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Regulatory Water Quality Monitoring Annual Report for the Greater Yellowstone Network

June–September 2005

Natural Resource Technical Report NPS/GRYN/NRTR–2009/203

ON THE COVER
A biologist takes a water sample in Bighorn Canyon National Recreation Area. National Park Service photo.

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June–September 2005

Natural Resource Technical Report NPS/GRYN/NRTR—2009/203

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J. SCHMIDT

In Yellowstone National Park, one station was adopted on Soda Butte Creek near the northeast park boundary.

1.0 Introduction

The Greater Yellowstone Network (GRYN) is conducting regulatory water quality monitoring to meet the requirements of the 1972 Clean Water Act and to satisfy requirements of the National Park Service Inventory and Monitoring (I&M) Program. Four water bodies in the GRYN were targeted for monitoring: the Shoshone and Bighorn rivers in Bighorn Canyon National Recreation Area and Soda Butte and Reese creeks in Yellowstone National Park. This report summarizes monitoring results from 2005, the first year of this monitoring program.

1.1 Background

The GRYN, park staff, and collaborators conducted regulatory water quality monitoring at fixed monitoring stations using an intermittent sampling scheme and methods similar to those being used by the Montana and Wyoming departments of environmental quality. The frequency of monitoring was based on the ability to calculate geometric means or chronic or acute concentrations, or conditions for results comparison with state standards. Collaborators sampled in the morning and afternoon to estimate diurnal variations for total and dissolved metals

1.2 Justification for Study

In response to section 303(d) of the Clean Water Act, states are required to develop lists of impaired waters that do not meet the water quality standards set by the states. Four water bodies in the GRYN were identified as impaired by the states of Montana or Wyoming and are included on their 303(d) lists of impaired waters. Causes for listing include exceedances in amounts of fecal coliforms, nitrogen/nutrients, metals, dewatering or the removal of water from a system, and habitat and flow alterations.

1.3 Objectives

The development of measurable objectives is a critical element of any monitoring program. The basic objective for regulatory water quality monitoring is to determine whether parameters exceed state standards. In addition, the GRYN plans to determine whether the Government Performance and Results Act (GPRA) goal of improved water quality is being achieved (National Park Service 2000), examine long-term data for water quality trends, and provide the network parks and states with credible data to assist management in decision making.

2.0 Methods

In 2005, the GRYN initiated monitoring at three fixed stations—two in Bighorn Canyon, one in Yellowstone—following detailed methods described in the network's regulatory water quality monitoring protocol (O'Ney 2005). Water samples were collected and analyzed for seven parameters: nitrate, total metals, dissolved metals, metals in sediment, benthic macroinvertebrates, fecal coliforms, and *Escherichia coli*. In addition, five basic water quality parameters (temperature, specific conductance, pH, dissolved oxygen, and discharge) were monitored at each location. At Reese Creek in Yellowstone, weekly measurements of flow or discharge were conducted under the supervision of the Division of Resource and Visitor Protection. The discharge measurements taken at the creek use a current velocity meter similar to procedures described in the network protocol. The Reese Creek measurements method departs from the protocol by measuring discharge weekly rather than on a continuous basis. The GRYN plans to adapt these measurement protocols to meet program objectives in the future.

At each site, quality assurance and quality control samples were collected for the parameter of interest. Staff calculated the relative percent difference (RPD) to determine if the duplicate samples were within an acceptable range. The results of these samples are summarized in a data validation report prepared for each station. For the purpose of this report, only data meeting the GRYN measurement quality objectives were used.

2.1 Study Area

The study area addressed in this report includes four streams (two in Yellowstone, two in Bighorn Canyon) that are listed as 303(d) impaired water quality by the state. In Bighorn Canyon, one station was established the Shoshone River near the south end of the park and another on the Bighorn River north of Afterbay Dam. In Yellowstone, one station was adopted on Soda Butte Creek near the northeast park boundary. Two stations will be formally established on Reese Creek in 2006. The Bighorn River and Soda Butte Creek stations were co-located with USGS (U.S. Geological Survey) gauging stations. Yellowstone Fisheries and Aquatic Sciences staff began monitoring the station at Soda Butte Creek in 2002.

3.0 Results and Discussion

This report summarizes the results and data analyses for sampling conducted from June to September 2005. The following results are presented for each stream monitored by the GRYN during this period.

3.1 Shoshone River

GRYN collaborators conducted four one-week sampling events for fecal coliforms and *E. coli* on the Shoshone River in June through September. The results for bacterial analyses indicate state standards for both *E. coli* and fecal coliforms were exceeded for all sampling periods (table 1). Clearly, water quality is affected by these exceedances and continued 303(d) listing appears to be warranted.

Table 1. Summary statistics of bacterial analyses for the Shoshone River near Bighorn Canyon National Recreation Area between June and September 2005

	cfu/100 ml			
	Minimum	Maximum	Geometric mean	Wyoming state standard
27 Jun–1 Jul				
E. coli	520	1,600	868.4	126
Fecal coliform	—[a]	—[a]	—	200
26–30 Jul				
E. coli	790	1,500	1,080	126
Fecal coliform	580	1,200	887.4	200
18–25 Aug				
E. coli	570	810	687.6	26
Fecal coliform	560	770	666.8	200
26–30 Sep				
E. coli	300	1,000	454.9	26
Fecal coliform	220	820	351.9	200

Note: cfu = colony forming units.

[a]Analyses not performed.

Table 2. Summary statistics for required field parameters from Shoshone River samples taken 27 June–30 September 2005 near Bighorn Canyon National Recreation Area

	Specific conductance (µS/cm)	Dissolved oxygen (% saturation)	pH	Temperature (°C)
Number of samples (n)	18	17	19	19
Minimum	374.2	94.1	7.69	10.35
Maximum	932.8	108.5	8.25	19.19
Mean	759.9	98.7	7.98	14.91
Historical Mean[a]	1,076	—	7.8	11.7

Note: µS/cm = micro Siemens per centimeter

[a]*Source*: Woods and Corbin 2003.

The number of colony forming units (cfu)/100 ml appears to have peaked in July, slowly decreasing through September. Increases and decreases in the numbers of cfu correlate closely with fluctuations in water temperature. Although it appears that large bacterial populations are entering Bighorn Lake via the Shoshone River, swim beaches along the lake were monitored once a week during the summer season by the ranger division, no exceedances were detected (Bighorn Canyon National Recreation Area staff, pers. comm.) and it is assumed that the bacterial populations become diluted after entering the lake. Statistics for the required field parameters are summarized in table 2.

3.2 Bighorn River

GRYN collaborators conducted four monthly sampling events for nitrate on the Bighorn River from June through September 2005. The results for nitrate analyses and required field parameters are summarized in table 3. No exceedances of the state standard for nitrate nitrogen (10 mg/L) were detected during this period.

3.3 Soda Butte Creek

During 2005, field parameters were collected from this site once every two weeks as part of Yellowstone's long-term water quality and ecosystem health program. Field parameters include water temperature, dissolved oxygen, pH, specific conductivity, and turbidity. Water samples were also brought back to the Yellowstone Fisheries and Aquatic Sciences field laboratory for total suspended solid analysis (TSS) (table 4). Water and sediment samples were analyzed for metals (arsenic, copper, iron, and selenium) in conjunction with the GRYN during both June and September (table 5). To better assess the overall health of this portion of Soda Butte Creek at the park boundary, the GRYN also collected benthic macroinvertebrate samples on 16 August 2005. These samples were sent to an independent laboratory for processing and analysis.

Table 3. Summary statistics for nitrate analyses and required field parameters from Bighorn River samples taken 28 June–28 September 2005 near Bighorn Canyon National Recreation Area

	Specific conductance (µS/cm)	Dissolved oxygen (% saturation)	pH	Temperature (°C)	Nitrate as N (mg/L)
Number of samples (n)	4	3	4	4	3
Minimum	692.5	93.3	7.4	9.14	0.36
Maximum	939	135.2	8.29	16.4	0.72
Mean	820	113.3	7.88	13.59	0.50
Historical Mean[a]	—	—	—	—	0.48

Note: µS/cm = micro Siemens per centimeter

[a]*Source*: Woods and Corbin 2003.

All required field parameters were within ranges expected of high elevation, coldwater streams (table 4). As expected natural variations were observed in the field parameters depending upon the time of day and month sampled. Mean water temperature was 5°C (range -0.1–13.7°C). Dissolved oxygen concentrations (range 7.7–10.5 mg/L) tended to correspond with changes in water temperature with high concentrations being recorded during the cold winter months and lower concentrations being recorded during the warmer periods of July and August. The pH of Soda Butte Creek was neutral to slightly basic and ranged from 7.3 to 8.4, considerably higher than pH values consistent with acid mine drainage (table 4). Values for specific conductance, turbidity, and total suspended solids tended to be directly related to flow. In general, specific conductance tended to be lower during the spring high flow period while turbidity and TSS tended to be higher. During the low-flow fall and winter periods the opposite seemed to be true, with higher specific conductance values and lower turbidity and TSS values (table 4).

During the collection period between June and September 2005, arsenic and selenium were below the specified laboratory reporting limits for both aqueous and sediment samples collected (table 5). Values for total and dissolved copper were compared to Montana aquatic life standard (5.2 µg/L at 50 mg/L hardness for acute levels, 7.3 µg/L at 50 mg/L hardness for chronic levels). Both dissolved and total copper concentrations were detected in water samples collected on the evening of 17 June 2005 (table 5). Dissolved copper concentration (3 µg/L) was below the Montana aquatic life standards for acute and chronic levels; however, total copper concentrations (11 µg/L) were above the specified chronic levels of copper in water. Although copper did exceed Montana's chronic aquatic life standard, the data may not be comparable because the GRYN did not measure water hardness at the time of sample collection. Copper in sediment was recorded at 17 mg/kg which is below the 33 mg/kg listed by Montana's aquatic life standards. Samples analyzed for dissolved iron did not exceed the Montana aquatic life standard of 1,000 µg/L. However, samples analyzed for total iron exceed this standard one time during the evening of 17 June 2005 (table 5). During September 2005, total iron concentration was 14,000 mg/kg. There are no recognized standards for iron in sediments.

3.4 Reese Creek

Discharge measurements were collected once each week on Reese Creek by resource management staff at Yellowstone between 17 May and 17 August 2005. Discharge measurements were collected from two locations: (1) just above the upper-most flume and (2) stream water flowing through the upper diversion ditch. The difference between these two readings will equal the amount of water entering the main channel of Reese Creek from the uppermost flume (table 6). The adjudicated water right stipulated that Reese Creek was to have a minimum flow of 0.037 m^3/sec between 15 April and October 15 during any given year. During 2005, discharge on Reese Creek ranged from 0.029 to 0.264 m^3/sec (table 6). Peak flow measurements were recorded on 22 June 2005 while the lowest discharge measurement was recorded on 21 July 2005 (table 6). Minimum flow requirements were not met on 3 of the 14 days sampled.

4.0 Management Implications

In addition to determining whether certain water quality parameters exceed state standards, the GRYN intends for the data gathered through this monitoring effort to assist resource managers with making well-informed decisions based on solid, scientific data regarding park water resources.

4.1 Shoshone River

Levels of both *E. coli* and fecal coliforms warrant continued monitoring and 303(d) listing of the section of the Shoshone River. Monitoring for *E. coli* is also recommended at swimming beaches

Table 4. Field parameter summary statistics for Soda Butte Creek at the northeast boundary of Yellowstone National Park, 2005

	Water temperature (°C)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Turbidity (NTU)	Total suspended solids (TSS; mg/L)
Observations (n)	22	22	22	22	22	21
Mean	5	9.32	8	164.92	6.66	0.01281
Minimum	-0.1	7.7	7.3	73	0.8	0.00068
Maximum	13.7	10.5	8.4	220	42.4	0.10832
Std. dev.	4.45	0.93	0.28	47.41	11.27	0.0292

Note: µS/cm = micro Siemens per centimeter; NTU = nephlometric turbidity units.

on Bighorn Lake. If this additional monitoring is continued in the future, data should be reviewed immediately after results are received to facilitate prompt closure of beaches where the state standards for contact recreation are exceeded.

The GRYN water quality specialist will inquire with the Wyoming Department of Environmental Quality representatives about the source of this contamination. Further study into the mammalian source of the contamination may be warranted.

Two changes will be made to the standard operating procedure for bacterial sampling and analysis to reduce the overall cost: (1) sampling for fecal coliforms will be discontinued in federal fiscal year 2006, though the State of Wyoming will monitor *E. coli* and (2) future samples will be analyzed in-house at Bighorn Canyon rather than sent to an analytical laboratory.

4.2 Bighorn River

No exceedances of the state standard for nitrate nitrogen were detected between June and September 2005. Lab results from sampling aquatic macroinvertebrates are not available yet and therefore the Montana impairment score has not been calculated for this station.

While the first four months of data look promising in that no exceedances in nitrate nitrogen were detected, sampling for nitrate nitrogen will continue at this station for at least another year but at a lesser frequency. Beginning in April 2006, the frequency will be quarterly rather than monthly.

4.3 Soda Butte Creek

It is recommended that monitoring water quality on Soda Butte Creek at the northeast park boundary be continued to establish seasonal and annual trends regarding basic field parameters, metal concentrations, and benthic macroinvertebrate communities. Although total metal concentrations appear to be minimal, Soda Butte Creek is still at risk of upstream contamination during an extreme flood event. Currently, state and federal agencies are participating in a long-term plan to remove the McLaren mine tailing from the streambed. Continued monitoring of Soda Butte Creek is imperative to evaluate current water quality conditions and to monitor changes, both favorable and adverse, that may occur in the event that the McLaren mine tailings are removed from the streambed.

Table 6. Stream flow discharge measurements on Reese Creek in Yellowstone National Park between June and September 2005

	(m^3/sec)		
Date	Upper Flume	Upper Diversion	Reese Creek
17 May	0.175	0.058	0.116
26 May	0.186	0.134	0.052
2 Jun	0.175	0.068	0.107
8 Jun	0.220	0.081	0.139
15 Jun	0.206	0.125	0.081
22 Jun	0.332	0.068	0.264
30 Jun	0.205	0.074	0.131
7 Jul	0.176	0.066	0.110
13 Jul	0.157	0.116	0.041
21 Jul	0.116	0.087	0.029[a]
28 Jul	0.109	0.076	0.032[a]
4 Aug	0.120	0.061	0.032[a]
11 Aug	0.109	0.064	0.044
17 Aug	0.100	0.066	0.034[a]

[a]Flows were below the minimum required flow of 0.037 m^3/sec.

4.4 Reese Creek

Water use rights surrounding Reese Creek continue to be a concern to Yellowstone resource managers. A minimum stream flow of 0.037 m^3/sec is required to maintain healthy fish and aquatic invertebrate populations. These low minimum streamflows seem to be of particular concern after spring runoff and during the heavy irrigation seasons of July and August. These reduced flows could ultimately affect the overall survival of resident fishes in Reese Creek. Continued monitoring of discharge during the summer months is important to conserving the native fish population and biological integrity of the park boundary stream.

Table 5. Field parameter summary statistics for Soda Butte Creek at the northeast boundary of Yellowstone National Park, 2005 Select metal concentrations on Soda Butte Creek at the northeast boundary of Yellowstone National Park between June and September 2005

				Measured Analyte			
Date	Matrix	Analysis	Time (MDST)	Arsenic	Copper	Iron	Selenium
17 Jun	Aqueous (µg/L)	Dissolved metals	0904	<8	<3	112	<20
			1846	<8	<3	85	<20
		Total metals	0904	<8	3	658	<20
			1846	<8	11	3,270	<20
22 Sep	Aqueous (µg/L)	Dissolved metals	0917	<8	<3	55	<20
			1809	<8	<3	51	<20
		Total metals	0917	<8	<3	219	<20
			1809	<8	<3	237	<20
22 Sep	Sediment (mg/kg)	Total metals	1809	<5	17	14,000	<5

5.0 Acknowledgements

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