# PROJECT REPORT

# *BODIE CREEK, MONO COUNTY*

## TOTAL MAXIMUM DAILY LOAD (TMDL) FOR METALS

Results of
Impairment Verification Sampling
April – June 2004

California Regional Water Quality Control Board
Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, California 96150

December 2004

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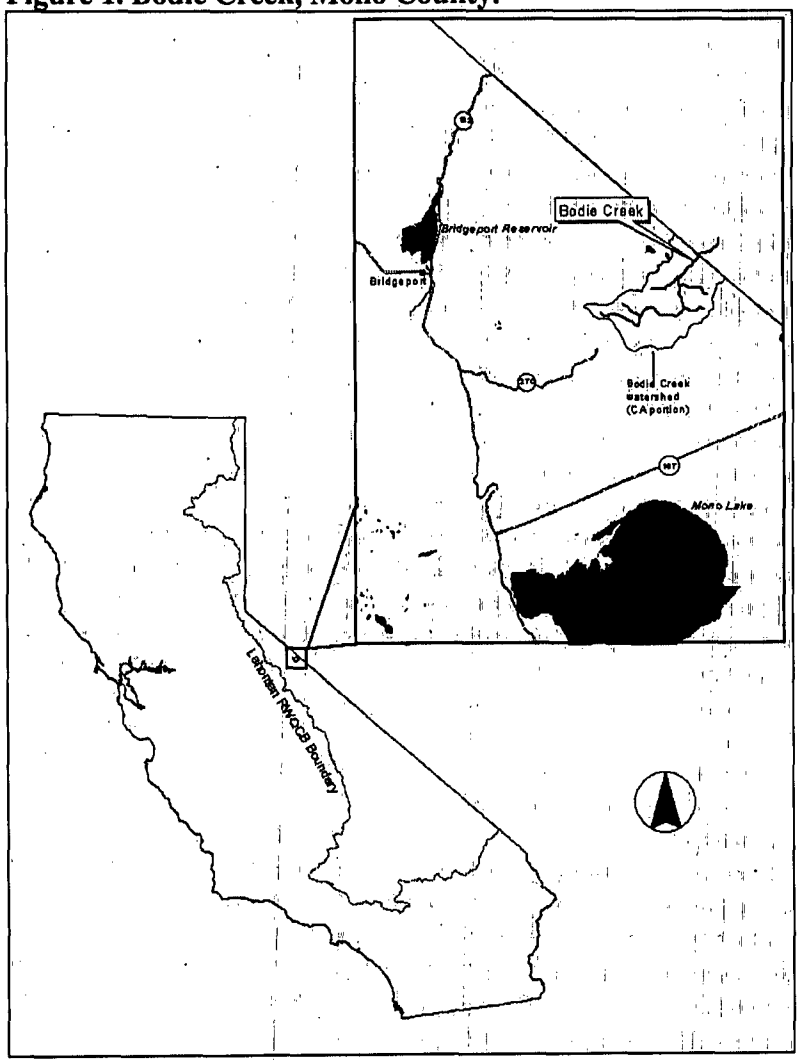
## Project Background

Bodie Creek is located in eastern Mono County, California, in the Bodie Hills, a group of mountains east of the Sierra Nevada at the western edge of the Great Basin (Figure 1). The topography of the area is mountainous, with elevations ranging from 7,520 feet above mean sea level (amsl) where Bodie Creek crosses the California-Nevada state line to 10,168 feet amsl atop Bodie Mountain. Stream flow in upper Bodie Creek is seasonal, with most flow occurring during the late fall through spring. Snowmelt runoff provides most of creek's seasonal flow.

The area can be accessed from U.S. Highway 395 by traveling approximately 13 miles east on State Route 270 to the Bodie State Historic Park (SHP), which is administered by the State of California - Department of Parks and Recreation. The small rural communities of Bridgeport, Lee Vining and Mono City are the nearest populated areas.

**Figure 1. Bodie Creek, Mono County.**



Bodie Creek is included on the Clean Water Act Section 303(d) list for metals impairment. In April, May and June of 2004, staff of the Lahontan Regional Water Quality Control Board (RWQCB) collected surface water samples from the creek to determine if metals detected in sediment during previous investigations (Dynamac, 2002) were present in surface water of Bodie Creek. Water samples from Bodie Creek were analyzed for dissolved and total metals and cyanide (see *Bodie Creek Sampling and Analysis Plan*, Lahontan RWQCB, April 2004). Four in-creek locations were sampled once per month during April and May 2004, and three locations were sampled in June. Sampling site locations and descriptions are contained in Table 1 and shown in Figure 2.

**Table 1. Sampling Locations and Descriptions**

| Site ID | Description | Latitude | Longitude |
|---|---|---|---|
| BC-1 | Headwaters, upstream (u/s) of major mining impacts (i.e., Bodie State Park area) | 38.21535 | -119.02032 |
| BC-2 | In Bodie State Park area, where creek flows through remnant tailings piles | 38.21743 | -119.00977 |
| BC-3 | U/s of Taylor Gulch, near former Syndicate millsite | 38.21905 | -118.98491 |
| BC-4 | U/s of Flying M club, near fish tissue sampling site (TSMP, '92 & '02) | 38.24859 | -118.96838 |

## Results

Analytical results indicate exceedances of water quality criteria for total aluminum (Al), iron (Fe), manganese (Mn), arsenic (As), mercury (Hg), and dissolved zinc (Zn). All other constituents were either not detected, or detected at levels below the most stringent applicable water quality criteria. Table 2 shows locations and dates of criteria exceedances. Table 3 shows the averages of all analytical results for those metals that exceeded criteria, by sampling site. Table 4 shows the number of samples collected for each analyte that exceeded water quality criteria, how many samples exceeded criteria, and gives a measure of the magnitude of criteria exceedances. Field measurements of pH, temperature, electrical and specific conductance (EC and SC) were recorded, as shown in Table 5.

**Figure 2. 2004 Sampling Locations, Bodie Creek.**

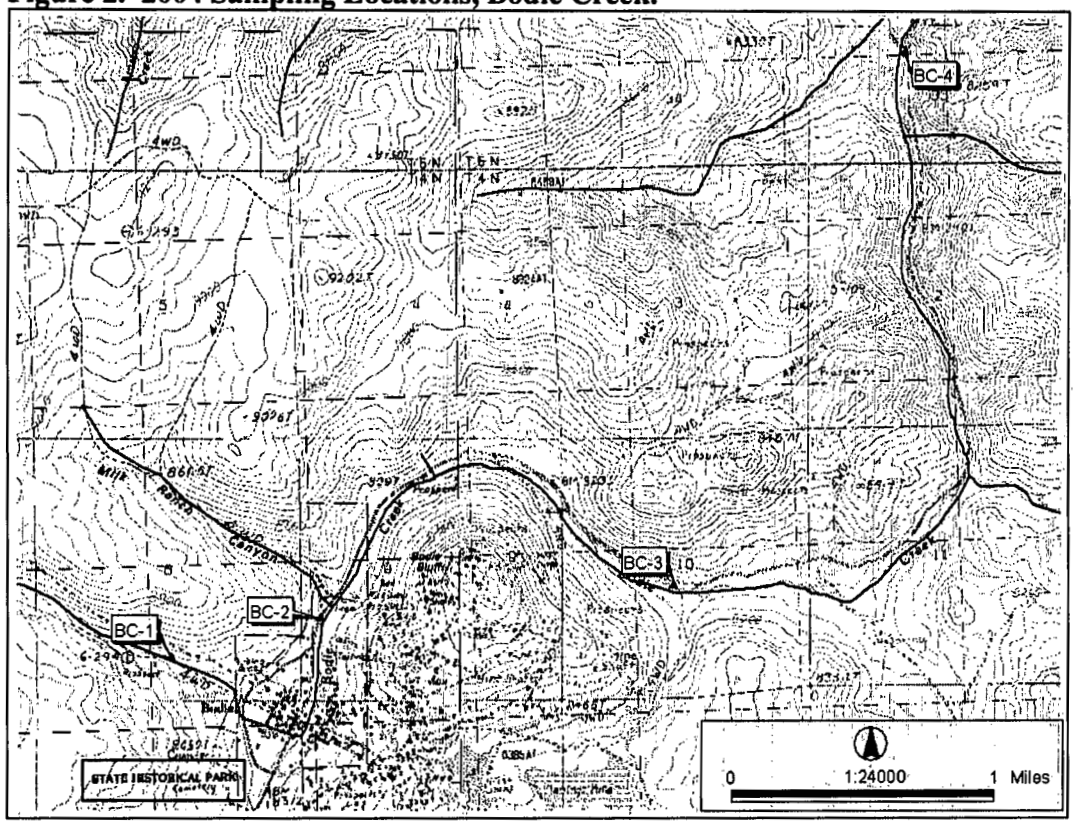



**Table 2. Sample results and water quality criteria exceedances (in shaded cells, bold font) by sampling site and date, Bodie Creek.**

| | | BC-1 | | | BC-2 | | | BC-3 | | | BC-4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Analyte** | **Criteria** | **April** | **May** | **June** | **April** | **May** | **June** | **April** | **May** | **June** | **April** | **May** | **June** |
| Total Al | 87 µg/L | **510** | 87 | nd | **200** | 27 | ns | **160** | **100** | nd | **290** | **120** | nd |
| Total As | 10 µg/L | nd | 0.58 | 1.7 | 8.3 | 6.6 | ns | 7.6 | 8.4 | **12** | 6.4 | 5.9 | 6.4 |
| Total Fe | 300 µg/L | **410** | 120 | 97 | **320** | 190 | ns | 240 | 190 | **330** | **420** | **420** | **340** |
| Dissolved Zn | (In parentheses*) µg/L | nd | **40 (29)** | nd | 19 (140) | 33 (140) | ns | 2.9 (82) | 23 (82) | nd | nd | 19 (66) | nd |
| Total Mn | 50 µg/L | 4.7 | 4.6 | 4.1 | **72** | 36 | ns | 12 | 16 | 31 | **57** | **72** | **67** |
| Total Hg | 50 ng/L | ns | 1.22 | 1.47 | ns | **154** | ns | ns | **68** | **99** | ns | 38.9 | 17.5 |

µg/L - micrograms per liter
ng/L - nanograms per liter
nd - not detected above minimum detection limit.
ns - not sampled. Hg was not sampled in April due to incorrectly preserved sample bottles; BC-2 was not sampled in June due to lack of water in creek at that location.
*Zinc criteria vary based on water hardness. Applicable criterion is shown in parentheses next to analytical result.

**Table 3. Average[1] of all results for constituents that exceeded criteria, by sampling site. Shaded cells indicate those averages that exceed water quality criteria.**

| | | BC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|---|
| Analyte | Criteria | Average Result | Average Result | Average Result | Average Result |
| Total Al | 87 µg/L | 207 | 114 | 95 | 145 |
| Total As | 10 µg/L | 0.9 | 7.5 | 9.3 | 6.2 |
| Total Fe | 300 µg/L | 209 | 255 | 253 | 393 |
| Dissolved Zn | (In parentheses) µg/L | 16.7 (40) | 26 (140) | 10.3 (82) | 9.7 (66) |
| Total Mn | 50 µg/L | 4.5 | 54 | 19.7 | 65.3 |
| Total Hg | 50 ng/L | 1.3 | 154 | 83.5 | 28.2 |

[1] Non-detects in the dataset were assigned a value of one-half the detection limit for the purpose of calculating an average.
µg/L - micrograms per liter
ng/L - nanograms per liter

**Table 4. Sample and exceedance summary, Bodie Creek.**

| Constituent | Number of Samples | Number of Criteria Exceedances | Exceedance Rate (# of criteria exceedances/ # of samples) | Exceedance Magnitude (percent difference between average exceedance and criteria) |
|---|---|---|---|---|
| Total Al | 11 | 6 | 54% | 141% |
| Total As | 11 | 1 | 9% | 20% |
| Total Fe | 11 | 6 | 54% | 24% |
| Total Mn | 11 | 4 | 36% | 34% |
| Total Hg | 7 | 3 | 43% | 114% |
| Dissolved Zn | 11 | 1 | 9% | 38% |

**Table 5. pH, Temperature, EC and SC.**

| April 7, 2004 | BC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|
| pH | 6.7 | 7.37 | 7.97 | 8.27 |
| Temp (°C) | 7.5 | 6.5 | 10.4 | 9.7 |
| EC (µs/cm) | 48 | 197.5 | 175.8 | 115.5 |
| SC (µs/cm) | 72 | 293.4 | 243.7 | 163.2 |
| **May 12, 2004** | **BC-1** | **BC-2** | **BC-3** | **BC-4** |
| pH | 6.98 | 7.62 | 8.02 | 8.6 |
| Temp (°C) | 10.3 | 13.4 | 14.1 | 15.3 |
| EC (µs/cm) | 55.5 | 338.4 | 153.7 | 122.1 |
| SC (µs/cm) | 77.2 | 433.7 | 194 | 149.9 |
| **June 22, 2004** | **BC-1** | **BC-2** | **BC-3** | **BC-4** |
| pH | 7.06 | No water | 8.2 | 7.72 |
| Temp (°C) | 11.2 | No water | 18.2 | 15.5 |
| EC (µs/cm) | meter malfunc. | No water | 198.4 | 121.3 |
| SC (µs/cm) | meter malfunc. | No water | 228 | 148.2 |

EC – electrical conductivity
SC – specific conductance
µs/cm – microsiemens per centimeter

## Discussion of Specific Constituents

### Aluminum

Aluminum exceeded EPA's National Recommended Water Quality Criteria of 87 µg/L in six out of eleven samples. The highest value of aluminum (510 micrograms per liter [µg/L]) and the highest average analytical results (refer to Tables 2 and 3) were detected at the headwaters site, indicating that background levels exceed this criterion. It is relevant to note that the EPA recommended criteria includes footnotes specific to aluminum, stating that for pH values between 6.5 and 9.0, a Water-Effects Ratio procedure (a type of site-specific objective) might be appropriate because (1) aluminum is less toxic at higher pH and hardness, but the relationship is not well quantified; (2) aluminum associated with clay particles may be less toxic than that associated with aluminum hydroxide particles; (3) many high quality waters in U.S. exceed 87 µg/L. Given that background values of aluminum exceed this criterion, a more appropriate value for comparison may be the California Department of Health Services (DHS) primary maximum contaminant level (MCL) of 1,000 µg/L; that criterion was not exceeded.

Arsenic

Arsenic was detected above EPA's primary MCL of 10 µg/L once at site BC-3 in June. The California DHS primary MCL for arsenic is 50 µg/L; this limit was not exceeded during this project. Primary MCLs are protective of human health.

Iron

Iron exceeded the California DHS secondary MCL of 300 µg/L in six out of eleven samples. Iron exceeded this criterion all three months at site BC-4; however, iron was also detected above criterion at BC-1, indicating that background levels may be higher than water quality standards. Secondary MCLs address taste and odors in drinking water. There is no primary MCL promulgated for iron in state or federal regulations.

Manganese

Manganese exceeded the California DHS secondary MCL of 50 µg/L all three months at site BC-4. The average value for manganese at BC-4 was 65 µg/L. There is no primary MCL promulgated for manganese in state or federal regulations.

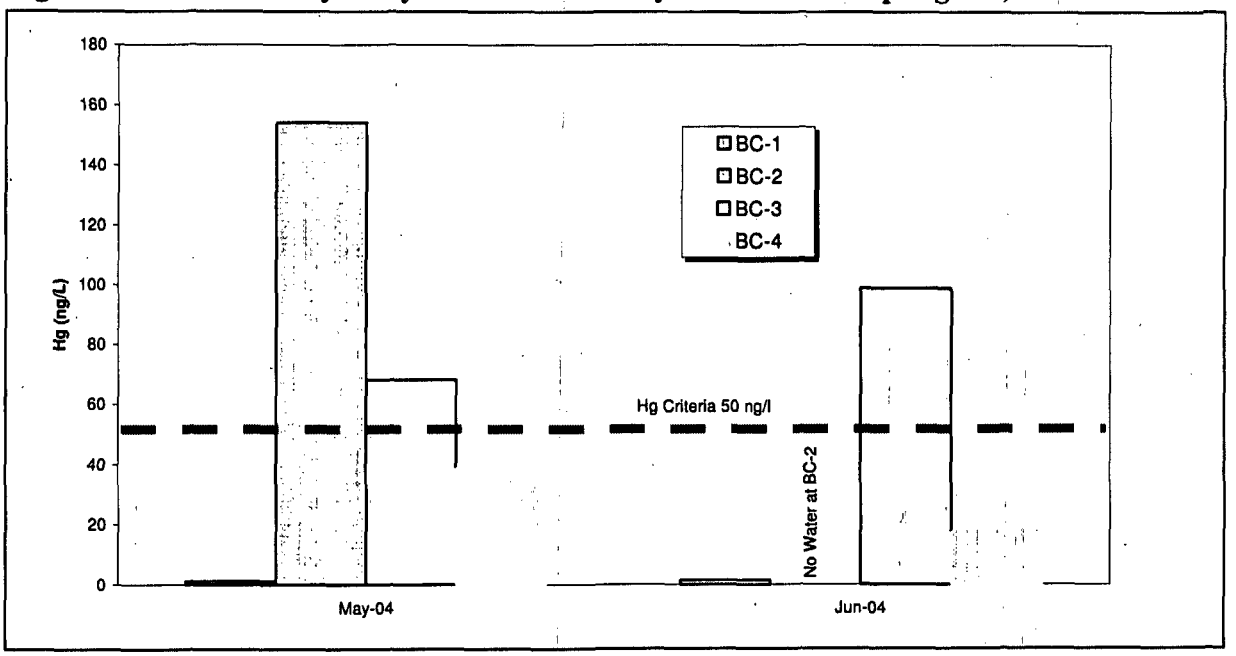
Mercury

Mercury exceedances occurred only at the sampling sites near historic mining occurrences, at BC-2 and BC-3. Mercury was detected in all samples, but exceeded criterion only at those locations. Mercury showed a consistent trend between sampling sites: the lowest levels were at the headwaters site (1.2 and 1.5 nanograms/liter [ng/L]), the highest levels (exceeding California Toxics Rule [CTR] water & fish consumption criteria of 50 ng/L [total fraction]) were detected through the historic mining areas, decreasing again to below criteria downstream of the major mining impacts. Figure 3 shows mercury results by date and sampling site.

Zinc

Zinc was detected above CTR aquatic life chronic criteria once, at 40 µg/l at BC-1 in May. CTR criteria for zinc vary according to water hardness, and are expressed in the dissolved metals fraction. Outside of this detection, all other zinc values measured were well below criteria. California DHS secondary MCL for zinc is 5,000 µg/L; this criterion was not exceeded.

**Figure 3. Total Mercury analytical data shown by month and sampling site, Bodie Creek.**




## Field Parameters and Flow Conditions

Measured pH values ranged from 6.7 to 8.6, with a linear trend increasing in the downstream direction. This range of pH is generally in compliance with the Basin Plan water quality objective range of 6.5 - 8.5. Conductivity (electrical and specific) was typically higher at sites BC-2 and 3, with the lowest values recorded at the headwaters site, BC-1. Low flow conditions dominated throughout the sampling period and did not allow for flow to be measured using an in-stream flowmeter. Site BC-2 was dry during June.

## Conclusions

Bodie Creek is currently 303(d)-listed for non-specific "metals." Analytical results from this limited sampling effort indicate exceedances of water quality criteria for total aluminum, iron, manganese, arsenic, mercury, and dissolved zinc. Beneficial uses of Bodie Creek include cold freshwater habitat (COLD), and domestic and municipal supply (MUN). The water quality criteria used for the comparisons in this report were selected to be protective of these beneficial uses.

Although the creek through the project area may not appear to support fish habitat due to low flow conditions, it contributes flow to downstream reaches where the COLD beneficial use is viable and existing. Therefore, criteria that are protective of aquatic life are appropriate measures of comparison, and metals detected with statistical significance

above those criteria should be 303(d)-listed. Aquatic life criteria applies to aluminum, zinc and mercury.

Aluminum results were compared to criteria that were issued as guidance by the EPA. This guidance recommends the use of a site-specific objective procedure and states that many high quality waters naturally exceed the recommended criteria. This appears to be true of Bodie Creek, where the highest level of aluminum was detected at the headwaters sampling location. Aluminum is not recommended for inclusion on the 303(d) list due to naturally elevated concentrations in the project area.

Zinc was detected above CTR's aquatic life protection criteria once in 11 samples. The average values for zinc recorded at each sampling site do not exceed criteria, as shown in Table 3; so, zinc is not recommended for listing.

Mercury was detected above criteria in 43 percent of the samples, with a high exceedance magnitude (114 percent of the criteria). Its inclusion on the 303(d) list is recommended.

Criteria applicable to arsenic, iron and manganese are drinking water MCLs, either primary (human health protection) or secondary (taste and odor thresholds). Arsenic was detected above criteria once in 11 samples, at 12 µg/L exceeding the EPA's primary MCL of 10 µg/L. This minimal exceedance rate and magnitude is not sufficient to warrant its inclusion on the 303(d) list.

Iron and manganese exceeded secondary MCLs six and four times out of eleven samples, respectively. The exceedance magnitudes were 24 and 34 percent for iron and manganese, respectively. Iron was also detected above criteria at the headwaters site, indicating that natural levels may be above criteria. Examination of average values for iron indicates that minimal water quality standards violations occurred only at BC-4, as shown in Table 3. The relatively low magnitude of average standards exceedances, coupled with elevated natural background levels, do not justify the inclusion of iron or manganese on the 303(d) list.

**Recommendations and Future Actions**

Bodie Creek is currently listed for "metals." Based on the results of the impairment verification sampling presented here, RWQCB staff recommends that the current listing be refined from metals to a specific listing for total mercury. As funding and staff resources allow, future efforts should focus on additional sampling to determine trends in mercury concentrations and locations of potential sources. Locations of previous sediment samples with elevated mercury detections (for example, as noted in Dynamac, 2002) should be identified to determine areas correlated with surface water concentrations that may offer relatively simple remediation potential (e.g., spot excavation).

Effectiveness of any early implementation strategies should be monitored through water and/or sediment sampling on a yearly basis as site conditions allow.

Because water quality standards exceedances were noted for aluminum, iron and manganese, any water samples collected should be analyzed for those constituents, in order to assemble a more complete dataset to inform future listing decisions related to those metals.

## References


Dynamac Corporation, 2002. *Final Sampling and Analysis Plan, Bodie Creek.* Prepared for U.S. Department of Interior, Bureau of Land Management.

Lahontan RWQCB, 2004. *Sampling And Analysis Plan, Bodie Creek, Mono County, Total Maximum Daily Load (TMDL) For Metals Impairment Verification Sampling.*