WATER RESOURCES PROGRAM
SURFACE WATER QUALITY
MONITORING & EVALUATION
1992
FIVE HIGH VISITOR USE AREAS

Project Report: NPS/YOSE/RM-12/92

US National Park Service
Resources Management Division
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I. MANAGEMENT OBJECTIVES:

A. PURPOSE:

The primary objectives of this water quality monitoring and evaluation program are: 1) to protect the health and safety of the Yosemite National Park's visitors and staff by assessing the potential for human exposure to water borne pathogens, 2) to utilize the gained knowledge to manage, preserve and protect the integrity of Yosemite's natural resources, and 3) to provide the park's management with a clearer understanding of how current and future visitor distribution and use throughout Yosemite may effect water resources in the future. The information from this monitoring and evaluation program will be important in assessing potential bacterial exposure during not only the recreational use of water but during domestic use as well.

The park's management has become increasingly aware that with the continuing increase in visitation comes the potential increase for water quality impacts. During the past few years a greater emphasis has been placed on water quality protection. Throughout the Tuolumne Meadows region, specifically, water quality protection efforts have been substantial over the past few years. The now established water quality protection program is the result of two primary factors. First, the region includes significant portions of the upper Tuolumne River watershed, an important domestic water supply source for the City of San Francisco. Secondly, the continues to be a increasingly popular recreational destination.

The results of this monitoring and evaluation work will allow program managers to assess the effectiveness of their previous efforts and actions and possibly provide additional correlations about the effects of visitor use. Therefore, the monitoring and evaluation program will allow for visitor and resource management decisions that will best preserve and protect water quality throughout Yosemite.

B. BACKGROUND:

Within Yosemite, water quality monitoring and evaluation programs have been conducted by a variety of organizations and individuals. This is evident in the varied collection of water resource information and the differing approaches taken in evaluating water quality. Regardless of the diverse approaches taken in previous water studies, the usefulness of all historical monitoring and evaluation programs is indispensable in providing essential baseline reference information.

In order to examine and correlate past information and data, the National Park Service (NPS), Water Resources Division has recently developed a water quality data management system. The use of this data management system will allow for easy correlations of 1992 conditions with earlier monitoring and evaluation results, and hopefully will help clarify the changes occurring in Yosemite's natural aquatic systems. By using this strategy, we hope to standardize the methodologies and approaches used to evaluate water quality conditions and impacts, thereby increasing the usefulness of the information gained and reducing future monitoring and evaluation costs.

II. PROGRAM DESCRIPTION:

During the summer of 1992, to complement current water quality protection efforts, a pilot program was initiated to monitor and evaluate the water quality of the upper Tuolumne River watershed above Hetch Hetchy Reservoir. Water quality was evaluated in an attempt to determine what effects, if any, current and past levels of visitor use in the watershed have had on water resources. The 1992 monitoring and evaluation program was completed as a cooperative effort by the Mather District and Wilderness Management Units of the Visitor Protection Division, the Physical Science Unit of the Resources Management Division and the Utilities Branch of the Maintenance Division.

Evaluation of water quality information has not been previously included as a part of NPS management efforts in the in the Tuolumne Meadows region. However, others have completed water quality studies investigating similar water quality indicators. The U.S. Geological Survey[1] (USGS) and Joe Holmes[2] have both completed water quality investigations for similar parameters. Correlations were made with these studies while developing the scope of the monitoring and evaluation program. When possible, the monitoring network, sampling design, and water quality parameters selected were common to the USGS and Holmes studies.

The cost of the monitoring and evaluation program has been a very important factor in determining the scope and extent of this pilot program. To keep program costs down and provide useful and representative water resource information, while maintaining the necessary quality control/quality assurance, a small number of sample sites and parameters were selected. The sites, however, represent the spectrum of visitor use patterns and impacts, and, the sample parameters focus on evaluating the human health and safety risks and exposure potentials to pathogenic bacteria.

The Monitoring Network includes six sampling sites (all lakes). Each site within the monitoring network is described below. To most effectively determine if human activities have impacted water quality, the Sampling Design included, among others, the

parameters fecal coliform (FC) and fecal streptococci (FS). Details of the Sampling Design are also outlined below.

Previous observations made of FC/FS ratios have suggested that it can be shown whether fecal contamination has derived from human or animal sources.[3] A relatively low ratio points to contamination from animal sources. A ratio greater than 4.1 is said to have derived from human sources. This ratio has been used to identify whether fecal contamination has come from humans or animals. It should be noted, however, that this ratio is questionable by some sources, and has not yet been verified as absolute.[4]

A. MONITORING NETWORK:

The monitoring network was developed jointly by the Mather District Unit, Wilderness Management Unit and the Resources Management Division. Sites were selected to be a part of the network based upon 1) existence of any previous monitoring results, 2) geographic similarity, and 3) visitor use and impact distribution. Except for Tenaya Lake (roadside example) and Upper Granite Lake (control example), all monitoring locations are common to previous studies performed in Yosemite. All lakes are in the same general region and are geographically similar or have similar hydrologic features. Finally, each of the lakes except Tenaya and Upper Granite have similar day and or overnight use patterns.

Dog and Elizabeth Lakes are both popular day-use destinations, but are closed to camping. Lower Cathedral and Lower Young Lakes are also popular day-use destinations, but are also popular for overnight trips since camping is allowed there. Tenaya Lake receives very heavy visitor day-use (estimated to be over a thousand people per day during the summer) because of it's proximity to the Tioga Road. However, no camping has been allowed at Tenaya Lake since the campground was closed in 1991. Upper Granite Lake was chosen as a control lake, because it receives very little visitor use and is closed to camping.

The Mather District Unit collected samples at Dog and Elizabeth Lakes. The Wilderness Management Unit collected samples at Lower Cathedral and Lower Young Lakes. The Resource Management Division collected samples at Tenaya and Upper Granite Lakes. All the lakes, with the exception of Tenaya and Lower Cathedral, are within the upper Tuolumne River watershed. Tenaya and Lower Cathedral Lakes are a part of the Merced River drainage. Coordination of sample pick-up and delivery to the laboratory was performed by Resources Management.

B. SAMPLING DESIGN:

An attempt was made to maintain consistency with previous water

quality monitoring programs conducted within Yosemite. Sampling was conducted on a monthly basis for three consecutive months during the 1992 summer season. The sample collection dates were July 20, August 17, and September 14, 1992.

The collection of water samples was intended to be analogous to the removal of drinking water by users. Samples were withdrawn carefully and consistently to avoid any contamination of the sample by the hand of the worker, the outside of the bottle, or by the material floating on lake or stream surface.

Prior to collecting water samples, the sample bottles were labeled with the sampling location, date and time the sample was collected, and the temperature and pH of the water at the time of sampling. The sampling bottle was then rinsed four to six times with the water to be sampled. Although the sampling bottles were sterilized before use, this step ensured the removal of any traces of contamination from the sample containers. Care was taken to not disturb bottom sediments where the sample was taken.

When rinsing or sampling, the bottle was submerged by holding the bottom of the bottle and aiming the mouth toward the current below the surface in a stream, or by moving the bottle in a sweeping arc below the surface in a lake. In lakes particularly, care was taken to make sure that any lake water which may have touched the hand or the outside of the bottle was not included in the final sample. Some of the sample thus taken was poured off so that the bottle was only about 80 percent full and could be easily mixed by shaking later in the laboratory.

C. SAMPLE POINT DESCRIPTION:

For each lake, water samples were collected at three locations, which included the inlet, midpoint, and outlet. All samples were collected from the shore at the following locations:

1. Dog Lake

1A: Inlet to Dog Lake, at east end of lake, 9 meters upstream from lake shore. If inlet to Dog Lake has dried up, sample should be collected from alternate location 1B.

1B: In Dog Lake, at east end, immediately north of inlet in #1A; used only when inlet to lake has dried up.

2: In Dog Lake, on south shore, midway from inlet to outlet. Approximately 15 meters west of a large rock in the water, where a small peninsula extends into the lake.

3A: Outlet to Dog Lake, at west end of lake, 1.5 m downstream from lake shore. If outlet to Dog Lake has dried up, sample should be collected from alternate location 3B.

3B: In Dog Lake at the outlet area, from logs protruding into lake at outlet - deepest water without getting feet wet; used only when outlet has dried up.

2. Elizabeth Lake

1: Inlet to Elizabeth Lake, at southeast corner of lake, from a 1.5 meter angular rock at inlet.

2: In Elizabeth Lake, at midpoint on north shore, where land protrudes south into lake and directly opposite (north of) peninsula on south side.

3: Outlet to Elizabeth Lake, 10 meters north of outlet on east-northeast shore near two large boulders approximately 20 - 30 meters offshore.

3. Lower Cathedral Lake

1: Inlet to Lower Cathedral Lake, at northeast end of lake, below a 9 m pool where the trail crosses the inlet.

2: In Lower Cathedral Lake, at a small sandy beach at the approximate midpoint on the north shore, 80 m from rocks near inlet and 100 m from the narrows towards outlet, and 30 m east of a fallen tree pointing into the lake.

3: Outlet to Lower Cathedral Lake, at west end of lake, 9 m downstream of lake surface, 2 m upstream of a small waterfall.

4. Lower Young Lake

1: Inlet to Lower Young Lake, at the east end of lake, 5 m from lake shore, on the south fork, near the large boulders on the southwest side of the stream channel.

2: In Lower Young Lake, near the west end of the north shore, just east of meadow area where trail from Tuolumne arrives at the lake, by 2.5 x 3.5 x 1 m boulder in trees.

3: Outlet to Lower Young Lake, at the north end of lake, approximately 30 m north of lake, and 5 m below log-free lake water, on east side of outlet.

5. Tenaya Lake

1A: Inlet to Tenaya Lake, at east end of lake (Tenaya Creek),

approximately 5 m from lake shore. If inlet (Tenaya Creek) to Tenaya Lake has dried up, sample should be collected from alternate location 1B.

1B: In Tenaya Lake, at east end, immediately north of Tenaya Creek. Used only when Tenaya Creek has dried up.

2: In Tenaya Lake, on north shore near Murphy Creek, approximately 5 m east of the Tenaya Lake boat ramp.

3: Outlet to Tenaya Lake, at southwest end of lake, approximately 10 m upstream from where trail to Sunrise Lakes crosses Tenaya Creek.

6. Upper Granite Lake (control)

1: There are no obvious inlets to Upper Granite Lake. Sampling point is from a small grassy area on the north-northwestern portion of lake.

2: On eastern shore, from a large flat rock that extends into water approximately midway between north shore and outlet, approximately 50 m south of trees on northeast shore.

3: Outlet of Upper Granite Lake, at south end, approximately 2 m west of rock and log dam.

D. ANALYTICAL PROCEDURES:

Analyses for water temperature and pH were conducted in the field at the time of sample collection. Temperature was taken using a partial immersion thermometer. The pH was determined by using Hydrion pH Paper of various ranges. Tests for the presence of fecal coliform (FC) and fecal streptococcus (FS) were conducted after samples were transported to the NPS - El Portal, Waste Water Treatment Plant water quality laboratory.

Standard laboratory methods were used for analyses of FC and FS. Briefly, the fecal coliform test (using EC medium) differentiates between coliform of fecal origin (intestines of warm-blooded animals) and coliform from other sources. This test is applicable to investigations of drinking water, stream pollution, raw water sources, waste water treatment systems, bathing waters, and general water quality monitoring.[4] Testing for FS was conducted in order to develop a FC to FS ratio and provide further information about the source of bacterial contamination. However, it should be noted again that this ratio is considered questionable by some sources, and has not yet been verified as

absolute.

The water samples were delivered to the laboratory and analyzed within the allowable 6 hour time limit. The Most Probable Number (MPN) procedure was used to evaluate the extent of FC and FS bacteria in the sample water. The MPN procedure is outlined in Standard Methods For the Examination of Water and Waste Water, 18th ed. and is summarized below.

1. Fecal Coliform Test

The Most Probable Number (MPN) method for the FC test consists of a presumptive phase and a confirmed phase.

For the presumptive phase of the FC test, the culture media EC medium was used. The EC medium was dispensed into fermentation tubes which each contained a small inverted vial. The tubes were then covered with metal caps and sterilized in an autoclave.

After the fermentation tubes with EC medium were sterilized, the tubes were inoculated with the sample water. For each water sample collected, three different dilutions of sample water were used in nine fermentation tubes. Three tubes received 10 ml of sample water, three tubes received 1 ml of sample water, and three tubes received 0.1 ml of sample water. A sterile pipette was used to inoculate the fermentation tubes with the three different dilutions of sample water.

Once the transfers were made, the fermentation tubes were incubated at 35° C. for 48 hours. The tubes were checked after 24 hours, and again at 48 hours for any positive growth of bacteria. Positive growth is any amount of gas trapped inside the inverted vile inside the fermentation tube. Any fermentation tubes showing positive growth after the 24 or 48 hour incubation were transferred to the confirmed phase of the FC test.

The confirmed phase of the FC test is used to confirm, or deny, the presence of coliform in the positive presumptive test. For the confirmed phase of the FC test, the culture media EC broth was used. The positive fermentation tubes from the presumptive test were gently shook or swirled. With a sterile metal loop, a transfer was made from each positive presumptive fermentation tube to a confirmed fermentation tube with EC broth.

After the EC broth tubes were inoculated, they were incubated in a water bath at 44.5° C. for 24 hours. The EC broth tubes were placed in the water bath within 30 minutes after inoculation. A sufficient water depth in the water bath was maintained to keep the tubes immersed to at least the upper level of the medium in the tubes.

Gas production with growth in an EC broth culture within 24 hours or less is considered a positive fecal coliform reaction. Failure to produce gas (with little or no growth) constitutes a negative reaction indicating a source other than the intestinal tract of warm-blooded animals.

The Most Probable Number (MPN) of fecal coliform colonies were then calculated from the number of positive EC broth (confirmed) tubes. The calculation was made from the coliform table "Most Probable Numbers per 100 ml of Sample," which is used at the NPS El Portal Waste Water Treatment Plant for potable water. The table is from the 10th ed. of Standard Methods, and is endorsed as the appropriate table from the State of California, Department of Public Health.

2. Fecal Streptococcus Test

The Most Probable Number (MPN) method was also used for the FS test, and consists of a presumptive phase and a confirmed phase.

For the presumptive phase of the FS test, an azide dextrose broth was used as the culture media. The azide dextrose broth was dispensed into fermentation tubes, but did not contain a small inverted vial like the tubes for the fecal coliform test. Double-strength broth was used for tubes which received 10 ml of sample water. The tubes were then covered with metal caps and sterilized in an autoclave.

After the fermentation tubes were sterilized, they were inoculated with sample water. As in the fecal coliform presumptive test, three different dilutions of sample water were used in nine fermentation tubes. The three tubes with double-strength azide dextrose broth received 10 ml of sample water. The three tubes receiving 1 ml of sample water and the three tubes receiving 0.1 ml of sample water each had regular strength broth. A sterile pipette was used to inoculate the fermentation tubes with the three different dilutions of sample water.

Once the transfers were made, the fermentation tubes were incubated at 35° C. for 48 hours, just as in the FC presumptive test. The tubes were checked after 24 hours, and again at 48 hours for any positive growth of bacteria. For the FS presumptive test, positive growth was any amount of turbidity formed in the clear azide-dextrose broth. Any fermentation tubes showing positive growth after the 24 or 48 hour incubation were transferred to the confirmed phase of the FS test.

Like the FC test, the confirmed phase of the FS test is also used to confirm, or deny, the presence of streptococci in the positive presumptive test. For the confirmed phase of the FS test, the culture media pfizer selective enterococcus (PSE) agar was used. The agar could not be made more than 4 hours before it was used.

After the agar was mixed from powder form and thoroughly heated and stirred, it was put into an autoclave for sterilization. Once the agar had cooled down considerably from the autoclave, it was poured into petri dishes and let harden to a gel consistency.

Positive tubes from the presumptive test were gently shook or swirled. With a sterile metal loop or pointer, a transfer was made from each positive presumptive fermentation tube to a streak on a petri dish with PSE agar.

After the FS petri dishes were streaked with positive growth from the presumptive tubes, they were inverted and incubated at 35° C. for 24 hours. The petri dishes were placed in the incubator within 30 minutes of being streaked with the positive growth from the presumptive test. Brownish-black colonies with brown halos after the 24 hour incubation confirmed the presence of fecal streptococci.

The Most Probable Number (MPN) of fecal streptococcus colonies was calculated the same way as the MPN for fecal coliform was calculated.

The six tables at the end of this report summarize the results of the water quality monitoring for the summer of 1992.

III. DISCUSSION/CONCLUSIONS/RECOMMENDATIONS:

This pilot water quality monitoring and evaluation program provided valuable information and insight regarding the quality of Yosemite's water resources and the difficulties found when evaluating them. Aside from observations indicating that two lakes may have elevated fecal bacteria levels, most water quality was found to be very good, indicating that Yosemite's past water quality protection programs may be successful and should continue. Also, the pilot monitoring and evaluation program helped develop an evaluation infra-structure and program outline that will easily allow for further water resource evaluations and or expansion to include other waters.

The Resources Management Division will be continuing to complete further data interpretation management and assessment and, as necessary, will continue to provide recommendations to park Divisions for protection and preservation of human health and safety and environmental quality within Yosemite.

Even though the data and information gained under the 1992 monitoring and evaluation program is limited, it still provides guidance to address the outlined management objectives and actions. Plus, the gained information supports the continuing National Park policy that visitors should purify any untreated

water before drinking. Finally, at the time of completing this pilot program report, no correlative interpretations with previous data had been completed to further evaluate temporal changes of bacterial densities. Providing adequate funding is available, data correlations with historical studies will be completed during the 1993 program.

A. HEALTH and SAFETY:

As stated, the prevention of human exposure to waterborne disease causing pathogenic bacteria is a primary concern for park managers. Since many different bacteria are found naturally in aquatic environments it is very important to be cautious when determining the potential risks facing recreational users of the park's waters. For recreational bathing waters, the U.S. Environmental Protection Agency has set standards for fecal coliform densities at an average of 200 colonies of FC per 100 ml of sample water.[5] For FS, densities of greater than 100 colonies per 100 ml of sample water is said to be high.[5]

In order to conduct a representative risk assessment for human exposure to bacterially contaminated surface waters, a methodology was selected that duplicates specific human water use actions. This methodology was also selected by Holmes and consisted of actions similar to those used when filling a water bottle from a lake or stream.

Fecal coliform and fecal streptococcus bacteria were selected as an indicator for other waterborne pathogenic bacteria as well as for the use of their ratio to identify contaminant sources. The majority of the water samples did not show very high levels of fecal coliform or streptococcus bacteria. The observed fluctuations in the amount of bacteria discovered can be generally interpreted as natural. For example, bacterial increases may accompany organic matter from surface runoff after seasonal rains.

However, two specific locations within the study area did show elevated levels of fecal bacteria. The outlet at Lower Cathedral Lake showed elevated levels of fecal streptococcus bacteria for two consecutive months. FS bacteria counts of 1,100 and >1,100 colonies per 100 ml sample were made for August and September, respectively. The midpoint at Tenaya Lake showed a very high fecal coliform count of 1,100 colonies per 100 ml for the July 20th sampling.

To draw conclusions as to the source and extent of the elevated levels of fecal contamination beyond the two locations would be conjecture at this point. However, the results do indicate that at the specific sample point at the time of sample collection bacteria was present at elevated levels. It can also be concluded that due to the existence of fecal contamination at the

observed elevated levels, there is indeed a potential for recreational exposure to pathogenic bacteria and thus there are potential risks to human health and safety as well. Conversely, exposure potential via formal domestic supply can be considered to be very minor at each of these two sites since neither lake is directly a part of a supply system. Both Tenaya and Cathedral Lakes drain into Tenaya Creek and eventually flow down Tenaya Canyon into the Merced River. The nearest domestic supply system which draws water out of the Merced River is many miles downstream well beyond the boundary of the park. Therefore, the most immediate health and safety risks are considered to exist at the lakes themselves via the indigenous recreational water uses.

Some recommended management actions for health and safety and water quality protection can be initiated without conducting further water quality monitoring and evaluation. These are outlined below. However, in order to more clearly understand to what degree potential exposure exists and to develop a successful strategy for natural resources management protection, further evaluations are strongly recommended.

B. RESOURCE PROTECTION/PRESERVATION:

Evaluating the natural resource damages, beyond the primary assessment of water quality conditions, has not been the main focus of this monitoring and evaluation program. However, at the locations where elevated levels of fecal contamination were observed, other substantial visitor use related impacts have been recognized.

For example, day use levels at Tenaya Lake have increased during the past decade.[6] Toilet facilities at Tenaya Lake have continually been recognized as heavily overburdened and beyond capacity. Additionally, Lower Cathedral Lake, along the renowned John Muir Trail, is a very popular day use destination that also has the additional stress of overnight use as well. No toilet facilities exist at Cathedral trail-head locations nor at the lake itself. Also at Cathedral, it is a continual effort to prevent campsites from encroaching and impacting the riparian vegetation along the lake shore. The riparian vegetation plays an important role in preserving water quality as an interceptor of surface runoff containing nutrients, bacterium and other organic materials.

Wildlife species also rely upon natural waters. Further monitoring and evaluation will be necessary to fully determine and assess potential wildlife impacts.

C. MANAGEMENT ACTIONS:

Management policies established by Marnell[7] in 1971 for Yosemite's aquatic resources specify that waters shall be

preserved in their natural condition, and that public visitation for scenic or aesthetic appreciation shall be allowed providing such activities do not threaten to impair the natural conditions. This pilot monitoring and evaluation program indicates that at some locations the levels of visitation may now be beginning to have a negative effect upon aquatic resources. In recognizing the potential impacts to aquatic resources, specifically, water quality, it is recommended that management actions begin to take steps to control potential contamination in specific areas where visitor use patterns require.

Based upon the results of the 1992 monitoring and evaluation program the following management actions are recommended:

1. Tenaya Lake

a. Continue to improve toilet facilities surrounding Tenaya Lake to accommodate current visitor use levels and future use projections.

b. Investigate as possible contaminate sources several abandoned leach lines and pit toilets around the lake.

c. To protect and preserve riparian areas, control and direct visitor access onto sandy beaches and other more resilient shores.

2. Lower Cathedral Lake

a. Continue to increase water quality education and protection efforts at Cathedral Lake in order to improve visitor use habits.

b. Continue to direct camping away from Cathedral Lake to locations that protect riparian zones and water quality. Consider further limits on camping capacity.

c. Determine significance of day-use impacts and consider installation of toilet facilities at the Cathedral trail-head or at the lake itself.

3. Monitoring and Evaluation

a. Continue to develop a programmatic approach to water quality monitoring and evaluation. Continue to utilize previous water quality data, visitor use statistics and aquatic habitat condition information as indicators for potential water quality impacts. Continue to modify the monitoring and evaluation network, sample design and sampling points in order to more clearly evaluate and understand potential impacts.

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WATERSHED PROTECTION PROGRAM
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Dog Lake Results

LOCATION & DATE	FC*	FS*	FC/FS	pH	Temp.°C
July 20, 1992					
#1A (inlet/e shore)	3.6	23	0.15	5.1	N.A.
#2 (s shore)	7.3	<3	>2.4	4.8	N.A.
#3 (outlet/w shore)	<3	<3	1	4.7	N.A.
August 17, 1992					
#1B (inlet/e shore)	<3	<3	1	5.1	N.A.
#2 (s shore)	<3	<3	1	5.1	N.A.
#3B (outlet/w shore)	3.6	23	0.16	5.2	N.A.
September 14, 1992					
#1B (inlet/e shore)	<3	<3	1	5.1	14.5
#2 (s shore)	<3	<3	1	5.1	14.2
#3B (outlet/w shore)	<3	<3	1	5.1	14.5

Notes:

FC = fecal coliform per 100 ml sample
FS = fecal streptococci per 100 ml sample
* = Most Probable Number method; see text for discussion
FC/FS = Ratio of fecal coliform to fecal streptococci; see text for discussion
N.A. = Water temperature is not available

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Elizabeth Lake Results

LOCATION & DATE	FC*	FS*	FC/FS	pH	Temp.°C
July 20, 1992					
#1 (inlet/se shore)	<3	6.2	<0.48	4.8	N.A.
#2 (midpoint/s shore)	<3	14	<0.21	4.6	N.A.
#3 (outlet/e-ne shore)	<3	<3	1	4.4	N.A.
August 17, 1992					
#1 (inlet/se shore)	<3	<3	1	4.8	N.A.
#2 (midpoint/s shore)	<3	<3	1	4.8	N.A.
#3 (outlet/e-ne shore)	<3	3.6	<0.83	4.8	N.A.
September 14, 1992					
#1 (inlet/se shore)	<3	3.6	<0.83	4.4	10.0
#2 (midpoint/s shore)	<3	<3	1	4.4	14.0
#3 (outlet/e-ne shore)	<3	<3	1	4.4	12.0

Notes:

FC = fecal coliform per 100 ml sample
FS = fecal streptococci per 100 ml sample
* = Most Probable Number method; see text for discussion
FC/FS = Ratio of fecal coliform to fecal streptococci; see text for discussion
N.A. = Water temperature is not available

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Lower Cathedral Lake Results

LOCATION & DATE	FC*	FS*	FC/FS	pH	Temp.°C
July 20, 1992					
#1 (inlet/ne shore)	3.6	15	0.24	4.4	N.A.
#2 (midpoint/n shore)	<3	<3	1	4.4	N.A.
#3 (outlet/w shore)	<3	<3	1	4.4	N.A.
August 17, 1992					
#1 (inlet/ne shore)	3.6	150	0.02	4.4	N.A.
#2 (midpoint/n shore)	3.6	3.6	1	4.4	N.A.
#3 (outlet/w shore)	150	1100	0.14	4.4	N.A.
September 14, 1992					
#1 (inlet/ne shore)	<3	9.1	<0.33	4.4	7.5
#2 (midpoint/n shore)	<3	<3	1	4.4	14.0
#3 (outlet/w shore)	23	>1100	<0.02	4.4	5.5

Notes:

FC = fecal coliform per 100 ml sample
FS = fecal streptococci per 100 ml sample
* = Most Probable Number method; see text for discussion
FC/FS = Ratio of fecal coliform to fecal streptococci; see text for discussion
N.A. = Water temperature is not available

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Lower Young Lake Results

LOCATION & DATE	FC*	FS*	FC/FS	pH	Temp.°C
July 20, 1992					
#1 (inlet/e shore)	<3	3.6	<0.8	4.3	N.A.
#2 (midpoint/n shore)	<3	<3	1	4.3	N.A.
#3 (outlet/w shore)	<3	<3	1	4.2	N.A.
August 17, 1992					
#1 (inlet/e shore)	39	21	1.9	4.3	N.A.
#2 (midpoint/n shore)	<3	<3	1	4.3	N.A.
#3 (outlet/w shore)	<3	3.6	<0.83	4.2	N.A.
September 14, 1992					
#1 (inlet/e shore)	<3	<3	1	4.9	4.0
#2 (midpoint/n shore)	<3	<3	1	4.4	15.0
#3 (outlet/w shore)	<3	15	<0.2	4.4	7.0

Notes:

FC = fecal coliform per 100 ml sample
FS = fecal streptococci per 100 ml sample
* = Most Probable Number method; see text for discussion
FC/FS = Ratio of fecal coliform to fecal streptococci; see text for discussion
N.A. = Water temperature is not available

TUOLUMNE RIVER
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Tenaya Lake Results

LOCATION & DATE	FC*	FS*	FC/FS	pH	Temp.°C
July 20, 1992					
#1 (inlet/e shore)	11	43	0.25	4.4	N.A.
#2 (midpoint/n shore)	1100	75	14.7	4.4	N.A.
#3 (outlet/w shore)	23	3.6	6.4	4.4	N.A.
August 17, 1992					
#1 (inlet/e shore)	<3	9.1	<0.33	4.4	N.A.
#2 (midpoint/n shore)	9.1	3.6	2.53	4.4	N.A.
#3 (outlet/w shore)	3.6	3.6	1	4.4	N.A.
September 14, 1992					
#1 (inlet/e shore)	<3	<3	1	4.4	19.0
#2 (midpoint/n shore)	3.6	93	0.04	4.4	20.0
#3 (outlet/w shore)	<3	<3	1	4.4	13.0

Notes:

FC = fecal coliform per 100 ml sample
FS = fecal streptococci per 100 ml sample
* = Most Probable Number method; see text for discussion
FC/FS = Ratio of fecal coliform to fecal streptococci; see text for discussion
N.A. = Water temperature is not available

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Upper Granite Lake Results

LOCATION & DATE	FC*	FS*	FC/FS	pH	Temp.°C
July 20, 1992					
#1 (n shore)	<3	<3	1	4.2	N.A.
#2 (e shore)	<3	<3	1	4.2	N.A.
#3 (outlet/s shore)	<3	<3	1	4.2	N.A.
August 17, 1992					
#1 (n shore)	3.6	<3	1	4.4	N.A.
#2 (e shore)	<3	<3	1	4.4	N.A.
#3 (outlet/s shore)	<3	<3	1	4.4	N.A.
September 14, 1992					
#1 (n shore)	<3	<3	1	4.4	9.0
#2 (e shore)	<3	<3	1	4.4	10.5
#3 (outlet/s shore)	<3	<3	1	4.4	6.5

Notes:

FC = fecal coliform per 100 ml sample
FS = fecal streptococci per 100 ml sample
* = Most Probable Number method; see text for discussion
FC/FS = Ratio of fecal coliform to fecal streptococci; see text for discussion
N.A. = Water temperature is not available

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