algal growths in the Las Vegas Bay region, due to the high level of algal nutrients influent from Las Vegas Wash. It appears that phosphorus and nitrogen may be limiting to algal growths during different seasons of the year.

Recommendation:

In Las Vegas Bay, it is recommended that both influent nitrogen and phosphorus be limited. It is recommended

that standards for influent phosphorus and nitrogen concentrations be set such that the receiving water does not exceed either 10 micrograms phosphate as phosphorus per liter, or more than 1 milligram per liter total nitrogen (all forms) as nitrogen. Based on through-flow rate, standards for discharge into Las Vegas Bay should be set at a maximum of 100 micrograms per liter total soluble phosphorous as phosphorus and 1 milligram per liter total (all forms) nitrogen as nitrogen.

Further analysis and monitoring should be performed in order to determine the critical conditions and periods during which specific nutrients trigger and/or limit algal growth.

3. Conclusion:

Las Vegas Wash effluent forms a density current containing roughly 1700 to 1900 milligrams per liter of sulfate. This current flows along the bottom of Lake Mead for an unknown distance. Several communities draw drinking water from this portion of Lake Mead.

Recommendation:

It is recommended that a provisional interim Total Dissolved Solids (TDS) effluent standard, based on ambient Lake Mead water quality and specific to Las Vegas Wash effluent be set. A mineral increment of 300 milligrams per liter above the water service level has been used elsewhere to control such inputs and to minimize further degradation of a raw water supply that already exceeds the recommended limits in the 1962 U.S. Public Health Service Drinking Water Standards for total dissolved solids and for sulfate.

The continued discharge of this effluent into Las Vegas Bay is very likely to have some detrimental effect on raw water quality at the water supply intakes. This effluent would cause a continual buildup in the Lake itself of conservative constituents, such as TDS, sulfate, trace metals, and trace organic compounds. Some of these will eventually reach water supply intakes serving the the Las Vegas area. Most of these constituents would not be removed by normal water treatment processes. Contamination from bacterial and viral constituents for the discharge is less likely due to the probable time delay before reaching intakes, but is possible in unusual

situations. It is preferable that the discharge from Las Vegas Bay be eliminated completely. Since this cannot be done immediately, it is recommended that the interim effluent standard mentioned above be used.

PROCEDURE

Area:

The study area extends from the upper end of Boulder Canyon in Lake Mead west to the tip of Las Vegas Bay. From Las Vegas Bay, it extends south to include the Colorado River from Hoover Dam to immediately below Davis Dam (Table 1). It is thought that these sampling sites reflect the water quality in the different sections of this region.

Methods:

Grab samples were collected throughout three sampling periods during the winter and one during the summer (Table 1). The samples were monitored for specific conductance, nitrogen forms, phosphorous, temperature, chlorophyll a (a specific measure of algal density), and algal growth potential (Tables 2, 3).

Growth potential bioassays were conducted to evaluate the effects of addition of various substances on algal growth (Table 3, References 1 and 6). Data gathered by the Bureau of Reclamation during 1968 in Las Vegas Wash and in Las Vegas Bay were used in preparing this report (Table 4, Reference 7). Data gathered in the consulting engineers' report were used (Reference 3).

Standard analytical methods as described in the 12th Edition of Standards Methods were used in both studies. The only different methods used were in the Bureau's tests for phosphorous, which were performed using methods developed by the California Department of Health, and in its tests for nitrate - nitrogen, which used a modified brucine methods (5, 2).

DISCUSSION

Earlier Work on Nutrients:

A report on eutrophic conditions in Lake Mead issued by the Federal Water Pollution Control Administration, in 1967, states

that Lake Mead and Colorado River water quality would be deleteriously affected by total phosphorous concentrations in excess of 5 micrograms per liter as phosphorus. The study group concluded that this level was acceptable and would support algal growth in excess of 2000 cells per milliliter. The report suggests that severe nuisance conditions may result from Lake phosphate concentrations greater than 15 micrograms per liter phosphorus. It also concluded that, to meet this standard, sewage treatment plant effluent standards should not exceed a concentration of 1.2 milligrams per liter of phosphates as phosphorus based on dilution calculations (4).

In 1970, the Federal Water Quality Administration released an interim report covering technical assistance work then in progress. This research was performed at the request of the State of Nevada in order to set workable algal nutrient standards for Lake Mead and the Lower Colorado River. Results of this study indicated that, during the winter months, phosphorus was the nutrient limiting algal growth in Lake Mead, the Lower Colorado River, and Las Vegas Bay. The study group concluded that, under existing conditions, the algal growth potential of Lake Mead water increases between Las Vegas Wash and the Willow Beach sampling point on Lake Mojave.

The group, therefore, recommended that the State of Nevada require that effluent addition to both Lake Mead and the Lower Colorado River be of such a content that algal growth would not be stimulated in the receiving waters. They recommended that water quality evaluation for this region be based on both total soluble phosphorus and algal growth potential studies. A 10-day algal growth potential maximum of approximately 10 to 20 micrograms chlorophyll _a_ per liter and a total soluble phosphorous limit of 10 to 20 micrograms per liter as phosphorus were also recommended. No attempt was made to set effluent standards (9).

A recent (1971) report by the Bureau of Reclamation indicated that measured summer algal bloom chlorophyll _a_ concentration (algal density) values in Las Vegas Wash were 20 to 25 times those recorded in the Boulder Basin. Las Vegas Wash effluent discharge appears to contribute to eutrophic nuisance conditions in Las Vegas Bay. No recommendations for the abatement of nuisance conditions were made.

The Present Study:

The present study, which includes and extends the earlier (1970) interim internal report of the Federal Water Quality

Administration, used the algal growth potential bioassay as its main evaluative standard for eutrophication. In essence, this test, which has been described fully in other reports, measures both the maximum algal biomass and growth rate possible in a given water (1,6). Five studies were performed on Lake Mead, Las Vegas Wash, and Colorado River waters to determine the growth response of indigenous algae to additions of nitrogen (nitrate), phosphorous (inorganic phosphate), and secondary sewage effluent (various forms of several nutrients). The results of these studies are summarized in Tables 1 through 3.

Phosphorous concentrations are limiting to algal growth throughout the study area during the winter months. This nutrient is limiting in Lake Mead proper and in the Lower Colorado River during the whole year. Further monitoring will have to be performed in order to determine whether nitrogen is limiting during the summer in Las Vegas Bay, as has been suggested by earlier studies (3, 4). The practicability of phosphorous removal from the Bay using as aquatic plant harvesting process similar to that used at Santee should also be investigated, as residual phosphorus in the system may otherwise remain a problem for years. A report on these should be available before the Nevada Water Quality Standards for Lake Mead and the Lower Colorado River are set in 1972, to aid the State of Nevada in evaluating these conditions and solutions (1, 6).

Presently, an interim nitrogen receiving water standard should be set for Las Vegas Bay. Such a standard should be based on total nitrogen, including organic, inorganic, and nitrate forms, since a large percentage of this nutrient is incorporated into algal cells during periods of high algal growth. This standard should be set to reflect ambient levels in Lake Mead above Las Vegas Bay, and should account for dilution of Las Vegas Wash effluent in Las Vegas Bay.

The finding that ground water is a more biostimulatory addition when mixed with Lake water than would be expected on the basis of its phosphorous and nitrogen content indicates that it may contain biostimulatory levels of other nutrients (Table 3). Since the Bureau of Reclamation report concurs with this finding, it is suggested that this discharge should be monitored to decide if the B.M.I. pond discharge should be collected before or after percolation, and treated and/or discharged below Hoover Dam. A provisional, interim Total Dissolved Solids effluent standard specific to Las Vegas Wash effluent, based on the ambient value of TDS in Lake Mead, should be set. The reason for this is twofold. (1) In addition to the nutrient problem mentioned earlier, (2) there is a high level of sulfate (1700 to 1900 milligrams per liter in 1968) in this effluent (8). These data

are substantiated by the engineering study performed by Cornell, Howland, Hayes, and Merryfield, together with Boyle, for the Las Vegas Valley Interagency Water Pollution Control Task Force. The material effluent from the Wash, by virtue of its high TDS content, flows along the bottom of the Las Vegas Bay as a density current. The high density limits diffusive dispersion of this material into the Lake water and permits the concentrated material to accumulate along the Lake's bottom. It does not appear to be substantially diluted as it moves along the bottom, and the ultimate fate of this material is unknown.

There is substantial risk that communities which draw domestic water from Lake Mead may find its level of sulfate unacceptably high. This level could cause gastrointestinal disturbances in the populations drinking this water and might seriously affect young children. Since Lake Mead provides the main drinking water source for several communities, this sulfate level could be a severe problem. The influent sulfate appears to be closely correlated to TDS level, and no single source of sulfate can be isolated. Therefore, a provisional interim standard specific to Las Vegas Wash effluent should be set in order to protect the people of communities using this water source.

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Table 1. - DESCRIPTION OF SAMPLING

Sampling Locations:

I. Lake Mead and the Lower Colorado River

Station No.	Description
1	Lake Mead upstream of Boulder Canyon, across from lighted marker on State line.
2	Lake Mead in Boulder Canyon, across from Canyon Point on State line.
3	Lake Mead in Boulder Basin, across from Callville Bay on State line.
3A	Callville Bay, across from marina.
3B	Callville Bay, at mouth of Bay.
4	Las Vegas Bay, about one-half mile from Las Vegas Boat Harbor near center channel.
4A	Las Vegas Bay, 0.15 mile from mouth of Las Vegas Wash.
5	Las Vegas Bay, about one-half mile from Las Vegas Boat Harbor toward Lake Mead.
6	Lake Mead at Hoover Dam.
7	Colorado River, upstream from Willow Beach and Geological Survey gage at Cableway.
8	Colorado River at head of Windy Canyon, six miles below Willow Beach.
9	Colorado River, 200 yards below Davis Dam at mid-channel.

II. Ground Water Samples near Las Vegas Wash

Station No.	Description
LVGW-1	Large gravel pit (NE 1/4, Sec. 31, T21S, R63E) down gradient of the B.M.I. ponds on the south side of Las Vegas Wash.

Table 1. - DESCRIPTION OF SAMPLING (Continued)

LVGW-2	Hand auger hole (NW 1/4, Sec. 31 T21S, R63E) immediately north of the upstream B.M.I. ponds. This represents the quality of seepage which moves from the B.M.I. ponds into Las Vegas Wash.
LVGW-3	Gravel pit (SE 1/4, Sec. 35, T21S, R62E).
LVGW-4	Hand auger hole located between Duck Creek and Las Vegas Wash, along the section line of Section 23 and 26, one-fourth mile east of Section corner in T21S, R62E.
LVGW-5	Outlet of Charleston Drain.

III. Las Vegas Wash*

Station No.	Description
W-1	Effluent, Las Vegas Waste Water Treatment Plant.
W-2	Nevada Power Co. Sunrise Station, cooling tower blowdown.
W-3	Clark County Sanitation District Waste Water treatment plant effluent.
W-4	Las Vegas Wash, 9.3 mile from Las Vegas Bay (confluence).
W-5	Nevada Power Company, Clark Station, cooling tower blowdown.
W-6	Basic Management Incorporated, influent to lower ponds.
W-7	Henderson oxidation pond effluent.
W-8	Basic Management Incorporated, influent to upper ponds.
W-9	Las Vegas Wash, 7.6 miles from Las Vegas Bay.
W-10	Las Vegas Wash, 6.0 miles from Las Vegas Bay, at the U.S.G.S. gauging station.
W-11	Las Vegas Building Materials Company, drainage to Las Vegas Wash from gravel pit.

Table 1. - DESCRIPTION OF SAMPLING (Continued)

W-12	Las Vegas Wash, 3.3 miles from Las Vegas Bay.
W-13	Las Vegas Wash, 0.6 miles from Las Vegas Bay, at North Shore Drive.

Sampling Times:

Las Vegas Wash*

Time	Location
12/1968	Las Vegas Wash - all samples.

IV. Lake Mead and the Lower Colorado River

Time	Location
1/25/1970 1/26/1970	Stations 3, 4, 6, 7, and 8.
2/16/1970 2/17/1970	Stations 1-9, excluding 3A, 3B, and 4A.
3/1/1970 3/4/1970	Stations 1-9, excluding 3A and 3B, plus ground water.
8/13/1970 8/14/1970	Stations 1-9, excluding station 4A, plus a waste water treatment plant sample taken from the Wash at the confluence of the Clark County and Las Vegas effluents.

Table 2. - BASIC CHEMICAL RESULTS LAKE MEAD - COLORADO RIVER STUDY (Continued)

Survey No.	Station Number	Date Collected	Sample Depth	Nitrate NO_3-N mg/l as N	Ammonia NH_3-N mg/l as N	Organic N mg/l as N	Total -N Kjeldahl mg/l as N	Phosphate Ortho mg/l as P	Phosphate Tot-Sol mg/l as P	Temp°C	Specific Electrical Conductance	Sc[illegible] D[illegible] F[illegible]
IV. Lake Mead-Colo. River	1	8/13	S	0.53	<0.04	0.20	--	<0.01	<0.01	31	1,120	>[illegible]
	2	8/13	S	0.40	0.13	0.12	--	<0.01	<0.01	32	1,140	[illegible]
	3	8/13	S	0.13	<0.04	0.26	--	0.01	0.02	31	1,140	1[illegible]
	3A	8/13	S	0.13	0.07	0.21	--	<0.01	<0.01	30	1,140	1[illegible]
	3B	8/13	S	0.14	0.05	0.46	--	0.01	<0.01	30	1,140	1[illegible]
	6	8/13	S	0.14	<0.04	0.43	--	<0.01	0.01	27	1,160	[illegible].5
	7	8/14	S	0.64	0.06	0.18	--	0.01	<0.01	15	1,150	>1[illegible]*
	8	8/14	S	0.64	<0.04	0.19	--	<0.01	0.01	15	1,150	>1[illegible]*
	9	8/14	S	0.47	0.08	0.10	--	0.01	<0.01	19	1,150	> 7*
Las Vegas Bay	4A	8/13	S	0.03	<0.04	0.62	--	0.02	0.03	33	1,230	4
	4	8/13	S	0.02	0.06	0.53	--	0.02	0.03	31	1,190	10
	5	8/13	S	0.02	<0.04	0.39	--	<0.01	0.01	31	1,160	7

* Estimated.

Table 2. - BASIC CHEMICAL RESULTS LAKE MEAD - COLORADO RIVER STUDY (Continued)

Survey No.	Station Number	Date Collected (1970)	Sample Depth	Nitrate NO_3-N mg/l as N	Ammonia NH_3-N mg/l as N	Organic N mg/l as N	Total -N Kjeldahl mg/l as N	Phosphate Ortho mg/l as P	Phosphate Tot-Sol mg/l as P	Temp°C	Specific Electrical Conductance
Las Vegas Bay	4A	3/4	S	0.17	0.40	0.38	0.78	0.138	0.184	14	1,[illegible]00
	4A	3/4	0.5' above bottom D = 12'	6.30	0.68	0.48	1.16	3.260	4.000	14	5,100
	4	3/4	S	0.32	0.07	0.39	0.46	0.005	0.054	13	1,300
	4	3/4	3' above bottom D = 70'	≤0.02	0.19	0.34	0.53	0.820	1.010	13	2,200
	4	3/2	S	0.38	0.05	0.34	0.39	0.025	0.050	13	1,350
	5	3/2	S	0.46	0.03	0.33	0.36	0.009	0.025	13	1,300
	5	3/2	120'	0.49	0.06	0.26	0.32	0.017	0.033	12	1,350
Ground Water Characterization											
Composite of Samples (LVGW 1-5)	--	3/2	--	9.80	0.05	--	0.60	--	0.160	--	--
Gravel Pit	LVGW-1	3/1	--	0.34	0.06	0.04	0.10	0.010	--	19	6,000
Seepage below BMI Ponds	LVGW-2	3/1	--	2.10	0.15	0.68	0.83	0.047	0.316	13	7,000
Gravel Pit	LVGW-3	3/1	--	0.06	0.04	0.62	0.66	0.035	0.069	14	6,250
Ground water between Duck Creek and Wash	LVGW-4	3/1	--	≤0.02	0.04	0.31	0.35	0.078	0.345	13	10,000
Outlet of Charleston Drain	LVGW-5	3/1	--	0.70	0.04	0.27	0.31	0.140	--	18	3,000
Duck Creek above NPC	LVGW-6	3/4	--	≤0.02	0.02	0.24	0.26	0.031	0.033	12	7,500

Table 2. - BASIC CHEMICAL RESULTS LAKE MEAD - COLORADO RIVER STUDY

Survey No.		Station Number	Date Collected (1970)	Sample Depth	Nitrate NO_3-N mg/l as N	Ammonia NH_3-N mg/l as N	Organic N mg/l as N	Total -N Kjeldahl mg/l as N	Phosphate Ortho mg/l as P	Phosphate Tot-Sol mg/l as P	Temp°C	Specific Electrical Conductance
I.	Lake Mead-Colorado River	3	1/26	S	0.56	0.03	0.21	0.24	0.003	0.020	14	1,300
		6	1/26	S	0.48	0.07	0.29	0.36	0.010	0.016	12	1,350
		7	1/26	S	0.51	0.03	0.34	0.37	0.013	0.020	13	1,350
		8	1/25	S	0.64	0.04	0.19	0.23	0.013	0.023	13	1,200
	Las Vegas Bay	4	1/26	S	0.41	0.04	0.10	0.14	0.007	0.020	12	1,400
II.	Lake Mead-Colorado River	1	2/17	S	0.66	0.07	0.23	0.30	0.002	0.007	14	1,250
		1	2/17	2/3 Depth	0.63	0.06	0.24	0.30	0.002	0.007	13	1,200
		2	2/17	S	0.48	0.05	0.33	0.38	0.003	0.10	13	1,300
		2	2/17	2/3 Depth	0.64	0.06	0.28	0.34	0.003	0.007	13	1,200
		3	2/17	S	0.36	0.07	0.28	0.35	0.007	0.016	13	1,320
		6	2/17	S	0.32	0.07	0.24	0.31	0.003	0.016	13	1,320
		6	2/17	104'	0.40	0.05	0.26	0.31	0.007	0.020	13	1,300
		6	2/17	254'	0.59	0.04	0.19	0.23	0.010	0.020	13	1,200
		7	2/16	S	0.37	0.06	0.23	0.29	0.007	0.016	14	1,200
		8	2/16	S	0.37	0.05	0.23	0.28	0.007	0.020	14	1,250
		9	2/16	S	0.30	0.04	0.23	0.27	0.003	0.013	12	1,300
	Las Vegas Bay	4	2/17	S	0.32	0.04	0.32	0.36	0.016	0.032	13	1,350
		5	2/17	S	0.34	0.03	0.25	0.28	0.007	0.020	13	1,320
III.	Lake Mead-Colorado River	1	3/2	S	0.47	0.05	0.31	0.36	0.007	0.016	13	1,280
		1	3/2	250'	0.61	0.05	0.23	0.28	0.004	0.009	12	1,250
		2	3/2	S	0.38	0.07	0.28	0.35	0.009	0.020	13	1,300
		2	3/2	250'	0.64	0.03	0.28	0.31	0.004	0.009	12	1,230
		3	3/2	S	0.52	0.07	0.21	0.28	0.006	0.016	13	1,300
		3	3/2	250'	0.54	0.04	0.26	0.30	0.008	0.015	12	1,300
		6	3/2	S	0.55	0.05	0.22	0.27	0.012	0.022	12	1,300
		6	3/2	104'	0.55	0.03	0.35	0.38	0.017	0.030	12	1,300
		6	3/2	254'	0.61	0.03	0.24	0.27	0.012	0.023	12	1,250
		7	3/3	S	0.62	0.01	0.24	0.25	0.012	0.015	13	1,260
		8	3/3	S	0.61	0.03	0.22	0.25	0.012	0.016	12	1,300
		9	3/4	S	0.40	0.03	0.23	0.26	0.005	0.006	12	1,350

Table 3. - SUMMARY OF BIOASSAY RESULTS

Bioassay 1, (Samples taken January 1970)

Sample No.	P *	N **	Max. Chl.a ***	Chl.a ***	u_b, † day^{-1}
3	0.06	0.59	12.2	2.8	0.13
3n	0.06	1.09	10.5	1.3	0.15
3p	0.16	0.59	35.2	25.8	0.33
4	0.06	0.45	33.4	14.7	0.34
4n	0.06	0.95	31.0	12.5	0.31
4p	0.16	0.45	59.6	41.0	0.53
6	0.05	0.55	17.9	9.3	0.21
6n	0.05	1.05	14.7	6.1	0.28
6p	0.15	0.55	45.7	37.0	0.48
7	0.06	0.54	16.8	7.8	0.17
7n	0.06	1.04	15.0	6.0	0.24
7p	0.16	0.54	52.7	43.7	0.61
8	0.07	0.68	10.1	1.3	0.06
8n	0.07	1.18	11.0	2.1	0.12
8p	0.17	0.68	60.3	66.8	0.50

* Total soluble phosphorous, mg./liter.

** Total inorganic nitrogen, mg./liter.

*** Chlorophyll a, micrograms per/liter.

† Growth rate, increase/day.

Table 3. - SUMMARY OF BIOASSAY RESULTS (Continued)

Bioassay 2, (Samples taken January 1970)

Sample No.	P *	N **	Max. chl. a.	Δ Chl. a.	u_b^+, $days^{-1}$ Max.
1	0.01	0.73	10.6	0.03	0.17
1n	0.01	1.23	10.3	0.02	0.11
1p	0.11	0.73	58.1	47.3	0.34
2	0.01	0.53	10.5	0.0	0.03
2n	0.01	1.03	9.8	0.2	0.03
2p	0.11	0.53	37.3	25.7	0.24
3	0.02	0.43	15.1	2.4	0.15
3n	0.02	0.93	15.2	2.4	0.10
3p	0.12	0.43	65.4	52.5	0.32
4	0.03	0.36	24.8	6.4	0.15
4n	0.03	0.86	30.5	12.1	0.14
4p	0.13	0.36	67.5	49.0	0.45
5	0.02	0.37	16.7	4.0	0.33
5n	0.02	0.87	15.4	2.7	0.24
5p	0.12	0.37	62.1	49.4	0.46
6	0.02	0.39	18.9	5.4	0.18
6n	0.02	0.89	16.8	3.3	0.06
6p	0.12	0.39	48.4	34.9	0.48
7	0.02	0.43	22.9	12.1	0.27
7n	0.02	0.93	23.2	12.2	0.30
7p	0.12	0.43	95.2	84.5	0.75
8	0.02	0.42	33.8	19.8	0.50
8n	0.02	0.92	33.5	19.4	0.45
8p	0.12	0.42	97.9	84.0	0.08
9	0.01	0.34	8.9	1.3	0.31
9n	0.01	0.84	8.4	0.8	0.22
9p	0.11	0.34	22.9	15.2	0.23

* Total soluble phosphorus.

** Total inorganic nitrogen.

\+ Growth rate, increase/day.

Table 3. - SUMMARY OF BIOASSAY RESULTS (Continued)

Bioassay 3, (Samples taken March 1970 at Station 3)

Sample No.	P *	N **	Max. Chl.a. ***
1a *	0.06	0.58	11.9
1b	0.011	0.58	12.4
1c	0.021	0.58	15.9
1d	0.036	0.58	18.2
1e	0.056	0.58	18.9
2a **	0.006	0.58	11.9
2b	0.008	0.58	11.1
2c	0.013	0.59	11.9
2d	0.019	0.61	14.5
2e	0.028	0.62	28.8
3a ***	0.006	0.58	11.9
3b	0.008	0.72	15.0
3c	0.013	1.00	19.9
3d	0.018	1.41	26.7
3e	0.028	1.96	40.8

* Lake Mead water with added inorganic potassium acid phosphate.

** Lake Mead water with added waste water treatment plant effluent.

*** Lake Mead water with added ground water composite sample.

Table 3. - SUMMARY OF BIOASSAY RESULTS (Continued)

Bioassay 4, (Samples taken March 1970 at Station 3)

Sample No.	P *	N **	Max. Chl.a. ***	Fe ****
1a[1]	0.006	0.58	16.3	20
1a	0.006	0.58	32.8	220
1b	0.021	0.58	41.4	220
1c	0.046	0.58	45.9	220
1d	0.086	0.58	45.9	220
2a[2]	0.006	0.58	32.8	220
2b	0.021	0.61	42.4	220
2c	0.046	0.65	52.3	220
2d	0.086	0.72	51.8	221
3a[3]	0.006	0.58	32.8	220
3b	0.021	1.51	47.5	230
3c	0.046	3.06	63.4	248
3d	0.086	5.51	107.5	275

* Total soluble phosphorus, milligrams per liter.

** Total inorganic nitrogen, milligrams per liter.

*** Chlorophyll a, micrograms per liter.

**** Inorganic iron, micrograms per liter.

1. Lake Mead water with iron and phosphorous added in varying amounts.

2. Lake Mead water with secondary effluent added.

3. Lake Mead water with a ground water composite, believed to represent that entering the Wash, added.

Table 3. - SUMMARY OF BIOASSAY RESULTS (Continued)

Bioassay 5, (Samples taken August 1970)

Sample No.	P *	N **	Max. Chl. a. +	Chl. a.
1a ***	0.01	0.57	4.9	3.5
1b	0.01	0.82	4.4	
1c	0.01	1.07	4.2	
1d	0.01	1.57	4.4	
1e	0.01	2.57	4.4	
1f	0.015	0.57	10.2	
1g	0.025	0.57	10.0	
1h	0.040	0.57	16.2	
1j	0.060	0.57	17.7	
2	0.01	0.53	5.0	3.3
3	0.02	0.17	13.5	11.8
3A	0.01	0.20	8.2	6.9
3B	0.01	0.19	8.8	7.3
4	0.03	0.07	29.8	25.0
4A	0.03	0.08	21.7	17.5
5	0.01	0.06	17.6	15.1
6	0.01	0.18	17.4	15.3
7a ***	0.01	0.70	11.2	9.1
7b	0.01	0.95	9.9	
7c	0.01	1.20	9.9	
7d	0.01	1.70	9.4	
7e	0.01	2.70	9.8	
7f	0.015	0.70	14.8	
7g	0.025	0.70	20.3	
7h	0.040	0.70	33.9	
7j	0.060	0.70	31.3	
8	0.01	0.68	10.2	8.6
9	0.01	0.55	9.9	7.6

* Phosphorous, milligrams per liter.

** Total inorganic nitrogen, milligrams per liter.

*** Samples 1a through 1e and 7a through 7e were spiked with nitrogen, while samples 1f through 1j and 7f through 7j were spiked with phosphorous.

\+ Chlorophyll a, micrograms per liter.

Table 4. - AVERAGE* 1968 LAS VEGAS WASH PARAMETERS OBTAINED BY THE BUREAU OF RECLAMATION

Station Number	W-10*	W-12**	W-13*
Parameter, mg. per liter (unless otherwise noted)			
pH, pH units	8.05	8.1	8.2
T.D.S.	3,353	5,354	5,245
Calcium, as Ca	335	535	514
Magnesium, as Mg	139	220	230
Sodium, as Na	478	688	646
Potassium, as K	39	87	74
Carbonate, as CO_3	0	0	0
Bicarbonate, as HCo_3	288	242	262
Sulfate, as SO_4	1,158	1,637	1,707
Chloride, as Cl	751	1,363	1,255
Nitrate, as NO_3	165	43	27.5

* Average of 4 samples, one taken in each of the months of March, May, August, and November.

** Average of two samples, one taken in each of the months of August and November.