

# L-1 Surface water monitoring for fecal indicator bacteria in high-use sites of the Lake Mead National Recreation Area

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## Abstract

The Lake Mead National Recreation Area incorporates 1.5 million acres, including Lake Mead and Lake Mohave. The abundance of recreational activities on Lakes Mead and Mohave can impact the contaminant levels in the water, potentially affecting the health of individuals in contact with the water. The purpose of this study was to review and synthesize information obtained for projects conducted by partner agencies from the Water 2025 Conservation Initiatives, specifically bacterial concentration in high-use areas. Surface water samples were collected between May and September, at 9 high-use sites from 2003 to 2007. Culture analysis was performed to determine the concentration of fecal coliforms, enterococci, fecal streptococci, and *Escherichia coli*. Test results of 324 water samples analyzed for *E. coli* showed only one instance of a concentration higher than the acceptable limit. Enterococci concentrations above the acceptable limit were found in 13% of the 165 samples. In addition, 9% of 317 samples exceeded the acceptable limit for fecal streptococci, and fecal coliforms were present in concentrations above the acceptable limit in 3% of the 324 samples analyzed. Throughout the five-year study, three sites, Middle Point Cove, Boxcar Cove, and 6-Mile Cove, were identified as those with the highest frequency of unacceptable levels of the indicator organisms monitored. The results of this study will be used to address the technical soundness of monitoring at the Lake Mead National Recreation Area, and will identify management recommendations to the National Park Service.

## Introduction

Created when the Hoover Dam was constructed on the Colorado River, the Lake Mead National Recreation Area includes Lake Mead and Lake Mohave. Lake Mead, the larger of the two lakes, attracts nearly eight million visitors annually, and supplies water and electricity to Nevada, California, and Arizona. The abundance of activities in the area can have an impact on the levels of lake contaminants, which in turn can affect the health of individuals who come in contact with the water. Stormwater runoff, fecal wastes from pleasure craft, and domestic and wild animal manure can also introduce microorganisms to the lake water. Microbiological monitoring of surface waters is of interest to public health officials, because elevated levels of bacteria are often associated with high levels of human pathogenic microorganisms. Due to the sustained drought and the growth of the Las Vegas Valley, there is increased demand for water and concerns over the conservation of this vital resource. These issues make it imperative to monitor the water quality of Lake Mead and Lake Mohave on a continual basis.

## Objectives

- To monitor the distribution and concentration of fecal indicator bacteria in high-use areas of Lakes Mead and Mohave over the summers of 2003 to 2007.
- To determine physical data, including water and air temperature, numbers of boats, visitors, and vehicles present during sample collection.

## Materials and Methods

### Study Sites (Figure 1)

- Nine high-use areas for boaters and/or beach bathers
- Lake Mead locations
  - Boulder Beach
  - Hemenway
  - Sandy Cove
  - James Bay
  - Middle Point Cove
  - Tea Kettle Cove
  - Boxcar Cove
- Lake Mohave locations
  - 6-Mile Cove
  - Telephone Cove/Katherine Cove swim beach

### Sampling Time and Frequency

- Samples collected in high-use months, mid-May to mid-September
- Twice per month and following a holiday
- 2003 to 2007 (in 2003, only Lake Mead was sampled)

### Sample Collection

- Surface water sampling
  - 20-30 ft from shoreline
  - 0.5 m below the surface
  - fill sterile 500 ml plastic sample bottles
  - cap, label, and transport in ice to laboratory within 6 hrs
- Physical data
  - water temperature
  - air temperature
  - numbers of boats, visitors, and vehicles

### Microbiological Analysis

- Microbiology Laboratory, Southern Nevada Water Authority
- 2003 - 2005 samples analyzed for *Escherichia coli*, fecal coliforms, and fecal streptococci
- 2006 - 2007, enterococci also monitored
- Standard membrane filtration techniques
- Data calculated as colony forming units (CFU) per 100 ml of lake water
- Lower detection limit typically ranged between <1 and <10 CFU/100 ml
- Enterococci culturable counts
  - membrane-Enterococcus Indoxyl-B-D-Glucoside agar
  - U.S. EPA Method 1600
  - Recommended freshwater quality criteria limit 62 CFU/100 ml
- E. coli* culturable counts
  - modified membrane-thermotolerant *Escherichia coli* agar
  - U.S. EPA Method 1603
  - Recommended freshwater quality limit 235 CFU/100 ml
- Fecal coliforms culturable counts
  - enriched lactose medium, M-FC
  - APHA Standard Method 9222D
  - Recommended freshwater quality limit 200 CFU/100 ml
- Fecal streptococci culturable counts
  - mE agar for enterococci
  - APHA Standard Method 9230C
  - Recommended freshwater quality limit 200 CFU/100 ml

## Results

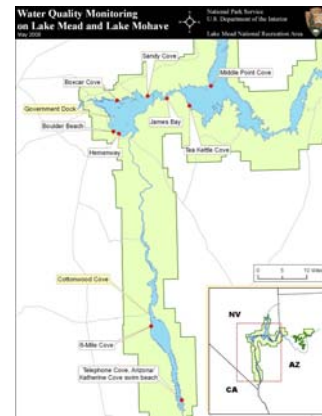


Figure 1. Map illustrating the locations of sampling sites in Lake Mead and Lake Mohave.

- Every site monitored between 2003 and 2007 had incidents of exceedance of recommended limits for one or more indicator bacteria (Table 1).
- Middle Point Cove (Fig. 2), Boxcar Cove (Fig. 3), and 6-Mile Cove (Fig. 4) had the highest frequency of unacceptable levels of the indicator microorganisms monitored. The data are presented as the concentration of target microorganisms expressed as colony forming units (CFU) per 100 ml of lake water for each date of sample collection. Because the median concentration detected for each target microorganism varied widely, the y-axis scales were adjusted accordingly.
- There were fourteen instances where more than one site had bacterial concentrations above the recommended criteria on the same date. Six of those instances were directly following a long holiday weekend.
- A water quality exceedance summary for the sites monitored is shown in Table 2. In 2003, there was one case where Boulder Beach, James Bay, Middle Point Cove, and Tea Kettle Cove had above-limit concentrations over the Labor Day holiday. Three instances occurred in 2005, with 2 or 3 sites involved; and 6 additional events were noted in 2006 and 2007. The instance where the highest number of sites was above the recommended bacterial limits occurred in 2006, and involved 6 sites (Table 2).
- The maximum number of visitors observed at any given location ranged between 38 and 65. The maximum numbers of boats and vehicles observed at any given location were 16 and 24, respectively.
- Water temperature ranged between 19.1 and 32.1°C. The minimum air temperature recorded was 21.2°C, and the maximum was 47.8°C.

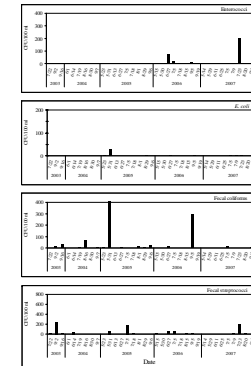


Figure 2. Concentrations of indicator bacteria in Middle Point Cove.

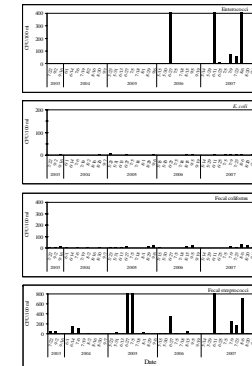


Figure 3. Concentrations of indicator bacteria in Boxcar Cove.

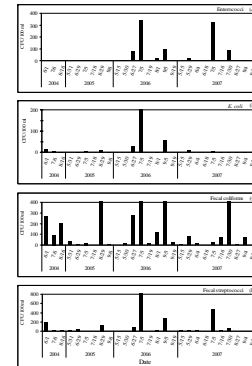


Figure 4. Concentrations of indicator bacteria in 6-Mile Cove.

Table 1. Number of events with exceedance of recommended limits observed per indicator bacteria monitored at high-use sites in Lakes Mead and Mohave.

Location	Number of exceedance events per indicator bacteria monitored			
	Enterococci	<i>E. coli</i>	Fecal coliforms	Fecal streptococci
Boulder Beach	2	0	0	5
Hemenway	1	0	0	1
Sandy Cove	2	0	0	1
James Bay	1	0	0	3
Middle Pt. Cove	2	0	2	2
Tea Kettle Cove	0	0	0	4
Boxcar Cove	5	0	0	7
6-Mile Cove	5	1	7	3
Tel/Katherine Cove	3	0	1	2

Table 2. Water quality exceedance summary. The "X" indicates that one or more of the indicator bacteria exceeded the recommended limits for freshwater recreational waters at multiple sites.

Location	Date									
	2003		2005		2006		2007			
	9/2	6/27	7/5	7/18	6/27	7/5	9/5	7/23	7/30	8/6
Boulder Beach	X			X	X					X
Hemenway				X	X					
Sandy Cove		X			X	X				
James Bay	X									
Middle Pt. Cove	X		X		X		X	X		
Tea Kettle Cove	X	X								
Boxcar Cove		X	X		X	X		X		
6-Mile Cove					X	X	X	X	X	X
Tel/Katherine Cove								X	X	
Number of sites above exceedance	4	2	3	2	6	2	2	2	2	2

## Conclusions

- Monitoring of surface waters in this study demonstrated occasions where fecal indicator bacteria were above the recommended limit. Because the presence of indicator bacteria in freshwater suggests that pathogenic microorganisms might also be present, swimming in these waters may pose a health risk. Monitoring should continue to include high-use areas during peak months.
- Recent research has demonstrated that significantly higher levels of indicator bacteria can be found near sediments than in surface waters, and that these bacteria can be reintroduced to the water column. For recreational waters, EPA recommends *E. coli* and enterococci as the preferred indicators of health risk from water contact. Because the choice of indicator bacteria monitored and the sampling depth can affect the perception of microbial water quality of a lake, it is recommended that future work includes monitoring of *E. coli* and enterococci at multiple depths, and implementation of faster, more sensitive molecular methods for water sample analysis.
- It is recommended that an education campaign be utilized in the Lake Mead National Recreation Area, to instruct the public on the hazards of introduction of fecal waste into the lake and shoreline.
- Effective water quality management requires familiarity with the body of water under investigation. Knowledge gained by the correct and timely application of analytical techniques, allows for early detection of abnormal conditions, and can be used to improve management and protect public health.

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