The Lake Mead Algal Bloom of 2001

A significant bloom of the green alga *Pyramiclamys disecta* occurred in Boulder Basin beginning in February and ending in late July. *Pyramiclamys disecta* is always present in Lake Mead and is commonly found in lakes and reservoirs all over the world. The only difference is that this year it had a sensational population boom in Boulder Basin. This bloom emanated from Las Vegas Bay, growing in biomass and extent until it reached the upper end of the narrows of Boulder Canyon in late April. It maintained its presence and vigor until early June when it began to very slowly die. Like other plant life, green algae are known to, at times, hang around and die back slowly. Other forms of algae such as blue-green species (which are really more closely related to bacteria than algae), diatoms and dinoflagellates are known to grow and die very quickly.

This particular bloom was extremely large when one puts it into perspective of algae growth in lakes and reservoirs of North America. There were relatively minor blooms in the Overton and Colorado River arms of Lake Mead, but they were neither near the magnitude nor extent of that which occurred in Boulder Basin. Those minor blooms are normal springtime events at inlets to reservoirs in the Colorado River system. This springtime phenomenon is best seen on the Flaming Gorge Reservoir, Utah-Wyoming. However, no significant algae bloom occurred in any of the other Colorado River reservoirs such as Lakes Powell, Mojave, and Havasu.

Limnologists agree that chloropyll *a* concentrations (a measure of the algae biomass) below 3 mg/m3 are low. Values between 5 and 20 mg/m3 are moderate and indicative of a healthy productive body of water. Those between 20 and 40 mg/m3 are indicative of a lake or reservoir that is too productive and not ecologically healthy. Finally, lakes and reservoirs with chlorophyll *a* concentrations over 40 mg/m3 are mildly to highly eutrophic and ecologically out of balance. Values measured during the algae bloom of 2001 were at times greater than 1,000 mg/m3. These higher values were from the narrows of Boulder Basin. Values from surface samples in other areas of Boulder Basin were consistently greater than 100 mg/m3.

The extent of the bloom was a mystery to scientists who had intensively studied the lake for more than a decade. The average chlorophyll concentration for Boulder Basin for the past 12 years is less than 5 mg/m3 with a statistical standard deviation of about 2 mg/m3. In addition, the lowest annual chlorophyll concentration for Boulder Basin was measured for year 2000. The 2001 event was not scientifically predictable either in occurrence or in its spatial or temporal magnitude.

So what caused this event to occur in 2001? Obviously something was different this year. Some event or events in 2001 were different than any during at least the last 12 years. The following are bullets of each item that has been identified by the Lake Mead Water Quality Forum Algae Task Force as things that were different this year. Comments follow each item.

- **Lower reservoir levels.** This is a key factor. We know from the 1993-95 period that the total dissolved solids in basin are higher when the reservoir is lowered. The significance of this is that everything else in the water also concentrates proportionately. Even more significant is the fact that during these periods there is much lower interflow flushing from the Colorado River within the Basin. Examination of specific conductance profile data from years of low versus those of higher inflow reveals the large influence of the Colorado River inflow on the entire basin and even throughout Las Vegas Bay. This interflow can be easily measured and as it completely flushes the basin in years of average inflow. This lack of dilution and mixing results in several limnological changes including an accumulation of nutrients that sustains algal growth and perseverance.

  The lowering reservoir levels resulted in the large exposed delta area. The wide shallow flow over the delta resulted in daytime warming of the water thus decreasing its density. The less dense water caused an overflow into the wash. The overflow, which is well within the euphotic zone, contained sufficient nitrogen and phosphorus to produce a substantial biomass of algae. Additionally, the increased contact of flow

from the Wash over and through an ever-expanding delta meant more contact with sediments that likely contain high nutrient concentrations.

Within the thermocline another impact of lower reservoir levels was seen when the perchlorate concentrations at the intake were elevated last November and December. In other years (we have only measured perchlorate during near average runoff years) there was adequate to more-than-adequate flushing from the Colorado River interflow to maintain levels of perchlorate at non-detectable to below 18 µg/L. Normally, as the thermocline sinks during destratification, the interflow from the Colorado River and Wash comingle (the thermocline includes the Las Vegas Wash interflow in the upper zone and the Colorado interflow below it) before the layer reaches the intake elevation. While the Colorado interflow decrease significantly when reservoir levels drop, the Wash interflow remain nearly stable.

- **Springtime weather anomaly.** The precipitation this spring was at or above normal. However, the numerous rainfall events in February were steady and penetrating. Non-point flows in the watershed essentially flushed the watershed. This flushing of the urban areas likely increased the nutrient load of the Wash. Although the rain events might only be equivalent to a few days of nutrient loading from the point source to the Wash, the timing of these events had some significance to the algal bloom.
- **Load of nutrients during winter months.** This is a key factor. The normal loading of nutrients by the Wash is always enough to produce an algae bloom in Boulder Basin. 20 µg/L of ortho-phosphate is more than adequate to cause serious blooms to at least Las Vegas Bay. In other years, this nutrient inflow was almost exclusively an underflow and/or an interflow. The nutrients were then well out of the eupohtic zone, or where the light is sufficient to grow algae. Since flushing of the basin by the Colorado River was minimized as described above, accumulation of this nutrient load was enhanced. Nutrients were available where light could promote algae growth.
- **Construction activities in and around LV Wash (City of Las Vegas, grade control structures, in and around Lake Las Vegas).** Construction within the lower watershed over the past 12 months have likely exposed sediments that contained

nutrients that were flushed into the Las Vegas Wash flow. The City of Las Vegas reported that some greater than normal phosphorus loading to their effluent due to construction activities at the water treatment facility. Lake Las Vegas continues to develop more land thus exposing more soil. Additional development of golf courses and common areas also occurred. Both of the above activities could have contributed additional loading of nutrients to Las Vegas Wash. Lake Las Vegas also held water for about 8 eight hours at least several days per week since October 2000 in order to allow repair and construction activities in and around the Las Vegas Wash channel. Upon release of the flow, this sudden surge of water into Las Vegas Bay may have influenced the limnology by affecting the temperature of the water and increasing the movement of sediment.

- **Formation of the Delta.** Density of the water decreases as temperature warms. The wide shallow flow over the nearly mile-long delta is heated during the day. Data collected from the Wash water quality study shows that water temperature increases up to 5 °C from the middle portions of the Wash to the Bay. Water enters the Bay less dense or lighter than the water it encounters. The flow then is an overflow.

Probable Scenario

There is always enough phosphorus and nitrogen in the Las Vegas Wash inflow to promote algae growth. However, the Wash flow usually forms an underflow in winter and an interflow in summer. Nutrients found in an interflow and an underflow makes them unavailable for algae growth. Although various small events of overflow have occurred in the past, this year there was a continual overflow of warm Wash over the exposed delta for a four-month period. Examination of limnological profile and water quality data from Boulder Basin shows this overflow quite clearly. This happened due to the fact that the density of water entering the Bay was less than in previous years. Add to this the fact that the discharge standards are relaxed in winter adding a larger phosphorus and nitrogen load into the basin, and there were measurable amounts of these nutrients added during the late winter storms.

Finally and significantly, the impact of greatly decreased flushing from the Colorado River and lower reservoir levels led to the accumulation of nutrients on the surface of the basin so that light can easily reach the nutrients for algae growth. The continued loading and accumulation of nutrients to the water surface with wind pushing them into all portions of the basin (especially notable in the coves and narrow portions of the reservoir) constantly fueled this algae bloom for over three months.

The algae bloom began to disappear in late July because the Wash was an interflow below11 meters, or below the euphotic zone. Once the nutrient supply was cut off from the layer that light could penetrate the algal bloom subsided. This happened as thermal stratification strengthened. The surface layer or epilimnion continued to warm due to solar heating, while the lower layer or hypolimnion, did not appreciably warm. Therefore the thermal pattern of the reservoir has become more normalized.

What will happen the rest of this year? There is a continuing algal bloom that is most noticeable in the inner bay that is seen during summer months. The Wash flow is once again mostly found as an interflow carrying nutrients below the euphotic zone. We should expect this to continue resulting in improved water clarity. There is some chance that a mild blue-green algae bloom will succeed the current diatom/dinoflagellate bloom of the inner bay. *Microcystis flos-aqua*, the most common species of blue green algae in Las Vegas Bay is already present. In past years it has formed blooms as the water temperature approached 28 to 30 degrees C. This is the usual case much of August. Blue-green algae growth in the inner bay should not be noticeable to the casual observer since it will likely not form in a thick layer, as did the species of green algae. The dissolved oxygen concentration in the thermocline and hypolimnion is much lower than normal. This is especially notable in Las Vegas Bay. The lower portion of the hypolimnion in Las Vegas Bay (from the delta to a point just beyond Blackbird Point) is at or near being anoxic due to the dead and dying algae biomass from earlier in the year. This zone is not available to fish and some elements and compounds found in the sediments may become soluble. We do not know enough about this in Lake Mead to

make any judgments as to degree or impacts. The anoxic state of the Las Vegas Bay hypolimnion has occurred in the past.

The possibility of higher concentrations of perchlorate reaching the intake, and the reasons for this, are previously discussed.

What will happen next year? It is easy to look at the available data from Lake Mead and make the judgement that the algae bloom will not happen next year. However, a closer look at the data, which includes the last period of time when the reservoir level was as low as it presently is (1993-95), forces one to be more cautious in making any prediction. Given a similar set of circumstances next late winter and early spring, the algae bloom could again occur. The data needs to be continually consulted to be able to have any forewarning.

Current Studies.

STREAM. This ongoing investigation includes weekly monitoring of five key sampling sites in Boulder Basin. Also included are monthly to twice monthly profiles from 32 additional sampling locations. Data from this program are defining the limnological conditions of Las Vegas Bay and Boulder Basin on a seasonal basis. This is an outstanding set of data that allows us to delineate the factors that both contributed to and were impacted by the 2001 algae bloom.

Las Vegas Wash Water Quality Investigations. These monthly sampling events are providing us information on the Las Vegas Wash that will help us understand cause and effect. Learning the nutrient concentration of the Wash along with the change in water temperature downstream are providing us answers to what was different this year to cause the algae bloom. In-situ water quality monitoring instrumentation has been installed at several locations along the Wash to collect real-time data on a continuous basis.

Urban Tributaries Water Quality Investigations. The amount of non-point contribution to the Wash has not been quantified. Collection of both water quality and stream flow data will provide us the information needed to calculate mass balance of nutrient input from various sources. We can then sort out the non-point portion that

enters Las Vegas Bay. Flow measurements are collected monthly and water quality data is collected quarterly.

Nutrient and Heavy Metal Accumulation in the Las Vegas Wash Delta Sediments. The sediments are flushed by flows from Las Vegas Wash, a yet to be quantified contribution of nutrients and heavy metals occurs to Las Vegas Bay. Sediment will be sampled from nine locations in the delta. At each site, replicate samples will be collected from the 0 to 6 inch and 6 to 12 inch depths. These will then be analyzed for nitrogen and phosphorus nutrients, heavy metals, and bacteria. This will give us a snapshot of the delta's role and influence on the limnology of Las Vegas Bay. Samples will be collected August 18, 2001

Committees that are looking into the challenges ahead.

Interagency Committee. This standing committee meets monthly with all the agencies that sample the wash and lake. This allows continual communication amongst those who collect field samples and process them in the laboratory.

Algae Task Force. This is a special committee organized by the Forum to look at all aspects of the algae bloom and to recommend action items to the parent Forum. Meetings have been every two to three weeks.

Sediment Task Force. This is another special work group organized by the Forum. It has met once (July 26, 2001) in order to look into the occurrence and possible remedies to the rapid movement of sediment into the inner Las Vegas Bay. Its function will likely be folded into the Algae Committee.

Lake Mead Water Quality Forum. This is the parent organization of the above-mentioned working groups. The Forum includes all the state, federal, and local, and private entities plus citizen representatives. Monthly to bi-monthly meetings are held to discuss agenda items and to hear and make recommendations.

Environmental Research Committee of the Las Vegas Wash Coordination Committee. This committee is playing only a limited role in the activities of the algae bloom. This committee meets every other month to discuss research and monitoring activities directly and indirectly related to the Las Vegas Wash.

Alternate Discharge Committee. This group is now concentrated in the efforts of the Clean Water Coalition and its contractor Black and Veech. Activities include finding solutions to discharging down Las Vegas Wash and into Las Vegas Bay. Information that is collected by the sampling programs listed above, and results of discussions held by other committees listed above, play a vital role in the path this group will take in planning near and long-term action items.