Comparative Study on Total Suspended Solids and Nutrients of the Las Vegas Wash Between the Demonstration Weir and its Terminus at the Las Vegas Bay Delta

September 2006

SOUTHERN NEVADA WATER AUTHORITY

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1.0 INTRODUCTION

The drought in the Western United States has resulted in a lake level decline of Lake Mead of more than 75 feet since 2000. As a result of the lower lake level, a large delta has been exposed that extends from the mouth of the Las Vegas Wash (Wash) into the Las Vegas Bay. The delta is composed primarily of sediments from the Wash that have been continually transported and deposited into Lake Mead. There has been considerable debate as to the sources of sediments on the delta, whether they are "new" sediments from the Wash or they are "old" sediments from the previous delta that have been reworked and carried toward Lake Mead due to the lower lake level. Another question arises as to whether additional nutrients (nitrogen and phosphorus) coming from the sediments could cause algal overgrowth (algae bloom) in Lake Mead. To answer these questions and to determine the amount of sediment and nutrients picked up and transported from the exposed delta into Lake Mead, a comparative study of total suspended solids (TSS) and nutrients between the point where the Wash enters the Las Vegas Bay and a point in the Wash was performed from July 2001 to November 2003.

The data collected from this study allows for the comparison of TSS and nutrient concentrations in the Wash water before and after the delta. This information can be used to determine the amount of TSS and nutrient loading due to the reworking process of the Wash flow over the delta versus the amount of TSS and nutrient contributed from the Wash flows.

2.0 STUDY METHODS

The Demonstration Weir (LW3.75) and the point where the Wash enters the Las Vegas Bay (LWLVB) were chosen as sample sites for this study (Figure 1).

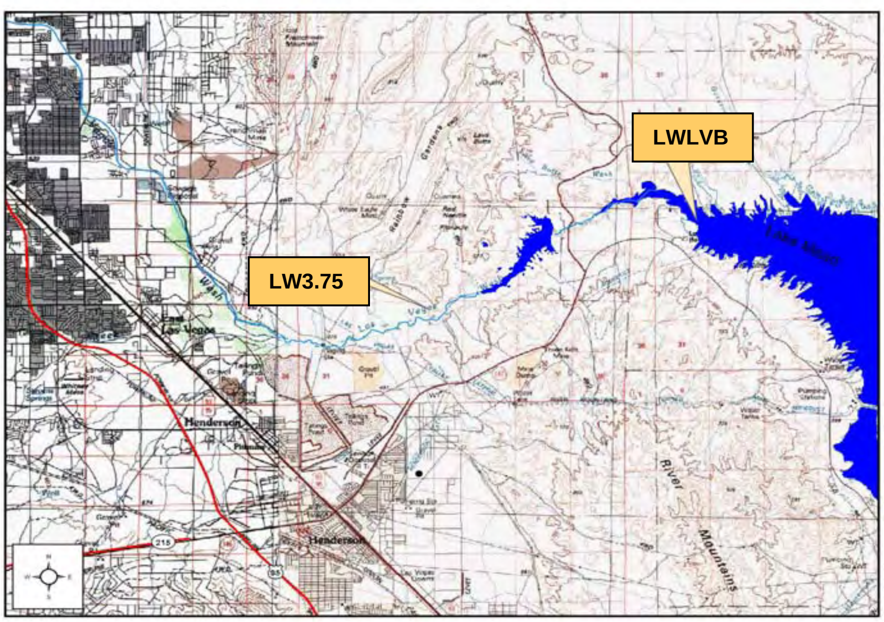

Figure 1: Map showing two sample locations (LW3.75 and LWLVB) for this study.

These sites were selected because LW3.75 reflects the concentrations of nutrients and TSS in the Wash at a location near Lake Mead, and LWLVB reflects the concentrations of nutrients and TSS after the Wash water has flowed over the delta in the Las Vegas Bay. Water samples were collected from below the Demonstration Weir (Figure 2) and the interface between the delta and Lake Mead (Figure 3) on a monthly basis for over two years. The LWLVB site varied from month to month due to the migration of the delta.

Figure 2: One sample location – below Demonstration Weir (LW3.75)

Figure 3: Second sample location – Las Vegas Bay Delta (LWLVB).

Each month, one set of samples was collected from LW3.75, while one to three sets of samples were collected from LWLVB (LWLVB_Left, LWLVB_Central, and LWLVB_Right). Multiple samples from more than one location at LWLVB were sometimes necessary because the Wash flows spread out across the delta, which has been extensively channelized (Figure 3). Average TSS and nutrient concentrations were used for loading calculations for both sample sites.

Water samples were collected from the south bank of the stream at LW3.75 (Figure 2). They were collected directly into the pre-cleaned bottles. At LW/LBV sites, water samples were collected using the sample boat from Southern Nevada Water System, which was driven as far into the delta as possible. Samples were collected with a large sampler (Van Dorn) and then transferred into pre-cleaned bottles.

Each sample set included five bottles (Table 1). Samples for orthophosphate (OP) analysis were filtered through 0.45-µm filters using a hand pump to remove organic constituents. Hydrochloric acid (HCl) and sulfuric acid (H_2SO_4) were added to preserve the water samples for total phosphate (TP) and ammonia (NH_3) analyses, respectively. After sample preparation, all samples were cooled to 4 °C while being transported to the laboratory. A chain of custody form accompanied all samples to the laboratory.

Nevada Environmental Laboratories analyzed all samples for this study. Methods SM 4500-NH3, EPA 300.0, SM 4500-P E, and SM 2540 D were used for NH_3, nitrate (NO_3), OP, TP and TSS analysis, respectively. The reporting limits were 0.1 mg/L for NH_3, 1.0 mg/L for NO_3, 0.010 mg/L for OP and TP, and 10.0 mg/L for TSS analysis.

Bottle Size	Filtering	Preservation	Analysis
1000 ml	No	No	TSS
250 ml	No	No	NO_3
250 ml	Yes	No	OP
250 ml	No	HCl	TP
500 ml	No	H_2SO_4	NH_3

Table 1: Information on sample collection, preparation and analysis.

3.0 RESULTS AND DISCUSSION

Results of the monthly water quality data collected from LW3.75 and LWLVB, including TSS, NH_3, NO_3, OP, and TP were summarized (Table 2). Average concentrations were calculated for LWLVB when more than one set of samples (i.e., left, central, and right) were collected from the delta.

Sample Location	Sample Date	TSS (mg/L)	NH4 (mg/L)	NO3 (mg/L)	OP (mg/L)	TP (mg/L)
LWLVB (Average)	7/24/2001	988	ND	14	0.07	0.69
	8/30/2001	752	ND	16	0.03	0.47
	10/15/2001	1393	0.57	13	0.04	0.66
	12/5/2001	699	ND	13	0.21	0.81
	1/8/2002	343	ND	14	0.27	0.79
	2/13/2002	516	ND	14	0.20	0.79
	3/20/2002	2090	ND	14	0.01	0.34
	5/15/2002	1430	ND	15	0.04	0.50
	6/21/2002	1360	ND	15	0.13	1.00
	7/31/2002	1460	ND	9	0.13	1.20
	8/30/2002	592	ND	14	0.05	0.68
	9/27/2002	793	ND	15	0.09	0.68
	10/28/2002	1360	ND	12	0.18	0.94
	11/22/2002	618	ND	16	0.21	0.79
	12/26/2002	857	ND	15	0.10	0.63
	1/23/2003	1340	ND	13	0.18	1.00
	2/24/2003	741	ND	13	0.07	0.80
	3/21/2003	554	ND	14	0.17	0.98
	4/30/2003	2250	ND	12	0.10	0.22
	5/16/2003	624	ND	13	0.09	0.85
	6/27/2003	1585	ND	14	0.10	1.37
	7/18/2003	938	ND	14	0.20	0.57
	9/22/2003	68	ND	14	0.10	0.57
	11/24/2003	392	ND	12	0.10	0.14
LW3.75	7/24/2001	43	ND	14	0.01	0.23
	8/30/2001	23	ND	15	0.03	0.07
	10/15/2001	26	0.3	13	0.03	0.06
	12/5/2001	30	ND	13	0.27	0.33
	1/8/2002	13	ND	13	0.27	0.39
	2/13/2002	16	ND	14	0.21	0.30
	3/20/2002	42	ND	14	0.01	0.87
	5/15/2002	10	ND	15	0.06	0.11
	6/21/2002	26	ND	14	0.16	0.29
	7/31/2002	54	ND	9	0.16	0.22
	8/30/2002	10	ND	13	0.05	0.10
	9/27/2002	20	ND	14	0.10	0.17
	10/28/2002	28	ND	12	0.21	0.26
	11/22/2002	10	ND	16	0.24	0.30
	12/26/2002	12	ND	15	0.10	0.16
	1/23/2003	19	ND	13	0.22	0.28
	2/24/2003	36	ND	13	0.08	0.12
	3/21/2003	61	ND	14	0.19	0.30
	4/30/2003	44	ND	12	0.12	0.23
	5/16/2003	26	ND	12	0.08	0.07
	6/27/2003	34	ND	14	0.12	0.21
	7/18/2003	13	ND	14	0.23	0.29
	9/22/2003	10	ND	14	0.12	0.19
	11/24/2003	11	ND	12	0.11	0.74

ND = Non Detect

Table 2: TSS and nutrient concentrations from Demonstration Weir and Las Vegas Bay.

3.1 Total Suspended Solids

Based on data collected during 2001–2003, average TSS concentration at LW3.75 and at LWLVB were 26 mg/L and 989 mg/L, respectively (Figure 4). TSS concentrations were greatly elevated after the Wash water flowed over the delta. In addition, a large amount of bed sediment was washed into the Las Vegas Bay daily. These results show that the majority of sediments moving into the Las Vegas Bay during the normal dry-weather seasons were due to the reworking of existing sediments in the delta by the Wash due to the elevation decrease of Lake Mead. With a lowering lake level, the sediments are being transported and re-deposited into the Las Vegas Bay, resulting in an expanding delta.

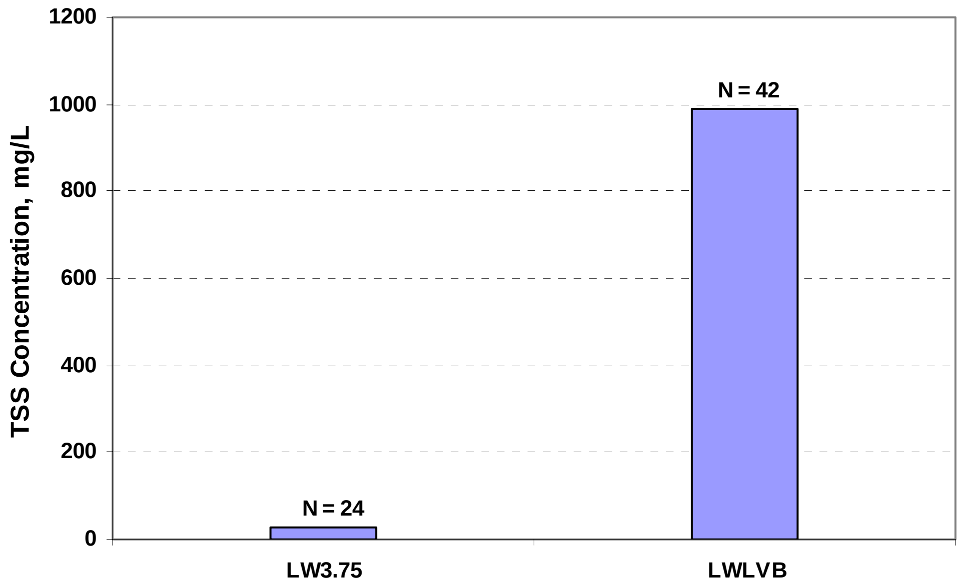

Figure 4: Average TSS concentrations at the Las Vegas Bay Delta (LWLVB) and Demonstration Weir (LW3.75)

3.2 Ammonia

As a chemically unstable species of nitrogen in aerated water, NH_3 concentrations from both sample locations were normally below the detection limit (<0.01 mg/L). The only exception during the sample period was the sampling event on October 15, 2001, when the NH_3 concentration was 0.57 mg N/L at LWLVB and 0.30 mg N/L at LW3.75, respectively (Table 2). No unusual changes in the Wash and in the Las Vegas Bay were noticed during the sampling; therefore, detected NH_3 from this sampling event might be due to contamination, either in the field or in the lab.

3.3 Nitrate

Unlike NH_3, NO_3, is a stable species in naturally aerated water. NO_3 was measured at the two sample locations on each sampling event. NO_3 concentrations were relatively consistent, not only for different sample dates at the sample locations, but also between the two sample locations. NO_3 concentrations ranged from 8.9 to 16 mg N/L with an average of 13.4 mg N/L at

LW3.75, and from 9.4 to 16 mg N/L with an average of 13.6 mg N/L at LWLVB (Table 1; Figure 5). The relative difference of average NO_3 concentrations between the two sample sites was less than 8%.

No dramatic increase or decrease in NO_3 concentrations was recorded from the sample site at LW3.75 to the sample site at LWLVB. This seems to indicate that the exposed delta played little to no appreciable role in changing NO_3 contributions to Lake Mead.

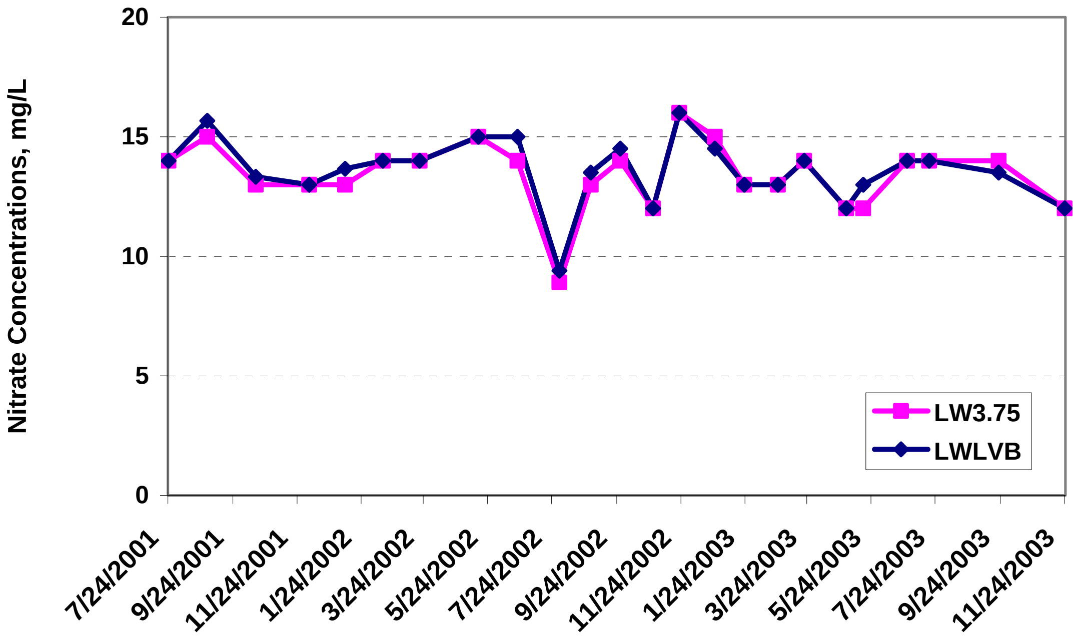

Figure 5: NO_3 concentrations from two sample sites during 2001–2003.

3.4 Orthophosphate

OP concentrations at the two sample sites varied from 0.01 to 0.27 mg/L. The magnitude of sample results mirrored each other throughout the sampling period; however, the OP concentration at LW3.75 was normally higher than those at LV/LBV by as much as 43% (Figure 6). OP concentrations in the Wash water decreased from LW3.75 to the end of the delta. As dissolved reactive phosphorus, OP would not last long in an aqueous environment. It can be readily consumed by abundant microorganisms and plants in the Wash and on the delta or dispersed into sediments on the delta.

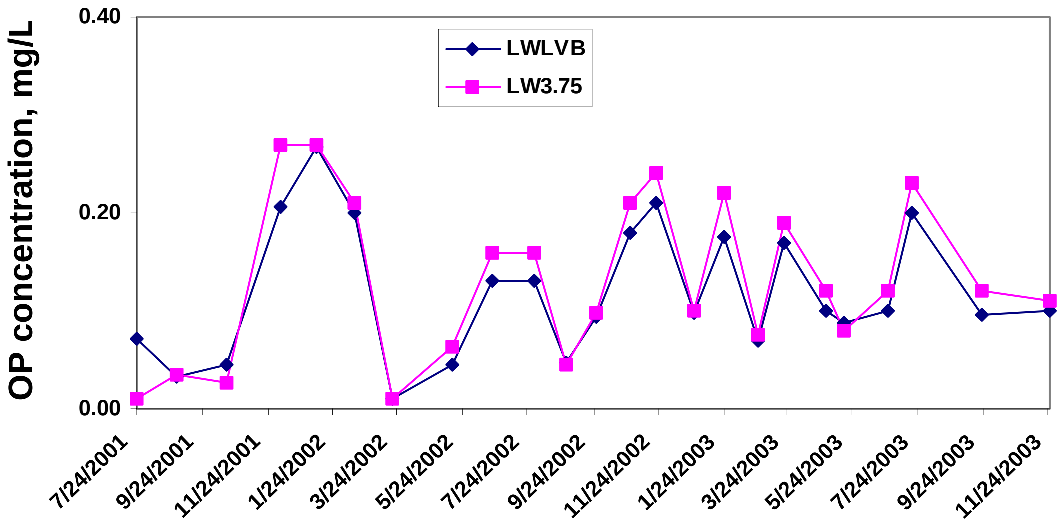

Figure 6: OP concentrations from two sample sites during 2001–2003.

In addition, OP concentrations fluctuated from month to month at both sample sites, generally higher in colder months (October to February) and lower in warmer months (March to September). These variations were mainly due to a reduction in phosphorus removal in three wastewater treatment facilities. More phosphorus, including OP, was discharged into the Wash during winter months because the permitted limit of phosphorus discharge to the Wash does not apply during the winter season. Also, less vegetation in winter results in lower phosphorus use in the Wash. Finally, inconsistency of sampling times and different discharging rates from the wastewater facilities to the Wash at different times of day could have contributed the fluctuations of OP concentrations from month to month.

OP into the Wash comes from two main sources: the effluent of three wastewater treatment plants and urban runoffs. It should be noted that soluble OP concentrations have been substantially reduced at most of the sampling sites in the Wash during the last several years due to year-round phosphorus removal by the three wastewater treatment facilities. Other processes may be also responsible for the reduction of OP to Lake Mead. First, the wetlands established behind erosion control structures completed within the period of this study in the Wash may have played a positive role in removing OP. Second, the reduction of soluble OP from LW3.75 to LWLVB may be due to the biological consumption of plants that have re-vegetated the Wash. This removal of OP between the two sample sites may be due to decreased erosion of the Wash by the above mentioned erosion control structures. Third, OP may be removed by percolation into the sediments as the Wash flows over the delta.

3.5 Total phosphate

TP concentrations varied from 0.06 to 0.87 mg/L at LW3.75 and from 0.14 to 1.37 mg/L at LWLVB (Figures 7 and 8). Generally, TP concentrations at LWLVB were much higher than those at LW3.75. Two exceptions were the sampling events of March 20, 2002, and November 24, 2003, when the Wash water was disturbed due to weir construction activities in areas upstream of the sampling locations (Figure 7).

TP concentrations, including soluble and insoluble phosphorus, are proportional to the concentrations of TSS in water (Figures 7 and 8). The Wash water flowing over the exposed delta in the Las Vegas Bay resuspends and transports fine sediments from previous deposits; therefore, TSS concentrations dramatically increased in the water samples collected at the delta terminus at the waters of Lake Mead. Higher TP concentrations at LWLVB were mainly due to the greater concentration of TSS in the water samples.

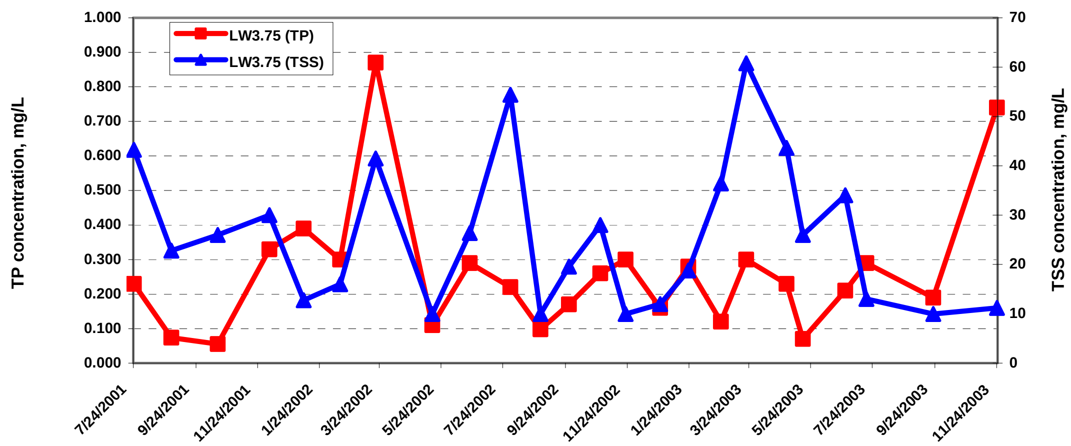

Figure 7: TP and TSS concentrations from LW3.75 during 2001–2003. Turbulent Wash water (spikes in the figure) was caused by construction activities in the Wash.

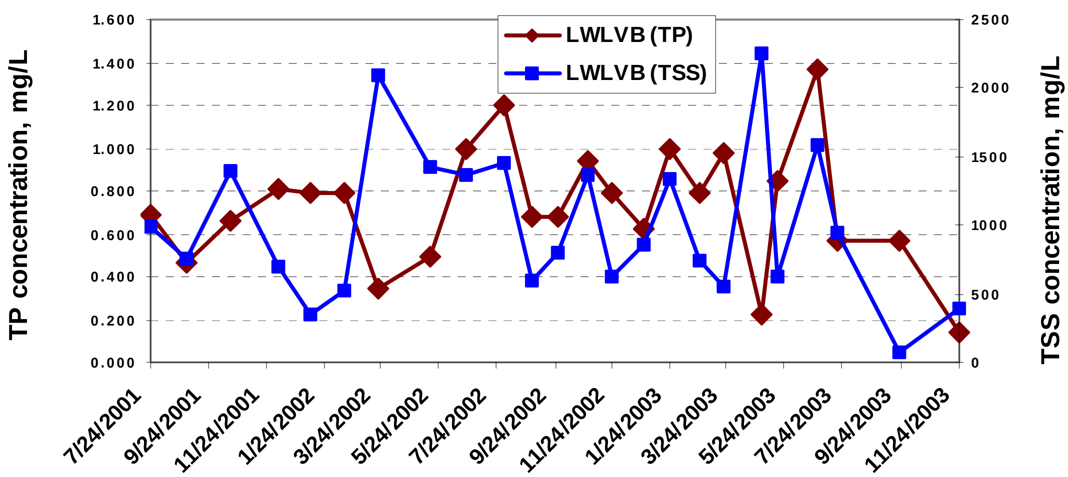

Figure 8: TP and TSS concentrations from LWLVB during 2001–2003.

3.6 Comparisons between LW3.75 and LWLVB

Average concentrations of TSS, NO_3, OP, and TP at LW3.75 and LWLVB, as well as daily mass loading rates of these parameters at each sample site and the relative difference of loading rates between LW3.75 and LWLVB, were calculated (Table 3).

Daily mass loading rates of TSS, NO_3, OP, and TP were computed using their average concentrations of the parameters, the average flow (255 cfs) of the Wash based on the U.S. Geological Survey stream gage records, and the following equation:

Mass Loading Rate (lbs/day)
= Concentration (mg/L) x Flow Rate (cfs) x 0.646317 x 8.34

In the equation, 0.646317 is the conversion factor for flow rate conversion [1 cfs = 0.646317 million gallons per day (MGD)]; and 8.34 is the constant used for daily mass loading rate (lbs/day) calculation when mg/L is used for concentration and MGD for flow rate.

From LW3.75 to LWLVB, TSS concentrations were greatly elevated due to the reworking of sediments over the delta by the Wash flow. Based on the mass loading calculations (Table 3), approximately 1,300,000 pounds (650 tons) of TSS, which resulted from the reworking of the previous sediments on the delta, are being carried and re-deposited daily into the Las Vegas Bay. Both TSS and bed loadings carried by the Wash flow resulted in the fast-paced migration of the Las Vegas Bay delta toward Lake Mead.

Corresponding to increasing TSS concentration, the average TP concentrations were elevated from 0.262 mg/L at LW3.75 to 0.726 mg/L at LWLVB. Consequently, a load of approximately 638 pounds of TP is mobilized from the delta sediments each day. Average NO_3 concentrations were slightly increased from LW3.75 to LWLVB, resulting in an increase of 239 pounds of NO_3 daily. Unlike TSS, TP, and NO_3, average OP concentrations were reduced by 0.013 mg/L from LW3.75 to LWLVB. Therefore approximately 18 pounds (~10%) of OP per day were consumed biologically and/or were removed from the Wash by the overflow of its waters over the sediments on the delta (Table 3).

	TSS (mg/L)	NO3 (mg/L)	OP (mg/L)	TP (mg/L)
Average Concentrations at LWLVB	989.2	13.59	0.119	0.726
Average Concentrations at LW3.75	25.7	13.41	0.132	0.262
Loading at LWLVB (lbs/day)	1359725	18674	164	998
Loading at LW3.75 (lbs/day)	35308	18436	182	360
Loading Difference (lbs/day)	1324417	239	-18	638

Table 3: Average TSS and nutrient concentrations from LWLVB and LW3.75 and loading differences (lbs/day) between LWLVB and LW3.75.

4.0 CONCLUSION

Water samples were collected monthly from two strategic locations, one in the Wash and another at the point where the Wash enters Lake Mead. The Wash follows a course that takes it over an extensive delta. The focus of this study was to compare the differences in TSS and nutrients at these two locations and to determine whether the sediments carried and re-deposited into Lake Mead are due to the reworking of previous sediments on the delta or come from the Wash, and how much nutrient (nitrogen and phosphorus) is mobilized from the delta sediments.

The delta is the result of the erosion of the Wash streambed and the retreat of Lake Mead due to a prolonged drought in the western United States. Based on the data collected during 2001–2003, TSS concentrations were dramatically increased from the location in the Wash to the point where the Wash enters Lake Mead due to the reworking of sediments over the exposed delta by the Wash flow. Approximately 650 tons (97%) of TSS, 640 pounds (64%) of TP, and 240 pounds (1%) of NO_3 were generated daily by this reworking process and discharged to Lake Mead. OP concentrations were slightly reduced (18 lbs/day or 10%) after the Wash water flowed over the delta.

This study indicates that the reworking of the Las Vegas Bay delta due to the lowering of Lake Mead stirs a large amount of TSS to Las Vegas Bay. The reworking process by the Wash flow over the delta is an important mechanism to carry and redeposit existing sediments to Lake Mead to form an ever-larger delta in the Las Vegas Bay. The process will continue with lowering lake elevation. However, as the drought continues the reworking and loading rates of sediment to the lake will be reduced due to the lowering of the gradient of the delta and the decrease in the amount of fine-grained sediments available in the flow over the delta. The reworking of previous sediments from the delta has also contributed to the amount of TP entering into the lake. However, this process played a limited role in adding or reducing NO_3 and OP to Lake Mead.