



Water Quality Monitoring in the Northern Colorado Plateau Network, 2005–2007

Natural Resource Technical Report NPS/NCPN/NRTR–2008/117



ON THE COVER

Clockwise from upper left: Halls Creek Narrows, Capitol Reef National Park; conducting pH calibration on North Creek, Zion National Park; Gunnison River at East Portal, Black Canyon of the Gunnison National Park; sampling in Blue Creek, Curecanti National Recreation Area; Curecanti Creek, Curecanti National Recreation Area. NPS photos.

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Contents

- Figures v
- Tables vii
- Acronyms and Abbreviations ix
- Executive Summary xi
- Acknowledgements xiii
- 1 Introduction 1
 - 1.1 Background..... 1
 - 1.2 Report Scope and Objectives 3
- 2 Methods.....5
 - 2.1 Study Areas 5
 - 2.2 Laboratory and Field Methods 5
 - 2.3 Partnerships 5
 - 2.4 Understanding Water-Quality Data and Criteria 6
- 3 Results, Discussion, and Management Implications 7
 - 3.1 Arches National Park 7
 - 3.2 Black Canyon of the Gunnison National Park 10
 - 3.3 Bryce Canyon National Park..... 12
 - 3.4 Canyonlands National Park..... 12
 - 3.5 Capitol Reef National Park..... 16
 - 3.6 Curecanti National Recreation Area 20
 - 3.7 Dinosaur National Monument..... 22
 - 3.8 Zion National Park..... 26
- 4 Literature Cited 29
- Appendix A. NCPN Sites Sampled 2005–2007, with Location and Date of Last Site Visit
Used in this Report.....31
- Appendix B. Petition to Change Use Classification of North Fork Virgin River.....33
- Appendix C. Parameter Summary for Sites in NCPN Park Units Monitored January 2005
through July 2007 35

Figures

Figure 1.1. Northern Colorado Plateau Network parks and park units monitored, 2005–2007..... 2

Figure 3.1. Water-quality sites sampled in Arches National Park, 2005–2007. 8

Figure 3.2. Water-quality sites sampled in Black Canyon of the Gunnison National Park, 2005–2007..... 11

Figure 3.3. Water-quality sites sampled in Bryce Canyon National Park, 2005–2007..... 13

Figure 3.4. Water-quality sites sampled in Canyonlands National Park, 2005–2007. 15

Figure 3.5. Water-quality sites sampled in Capitol Reef National Park, 2005–2007. 18

Figure 3.5.4-1. Time-series water temperature profile created for interpretive staff at Capitol Reef National Park to inform hikers entering the Halls Creek Narrows. 19

Figure 3.5.4-2. Total phosphorus concentration, Fremont River at U12 crossing sample site, October 1986–June 2001. 19

Figure 3.6. Water-quality sites sampled in Curecanti National Recreation Area, 2005–2007..... 21

Figure 3.7. Water-quality sites sampled in Dinosaur National Monument, 2005–2007. 24

Figure 3.7.4. Historical total phosphorus concentrations (1977–2002) on the Green River (A), including and (B) excluding water-quality data from the monitoring station at Green River near Jensen, Utah..... 25

Figure 3.8. Water-quality sites sampled in and near Zion National Park, 2005–2007. 27

Tables

Table 3.1. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Arches National Park, 2005–2007.	7
Table 3.2. Exceedances of water-quality standards established by the State of Colorado for surface water-quality sites sampled in Black Canyon of the Gunnison National Park, 2005–2007.	10
Table 3.4. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Canyonlands National Park, 2005–2007.	14
Table 3.5. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Capitol Reef National Park, 2005–2007.	17
Table 3.6. Exceedances of water-quality standards established by the State of Colorado for surface water-quality sites sampled in Curecanti National Recreation Area, 2005–2007.	20
Table 3.7. Exceedances of water-quality standards established by the states of Colorado and Utah for surface water-quality sites sampled in Dinosaur National Monument, 2005–2007.	23
Table 3.8. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Zion National Park, 2005–2007.	26

Acronyms and Abbreviations

General acronyms and abbreviations

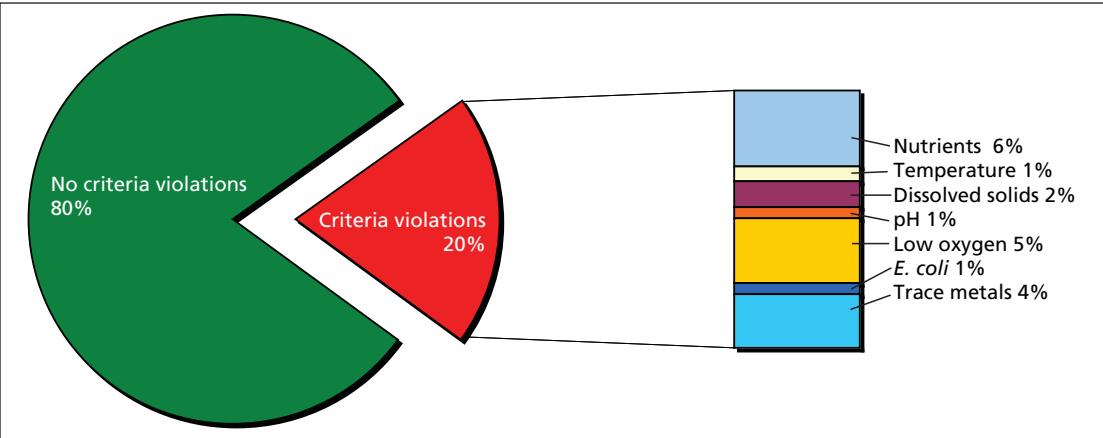
303(d)	Section 303(d) of Clean Water Act, requiring a reporting of waters not meeting criteria
CO	Colorado
CWA	Clean Water Act
DO	dissolved oxygen
<i>E. coli</i>	<i>Escherichia coliform</i> bacteria
EPA	U.S. Environmental Protection Agency
GPRA	Government Performance and Results Act
mg/L	milligrams per liter
NPS	National Park Service
NCPN	Northern Colorado Plateau Network
NWQL	National Water Quality Laboratory
ONRW	Outstanding Natural Resource Waters
OHV	off-highway vehicle
SOP	standard operating procedure
TDS	total dissolved solids
TMDL	total maximum daily loading
µg/L	micrograms per liter
U12	Utah Highway 12
UT	Utah
UDWQ	Utah Division of Water Quality
UDEQ	Utah Department of Environmental Quality
USGS	U.S. Geological Survey

Acronyms for NPS entities

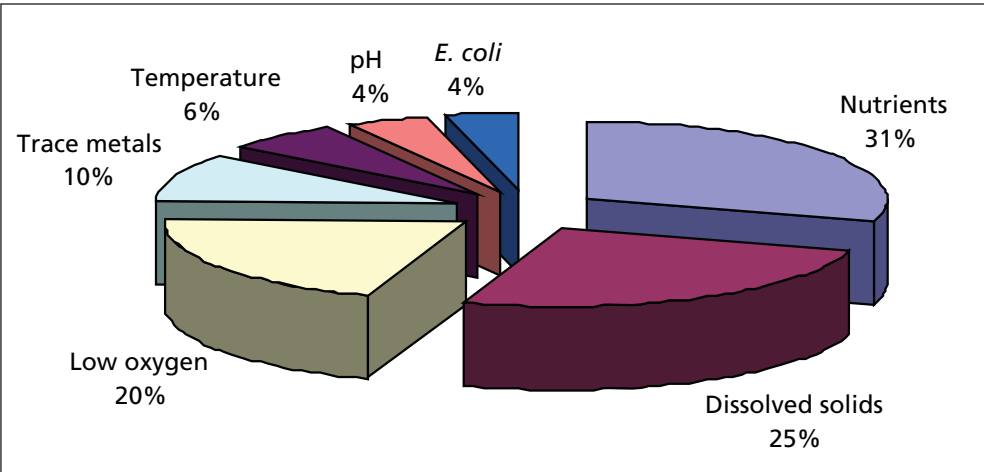
ARCH	Arches National Park
BLCA	Black Canyon of the Gunnison National Park
BRCA	Bryce Canyon National Park
CANY	Canyonlands National Park
CARE	Capitol Reef National Park
CURE	Curecanti National Recreation Area
DINO	Dinosaur National Monument
HOVE	Hovenweep National Monument
NABR	Natural Bridges National Monument
NCPN	Northern Colorado Plateau Network
SEUG	Southeast Utah Group (includes ARCH, CANY, HOVE, and NABR)
ZION	Zion National Park

Executive Summary

Water-quality monitoring in Northern Colorado Plateau Network parks is made possible through partnerships between the National Park Service's Inventory and Monitoring Program, individual park units, the U.S. Geological Survey, and the State of Utah's Division of Water Quality. This report evaluates data from 916 site visits made at 47 different locations on NCPN streams and rivers in 8 NCPN park units between January 1, 2005 and July 31, 2007. Evaluation of water-quality parameters relative to state water-quality criteria indicated that 180 (19.7%) site visits exceeded state water-quality criteria for one or more parameters. While some exceedances were reoccurring and may have been caused by human activities in the watersheds, many were due to naturally occurring conditions characteristic of the geographic setting. The most common exceedances, in order of abundance, were due to elevated nutrients, low dissolved oxygen, elevated trace metals, elevated total dissolved solids, elevated temperature, elevated pH, and elevated bacteria (*E. coli*) (see figures). In general, water-quality parameters fell within expected ranges for the sites relative to historical results. That is, sites that did not meet water-quality criteria still did not, and sites that did meet water-quality criteria continued to meet water-quality criteria. Water bodies whose natural conditions preclude their meeting assigned water-quality standards could be re-evaluated with respect to natural conditions and their assigned designated-use class.



Percentage of site visits that had water-quality criteria violations and cause of violation at selected sites sampled in NCPN park units, 2005–2007.



The stacked bar from above, expanded in pie-chart form here, illustrates the most common water quality exceedances in NCPN parks, 2005–2007.

The NCPN water quality monitoring program achieved the following milestones in 2007:

- 1) Petitioned Utah Division of Water Quality to upgrade classification of North Fork Virgin River from secondary-contact to primary-contact recreation. Reclassification pending.
- 2) Utah Division of Water Quality removed North Creek from 303(d) list of impaired water bodies in 2007.
- 3) Completed peer review of water-quality protocols, December 2007.

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Thanks to Julianne Brown (USGS), who built and imported most of the recent data to the NCPN water-quality database, and who provided constructive comments on this report. Russ DenBleyker (NPS-NCPN) also imported data and helped develop report functions in Access. Trisha Solberg and Kirby Wynn (USGS) helped with interpretations for the Colorado data, and Dave Sharrow (NPS-ZION) helped every step of the way, from program development through data interpretation. Alice Wondrak Biel helped with editing and formatting. Special thanks go to Jeff Ostermiller, Arne Hultquist, Amy Dickey, and Tom Toole (Utah Division of Water Quality) for providing laboratory analysis, data management, and consultation.

1 Introduction

1.1 Background

The National Park Service's Inventory and Monitoring Program is designed to provide park managers with information they need to perform science-based management of natural resources. Under the program, 32 networks of parks in geographic proximity and with similar ecological processes have been organized to support the development of integrated park natural resource inventory and monitoring programs and other strategic stewardship actions. The program is structured around the inventory and monitoring of park "vital signs"—chemical, biological, and physical factors that determine the health of park ecosystems.

Service-wide goals for vital-signs monitoring include the following:

1. Determine status and trends in selected indicators of the condition of park ecosystems, in order to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources;
2. Provide early warning of abnormal conditions of selected resources to help managers develop effective mitigation measures and reduce costs of management;
3. Provide data that will help managers to better understand the dynamic nature and condition of park ecosystems, and provide reference points for comparisons with other altered environments;
4. Provide data that will help managers to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment; and
5. Provide a means of measuring progress toward performance goals.

The Northern Colorado Plateau Network (NCPN) consists of 16 park units in Utah, Colorado, Arizona, and Wyoming (Figure 1.1). Through comprehensive scoping processes, water quality and quantity were identified as vital signs that should be monitored. The water-dependent ecosystems in these unique landscapes are protected by the National Park Service (NPS) Organic Act, *NPS Management Policies*, and the Clean Water Act (CWA).

Under authority of the U.S. Environmental Protection Agency (EPA), U.S. states have developed a regulatory system under the CWA that provides for specific concentrations or measures for water-quality constituents that protect a class of uses. The protected uses vary by state, but generally include irrigated agriculture, domestic water supply, cold-water aquatic life, warm-water aquatic life, water-based recreation, and livestock watering. Pristine and high-quality water bodies in national parks are further protected by the NPS Organic Act, *NPS Management Policies*, and the antidegradation provision of the CWA.

1.1.1 Program justification

In order to mitigate past and future threats to park water resources, managers need objective information on status and trends in surface-water quality and quantity.

1.1.2 NPS Management Policies

Section 4.3.6 of *NPS Management Policies* sets forth expectations for park managers regarding water resources (NPS 2006):

The pollution of surface waters and groundwaters by both point and non-point sources can impair the natural functioning of aquatic and terrestrial ecosystems and diminish the utility of park waters for visitor use and enjoyment. The Service will determine the quality of park surface and groundwater resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside the parks. The Service will

- a) work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for the protection for park waters;
- b) take all necessary actions to maintain or restore the quality of surface waters and groundwaters within the parks consistent with the Clean Water Act and all other applicable Federal, State, and local laws and regulations; and
- c) enter into agreements with other

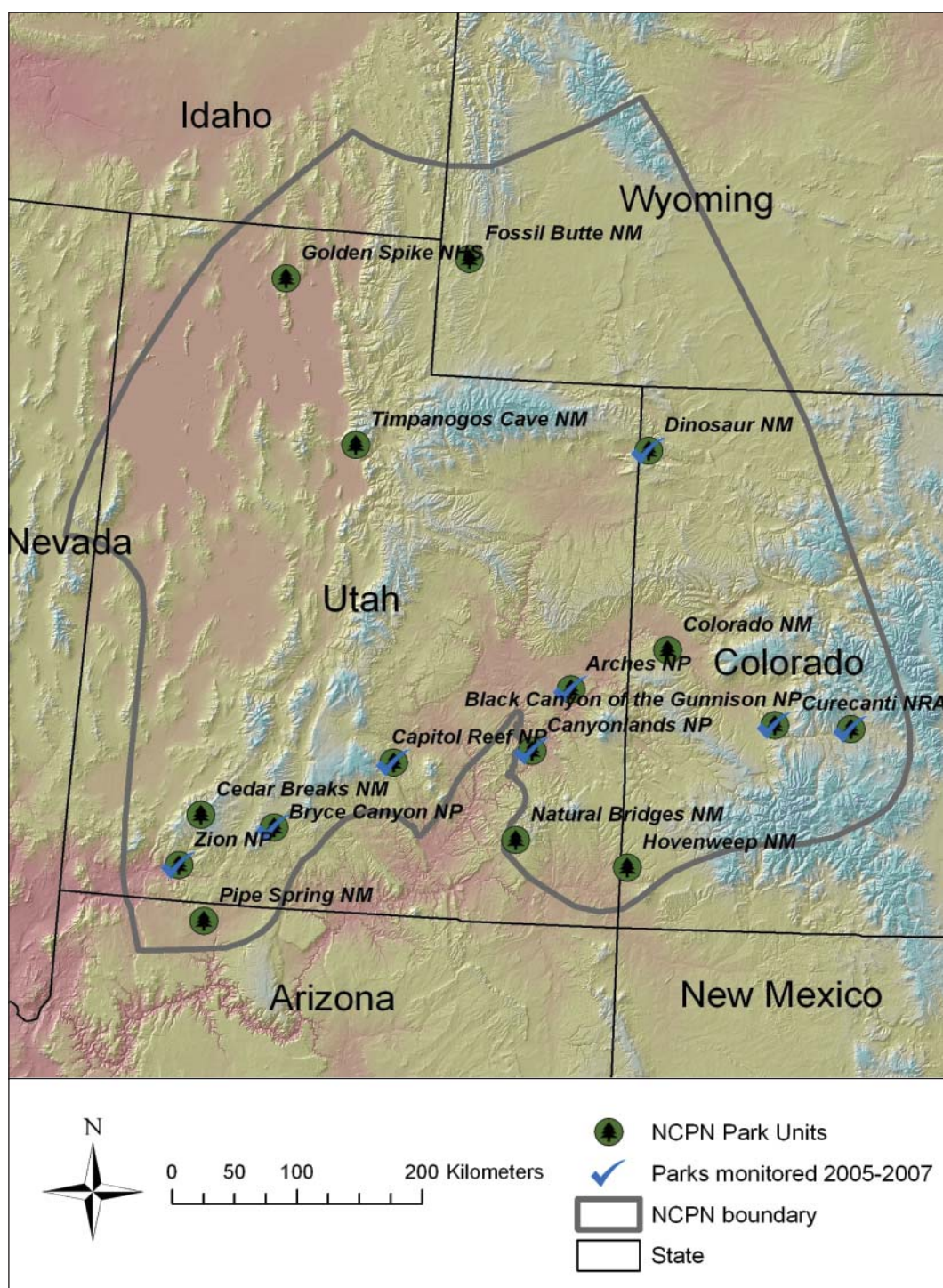


Figure 1.1. Northern Colorado Plateau Network parks and park units monitored, 2005–2007.

agencies and governing bodies, as appropriate, to secure their cooperation in maintaining or restoring the quality of park water resources.

1.1.3 Long-term monitoring objectives

Measurable objectives of this long-term monitoring program focus on status and trends in water-quality parameters, and include the following:

- a) Establish range and variability of water-quality parameters under base flow conditions as they vary with seasonal and climatic conditions using descriptive statistics.
- b) Determine status and trends in selected water-quality parameters as a function of flow, season, and climatic conditions, using trend-analysis techniques.
- c) Compare water-quality data against state criteria for acute and chronic exceedance on a monthly basis.
- d) Analyze long-term data for designation as Outstanding Natural Resource Waters (ONRW).
- e) Determine point and nonpoint sources of pollution within watersheds via association with ancillary data or knowledge of land-management practices or activities in the watersheds.

1.1.4 Management outcomes

The knowledge gained by achieving the measurable objectives (see Section 1.2) will be used to evaluate and report on the condition of water bodies in NCPN park units. Additionally, it can be used to inform management of water resources in order to:

- a) Maintain waters that vary within their natural chemical and biological ranges and meet applicable federal and state water-quality criteria.
Justification: Waters that vary within their natural ranges can typically support healthy aquatic ecosystems and most beneficial uses.

- b) Improve water quality of impaired waters.
Justification: The NPS GPRA goal is that 99.3% of streams and rivers managed by the NPS will meet state and federal water-quality standards.

- c) Demonstrate and maintain high water quality where it exists.
Justification: The antidegradation provision of the Clean Water Act specifies that high-quality waters will be maintained (EPA 2006; section 303).

1.2 Report Scope and Objectives

This is the first in a series of annual reports on activities and results of the NCPN stream and river water-quality monitoring program. It focuses on sites monitored by the NCPN and selected sites monitored by cooperating hydrologists and agencies working in and near NCPN parks. Although long-term data records exist for some of these sites, the period considered in this report is from January 1, 2005 through the most current available record for each site in the NCPN water-quality database as of October 1, 2007.

NOTE: Not all site data collected during this period are available for analysis or entered in the NCPN water-quality database. For example, site visits were made at Natural Bridges NM and Hovenweep NM during this period, but the data were not available at the time of writing. Those data will be included in the next annual report.

The objectives of this report are (1) to evaluate water-quality criteria exceedances, and (2) to provide descriptive statistics for the time period specified. A more comprehensive report on trends will be made in the fourth year of monitoring, after the third year of monitoring data has been compiled. At that time, the entire data record will be considered in analysis.

2 Methods

2.1 Study Areas

The target population is a subset of potential day-time water-quality measurements in perennial streams and rivers, selected through a judgmental or targeted process involving the participation of park resource managers, NCPN staff, U.S. Geological Survey (USGS) staff, and other water-quality specialists (O'Dell et al. 2005; Thoma et al. 2007).

Specific water sources were selected based on the following hierarchy:

- a) **303(d)-listed waters**, where previous sampling indicated that one or more parameters regularly approached or exceeded criteria or recommended levels.
- b) **Waters with demonstrated threat levels**, where an analysis of available data indicated that measured conditions regularly approached or exceeded criteria or recommended levels, but where the frequency of exceedance or the quality of the data did not support a 303(d) listing.
- c) **Data gaps:** Waters identified as important, but where little or no water-quality information existed.
- d) **Waters of management concern**, where past sampling may not have indicated constituent values of concern, but where anthropogenic activities indicated that contamination was a significant threat.
- e) **Other perennial waters** with no specific threat.

Perennial waters were preferentially selected over ephemeral or seasonal water sources because they support year-round ecological process and function and have established criteria that allow monitoring for CWA compliance. Forty-seven sites in eight NCPN units were sampled between January 1, 2005 and July 31, 2007 (see Figure 1.1 and Appendix A).

2.2 Laboratory and Field Methods

Approximately 30 parameters were measured for each site visit. The core parameters, or those measured in the field, included dissolved oxygen, pH, temperature, conductivity, and flow. Other

parameters measured in the laboratory from samples collected in the field fell into general categories, including metals, major ions, total chemistry, and bacteria.

Laboratory analytical methods are discussed in detail in SOPs 11–13 of the NCPN water-quality monitoring protocol. The NCPN ensures comparability of the laboratory data created by this monitoring program by using USGS National Water-Quality Laboratory (NWQL) methods for Colorado parks (SOP 12), and EPA standard methods or methods outlined in Standard Methods for Analysis of Water and Wastewater for Utah parks (APHA, 1998; SOP 13). More detail regarding the quality-control process for NWQL and the Utah Environmental Laboratory (which includes the Water-Quality Laboratory) is provided in SOP 7, Appendices A and B.

Field methods used to collect data for this report are outlined in the NCPN Standard Operating Procedures (SOPs) for Water Quality (Thoma et al. 2007). Specifically, SOPs 3–11 outline the techniques for measurement of core parameters and sample collection and handling in the field.

2.3 Partnerships

The water-quality monitoring program is a collaborative venture between the NCPN, Black Canyon of the Gunnison National Park (BLCA), Curecanti National Recreation Area (CURE), the Southeast Utah Group (SEUG), the USGS, and the Utah Division of Water Quality (UDWQ). NCPN and SEUG staff conduct field work and deliver samples to the Utah Department of Environmental Quality (UDEQ) Laboratory according to a partnership agreement between the NPS and UDWQ. BLCA and CURE conduct field work and have laboratory analysis conducted at the National Water Quality Laboratory (NWQL) in Lakewood, Colorado, via agreements with the USGS. Dinosaur National Monument (DINO) sites are visited by USGS staff, who deliver samples to the NWQL for laboratory analysis. Other nearby sites (outside park boundaries) that are routinely monitored by the states of Colorado and Utah are also considered. Regardless of which entity does field work or laboratory analysis, the data are stewarded through the NCPN database, which was used for this analysis.

2.4 Understanding Water-Quality Data and Criteria

The sampling methodology used in the NCPN water-quality monitoring program has implications in data interpretation for management. Monthly grab samples represent conditions at the point and time of sampling; they do not represent the condition of the entire water body, spatially or temporally. Samples are routinely collected several times per year in order to build a database that represents the range of conditions that occur, with a focus on base flow conditions. Thus, rare and short-term events are often not captured.

For a single parameter, water-quality criteria are written for potential effects of both chronic exposure over an extended period of time (months), or for acute exposure over a short period of time (hours or days). Permitted levels are much lower for chronic exposure than for acute exposure. Criteria for chronic exposure are not directly comparable to the results obtained from a one-time monthly grab sample. From a compliance standpoint, the acute instantaneous criteria afford the only direct comparison for such data. However, from a resource-conservation standpoint, instantaneous grab-sample data, when compared against more stringent chronic criteria, can provide a means of early warning and an indication of a problem that may require more attention. For these reasons, both chronic and acute criteria were evaluated in this report.

When criteria for a parameter differ by designated beneficial use or within a use class by aquatic-life stage, the more stringent standard value is used as the basis for comparison in this report. The goal is to provide advance warning of an impending problem before it becomes severe.

The State of Utah does not have criteria for total phosphorus (Tom Toole, pers. comm. 12/20/07). Rather, the value of 0.05 mg/L is used as an indication of impairment when dissolved oxygen concentrations are also low. Phosphorus concentrations above 0.05 mg/L indicate that further assessment is warranted, in the form of corroborating evidence that eutrophication is a problem at sites with high total phosphorus. Corroborating evidence may include other chemical parameter values associated with eutrophication, as well as supporting bioassessments.

The National Park Service does not have regulatory authority over waters in U.S. states, or even the authority to evaluate beneficial designated use. For that reason, this report compares water-quality data to beneficial designated use criteria without stating whether a beneficial designated use was attained. Those designations are left to states, in their triennial 305(b) reports to congress. However, the NPS participates with states in collecting data used in the protection of water bodies under state jurisdiction.

3 Results, Discussion, and Management Implications

3.1 Arches National Park

Four of seven sites monitored in Arches National Park (ARCH) during the period covered by this report had no water-quality exceedances or indication of impairment. These sites included Freshwater Spring in Salt Wash, Sleepy Hollow Spring, (D-24-21)20CAD-S1, and (D-23-22)47CAB-S1. The latter two are sites sampled by the Utah Division of Water Quality. Three of seven sites sampled had State of Utah water-quality exceedances (Table 3.1, Figure 3.1). The following discussion focuses only on sites that had exceedances.

3.1.1 Courthouse Wash

Near its confluence with the Colorado River, Courthouse Wash had exceedances for dissolved oxygen (DO), total phosphorus, and temperature for 8%, 50%, and 8% of site visits, respectively. The DO exceedances were below the four-day average standard value for warm-water game fish. Total phosphorus was greater than the indication for impairment for secondary-contact recreation and early life stages of warm-water game fish. Temperature exceeded the one-day average for warm-water game fish.

3.1.2 Upper Courthouse Wash

There were exceedances for DO and temperature near the west boundary, where Courthouse Wash enters the park, for 7% of site visits. The DO exceedances were below the minimum standard value for warm-water game fish. Temperature exceeded the one-day average for warm-water game fish. Sampling at this site was only conducted a few times, and has been discontinued.

3.1.3 Salt Wash at Wolfe Ranch

Salt Wash at Wolfe Ranch had exceedances for DO, total phosphorus, and total dissolved solids for 9%, 30%, and 82% of site visits, respectively. Dissolved oxygen concentrations were below the one-day average for early aquatic life stages. Total phosphorus was greater than the indication for impairment for secondary-contact recreation and early life stages of warm-water game fish. Total dissolved solids were greater than the maximum allowed for agricultural uses.

3.1.4 Discussion

Dissolved oxygen concentrations measured as below criteria typically occur in summer, during

Table 3.1. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Arches National Park, 2005–2007.

Site	Exceedances	Visits	% visits exceeded standard	Constituent	Use code	Standard	Units
Courthouse Wash (near Moab, UT)	2	24	8%	Dissolved oxygen	3B	6	mg/l
	3	6	50%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l
	2	24	8%	Temperature, Water	3B	27	deg C
Upper Courthouse Wash (near park boundary)	1	7	14%	Dissolved oxygen	3B	4	mg/l
	2	7	29%	Temperature, Water	3B	27	deg C
Salt Wash at Wolfe Ranch	2	23	9%	Dissolved oxygen	3B	5	mg/l
	3	10	30%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l
	18	22	82%	Total dissolved solids	4	1,200	mg/l

Use codes: 2B = secondary-contact recreation; 3B = warm-water game fish; 4 = agricultural uses

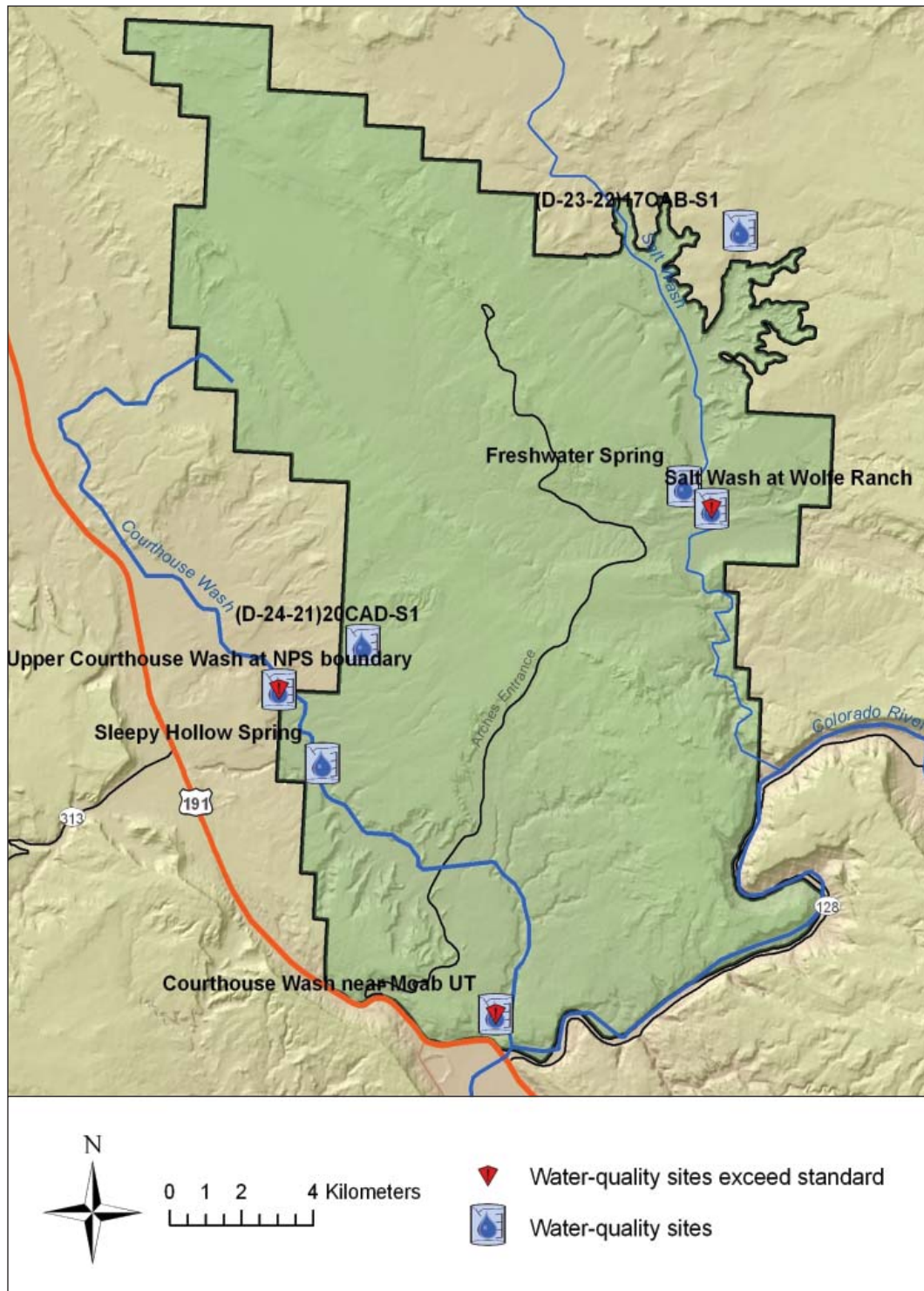


Figure 3.1. Water-quality sites sampled in Arches National Park, 2005–2007.

low-flow conditions when water temperatures are high and surface flow is low, resulting in stagnant pools. Decomposition of organic matter depletes oxygen, and warm water reduces the amount of oxygen that can remain dissolved. High water temperatures are expected in unshaded reaches during summer periods of low flow. Dissolved solids likely have a geologic origin, as there are few human activities near Salt Wash. These results are consistent with 10 years of sampling in ARCH described by Schelz and Moran (2004).

Phosphorus levels above the indication for impairment should be evaluated in consideration of commensurate DO concentrations and in light of surrounding land uses, potential geologic sources, and seasonal flow patterns. The Courthouse Wash sample site near Moab, Utah, is approximately 1 km upstream from the park's southern boundary (see Figure 3.1), and the wash flows into the Colorado River a few hundred meters beyond this boundary. Courthouse Wash, though a perennial pool at the sample site, is an intermittent stream; there is commonly flow into the sampling pool and for several hundred meters upstream from the site. In springtime, the wash commonly has low flow for its entire 10–15-mile length through ARCH, but occasionally flows high after large rain events. These events usually happen a few times per year, usually in late summer or fall.

There is no off-highway vehicle (OHV) use permitted in the immediate area around the Courthouse Wash sample site, and only once every several years does a cow trespass there. Trespass cattle and, to a lesser extent, trespass OHVs have been common in Courthouse Wash generally, but have usually accessed the wash at its entrance to the park, more than 10 miles upstream from this sample site. There is OHV use and cattle grazing in the headwaters at least 20 miles upstream, but this lower part of the stream only flows after large rain events.

A causal relationship between land use and total phosphorus in Courthouse Wash is difficult to ascertain. However, before assuming that a geologic source is responsible for the high phosphorus, a more careful evaluation of phosphorus levels, flow, and DO is necessary. Antecedent flows inferred from weather stations at the ARCH visitor center and the weather station at the Canyonlands Field airport, near the headwaters of Courthouse Wash, will be useful in this respect.

Another action that might help us to discern the

source of phosphorus in Courthouse Wash would be to re-initiate water-quality monitoring at Upper Courthouse Wash. Results from the upper and lower sites could then be evaluated for increases in total phosphorus in the downstream direction, which might indicate a source in the park.

3.1.5 Management implications

Many of the standard exceedances for water bodies in ARCH are likely due to naturally occurring conditions, and result from the application of use designations to water bodies in ARCH that are better suited to perennial flows than to the intermittent flow commonly observed in the park during the summer. Additionally, the presence of salt-bearing geologic layers near the surface results in unique conditions that may allow the exemption of Salt Wash from total dissolved solids (TDS) criteria. In cooperation with the State of Utah, a thorough evaluation of Salt Wash with respect to its assigned designated beneficial use and geologic setting should be made using a longer data record. Depending on the outcome of the investigation, the water body could be reclassified to a different designated beneficial use, or could be considered for site-specific criteria based on the 90th percentile of historical observations. In fact, most of the sites in ARCH are good candidates for these considerations because of the unique geologic setting and predominantly intermittent streams that may contribute constituent loads that are naturally elevated and persistently exceed criteria. The Outstanding Natural Resource Waters (ONRW) provision of the Clean Water Act may provide a means of establishing water-quality criteria specific to this setting.

The sample site at Upper Courthouse Wash is just outside the fence delineating the ARCH boundary. It is not clear if the fence is actually on the property boundary (Mary Moran, pers. comm.), and seasonal OHV and cattle use at the site is evident. The fence was erected in 2003, to address ongoing issues of cattle and, to a lesser extent, OHV trespass into the park in this area. Most of the cattle trespass events into the Courthouse Wash drainage originated in this area. The fence has successfully excluded almost all OHV trespass, and lowered the frequency of cattle trespass events to approximately one event per year or less. The most common entry point was at a flood fence across the wash a few hundred meters downstream from the sample site. A flood event in May 2004 piled enough debris against the flood fence that at least 38 cattle were able to walk over

the debris and into the park. In early 2006, a few motorcyclists swung the fence out of the way and penetrated several miles down Courthouse Wash. To further minimize these trespass events, park resource management staff who measure flow at this site each month have been checking the fence condition and reporting problems to rangers for the last few years.

3.2 Black Canyon of the Gunnison National Park

The Gunnison River below the Gunnison Tunnel had no water-quality exceedances during the period covered by this report. Two other sites had State of Colorado water-quality exceedances (Table 3.2, Figure 3.2). Only a few samples were collected and analyzed from Red Rock Creek during this period. The following discussion focuses only on sites that had exceedances.

3.2.1 Red Rock Canyon at mouth near Montrose, Colorado

At its mouth near Montrose, Red Rock Canyon had exceedances for dissolved selenium for 100% of site visits. Dissolved selenium exceeded the chronic and acute standard for warm-water aquatic life for all three site visits.

3.2.2 Red Rock Canyon near the NPS boundary near Montrose, Colorado

Near the NPS boundary near Montrose, Red Rock Canyon had exceedances for *E. coli*, selenium, and dissolved manganese for 80%, 100%,

and 50% of site visits, respectively. *E. coli* exceeded the standard for primary-contact recreation. Dissolved selenium exceeded the chronic and acute standard for warm-water aquatic life for all four site visits. Manganese occasionally exceeded the standard for drinking-water supply, which at 50 ug/L, is set for color and staining. The EPA's 300-ug/L human-health advisory level was not exceeded. No drinking water intakes occur within the park.

3.2.3 Discussion

Although selenium and manganese weather naturally from bedrock and soils in the drainage, statewide debate exists about the impact of irrigation on this weathering. The majority of Red Rock Creek's discharge is return flow from an upstream irrigation headgate. The concentration of manganese in these water bodies does not exceed criteria for aquatic life, and the drinking-water standard is for color and staining—not human health. Because there are no drinking-water intakes and the concentrations do not exceed human-health criteria, these concentrations are not problematic. Infrequent bacteria exceedances are not uncommon and could be due to wildlife, domestic animals, or human sources.

3.2.4 Management implications

As long as no drinking-water sources exist on the water bodies, it may be possible and logical to request exemptions or site-specific manganese criteria if sufficient evidence exists to make a strong case for naturally occurring manganese concen-

Table 3.2. Exceedances of water-quality standards established by the State of Colorado for surface water-quality sites sampled in Black Canyon of the Gunnison National Park, 2005–2007.

Site	Exceedances	Visits	% visits exceeded standard	Constituent	Use code	Standard	Units
Red Rock Canyon at mouth near Montrose, CO	3	3	100%	Selenium, Dissolved	19	4.6 (chronic)	ug/l
	3	3	100%	Selenium, Dissolved	19	18.4 (acute)	ug/l
Red Rock Canyon near NPS boundary near Montrose, CO	4	5	80%	<i>E. coli</i>	primary contact	126	cfu/100 mL
	4	4	100%	Selenium, Dissolved	19	4.6 (chronic)	ug/l
	4	4	100%	Selenium, Dissolved	19	18.4 (acute)	ug/l
	2	4	50%	Manganese, Dissolved	50	50	ug/l

Use codes: 19 = aquatic life warm-water class 2 (similar to class 1 but recognized as impaired); 50 = drinking-water supply

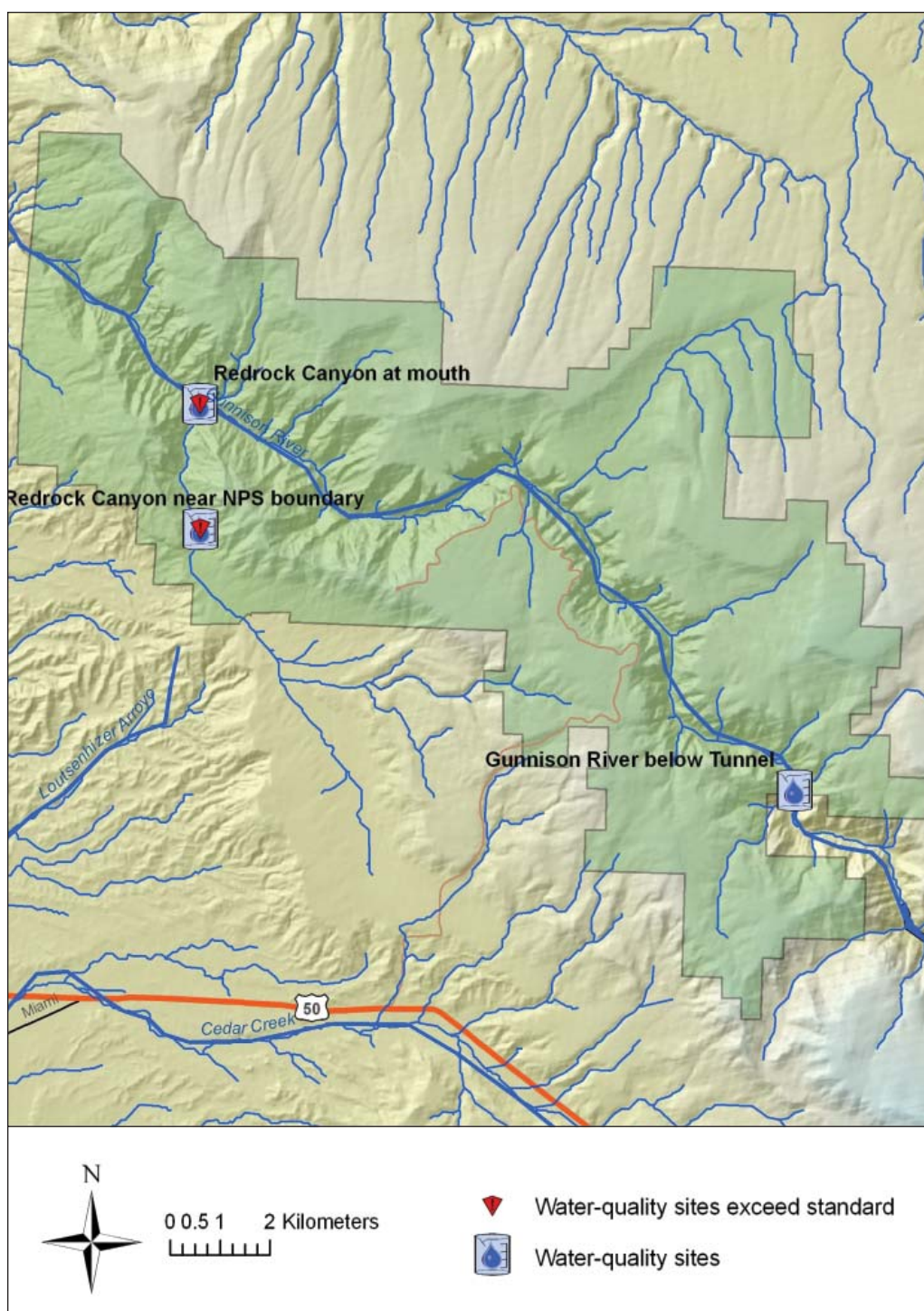


Figure 3.2. Water-quality sites sampled in Black Canyon of the Gunnison National Park, 2005–2007.

trations that exceed criteria. Such a change would not improve water quality, but would make accounting for exceedances more straightforward.

Selenium exceedances in Red Rock Canyon have been documented, and the tributary is included on the 303(d) list of impaired waters in Colorado. Selenium exceedances are ubiquitous throughout the Grand Valley, and Red Rock Creek is no exception. Given the heterogeneity of naturally occurring *E. coli* in aquatic systems, the frequency of monitoring and number of exceedances for the time period does not warrant management action, but continued monitoring at these sites is justified.

3.3 Bryce Canyon National Park

There were no State of Utah water-quality exceedances measured in Bryce Canyon National Park during the monitoring period covered in this report (Figure 3.3). However, there were occasional signs of cattle trespass in the riparian corridor.

3.3.1 Discussion

In part, Sheep and Yellow creeks were included in the NCPN monitoring plan because there are segments of the Paria River on the State of Utah's 303(d) list of impaired water bodies for total dissolved solids. Although TDS exceedances are common on these streams below the park boundary (Judd and Adams 2006), there were no exceedances observed at the park boundary during this period of sampling.

3.3.2 Management implications

During monthly monitoring visits, cattle were occasionally observed in the park along the riparian corridors of Sheep and Yellow creeks. Some were herded out of the park at the time of sampling, and both resource-management and law-enforcement personnel were alerted to their presence. After the fence was repaired on Sheep Creek in summer 2007, no other trespass cattle, nor sign of them, were observed in the park along Sheep Creek. In September 2007, a flood destroyed the boundary fence at Yellow Creek; this fence was still down as of December 2007. Repairing the fence could mitigate potential impacts caused by trespass cattle in the biologically rich riparian area along the stream.

3.4 Canyonlands National Park

Three of 12 sites monitored in Canyonlands National Park (CANY) during the period covered by this report had no water-quality exceedances. Those sites included Little Spring Canyon Creek, Loop Spring, and Maze Overlook Spring. Nine of 12 sites sampled during the period covered in this report had State of Utah water-quality exceedances (Table 3.4, Figure 3.4) or indication of impairment. Between 1 and 15 site visits were made at these sites during the evaluation period. The following discussion focuses only on sites that had exceedances.

3.4.1 Chocolate Drops Spring

Chocolate Drops Spring, in the Maze district, had a single exceedance for dissolved oxygen in July 2005, representing just 10% of site visits. The DO concentration was less than the standard for warm-water non-game fish.

3.4.2 Horseshoe Canyon

Horseshoe Canyon had exceedances for dissolved oxygen and indication for impairment due to total phosphorus for 25% of site visits. The DO concentration was less than the standard for warm-water non-game fish. The total phosphorus concentration was greater than the indication for impairment for secondary-contact recreation. The DO exceedances were in August and September 2005; the phosphorus exceedance was in May 2006.

3.4.3 Cave Spring

Cave Spring exceeded the indication for impairment for total phosphorus for 38% of site visits. Total phosphorus concentrations were greater than the indication for impairment for warm-water game fish.

3.4.4 Salt Creek near Crescent Arch

Salt Creek near Crescent Arch had exceedances for dissolved oxygen and an indication for impairment for total phosphorus. The DO concentration was less than the standard for warm-water game fish for 40% of site visits, and less than the standard for warm-water game fish early life stages for 33% of site visits. The total phosphorus concentration was greater than the indication for impairment for secondary-contact recreation and warm-water game fish for 33% of site visits.

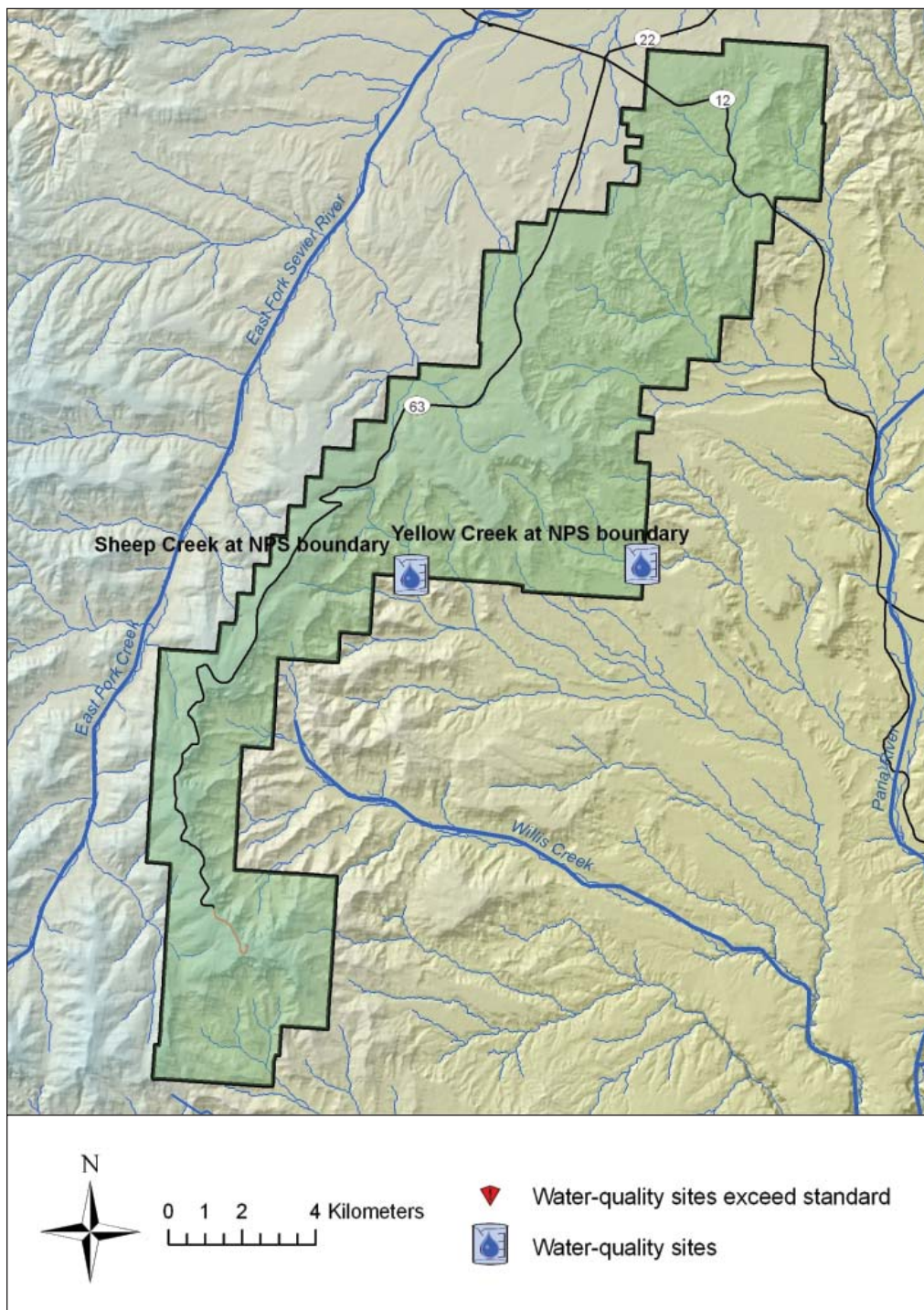


Figure 3.3. Water-quality sites sampled in Bryce Canyon National Park, 2005–2007.

Table 3.4. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Canyonlands National Park, 2005–2007.

Site	Exceedances	Visits	% visits exceeded standard	Constituent	Use code ¹	Standard	Units
Chocolate Drops Spring (Maze)	1	10	10%	Dissolved oxygen	3C	3	mg/l
Horseshoe Canyon (0.3 mi above confluence with Water Canyon)	2	8	25%	Dissolved oxygen	3C	3	mg/l
	1	4	25%	Phosphorus, Total (as P) - SW	2B	0.05	mg/l
Cave Spring	3	8	38%	Phosphorus, Total (as P) - SW	3B	0.05	mg/l
Salt Creek near Crescent Arch	5	15	33%	Dissolved oxygen	3B ²	3	mg/l
	6	15	40%	Dissolved oxygen	3B ³	5.5	mg/l
	1	3	33%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l
Salt Creek near Peekaboo Spring	1	3	33%	Boron, Dissolved	4	750	ug/l
	1	11	9%	Dissolved oxygen	3B	4	mg/l
	2	11	18%	Dissolved oxygen	3B	6	mg/l
	1	1	100%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l
Colorado River at Potash boat ramp	9	10	90%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l
Colorado River below Big Drop #3	2	9	22%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l
Green River above confluence with Colorado River	12	12	100%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l
Green River at Mineral Bottom	12	12	100%	Phosphorus, Total (as P) - SW	2B, 3B	0.05	mg/l

¹ Use codes: 2B = secondary-contact recreation; 3B = warm-water game fish; 3C = warm-water non-game fish; 4 = agricultural uses
² Dissolved-oxygen concentration for 1-day average, early life stages
³ Dissolved-oxygen concentration for 30-day average, all life stages

3.4.5 Salt Creek near Peekaboo Spring

Salt Creek near Peekaboo Spring had exceedances for dissolved boron and dissolved oxygen, and an indication for impairment for total phosphorus. The dissolved boron concentration was greater than the standard for agricultural use for 33% of site visits. The DO concentration was less than the standard for warm-water game fish for 18% of site visits, and less than the standard for warm-water game fish early life stages for 9% of site visits. The total phosphorus concentration was greater than the indication for impairment for secondary-contact recreation and warm-water game fish (data available from only one site visit).

3.4.6 Colorado River at Potash boat ramp

The Colorado River at Potash boat ramp exceeded the indication for impairment for total phosphorus for secondary-contact recreation and warm-water game fish for 90% of site visits.

3.4.7 Colorado River below Big Drop #3

The Colorado River below Big Drop #3 exceeded the indication for impairment for secondary-contact recreation and warm-water game fish for 22% of site visits.

3.4.8 Green River above confluence with Colorado River

The Green River above the confluence with the Colorado River had exceedances for total phosphorus for 100% of site visits. The total phosphorus concentration exceeded the indication for impairment for secondary-contact recreation and warm-water game fish.

3.4.9 Green River at Mineral Bottom

The Green River at Mineral Bottom had exceedances for total phosphorus for 100% of site visits. The total phosphorus concentration exceeded the indication for impairment for secondary-con-

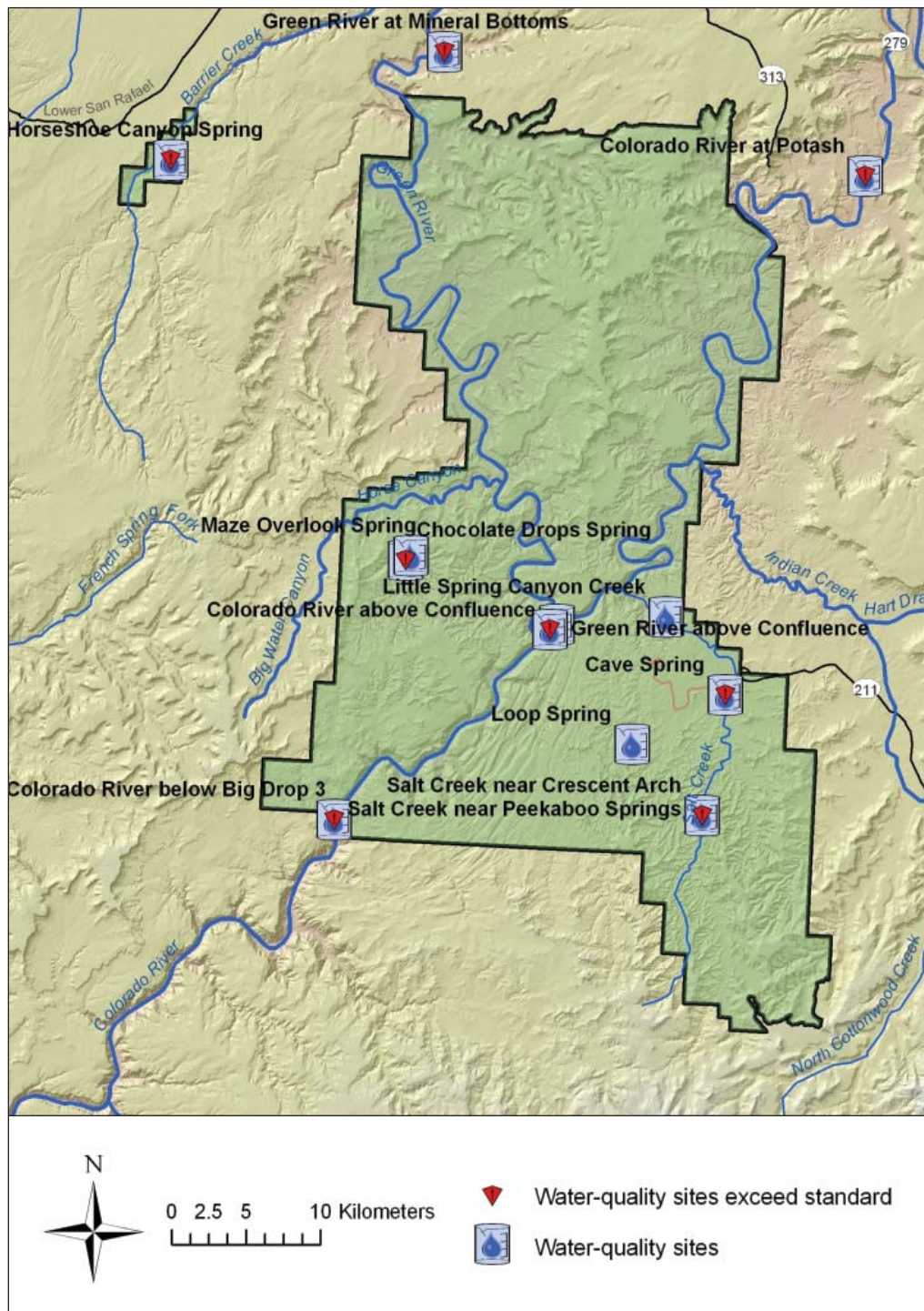


Figure 3.4. Water-quality sites sampled in Canyonlands National Park, 2005–2007.

tact recreation and warm-water game fish.

3.4.10 Discussion

The results from this monitoring period are consistent with 10 years of sampling in CANY described by Schelz and Moran (2005). In intermittent streams, dissolved oxygen concentrations measured as below criteria typically occur in summer, during low-flow conditions when water temperatures are high and surface flow is low, resulting in stagnant pools. Decomposition of organic matter depletes oxygen, and warm water reduces the amount of oxygen that can remain dissolved. High water temperatures are expected in unshaded reaches during periods of low flow.

Phosphorus may have a natural source in the smaller streams, because with the exception of Salt Creek, there are few human activities near these water sources. A number of studies have been underway in Salt Creek for the last several years to evaluate various effects of OHV use. A more thorough evaluation of phosphorus levels related to commensurate DO levels will provide a better understanding of phosphorus on biological processes.

Total phosphorus exceedances in small perennial and intermittent streams may result from rock weathering, airborne deposition, or soil erosion. Phosphorus comes in several forms, including a form sorbed to soil particles that may be transported to water bodies where dissolution can occur, resulting in phosphorus that is bioavailable. In the headwaters areas of these stream basins, soil-erosion rates on uplands may have been accelerated due to grazing, and may still be occurring if soil-surface crusts have not stabilized despite the absence of grazing for many years. Although speculative, this scenario may have important management implications. The other possibility is that phosphorus has a geologic origin and is naturally occurring at high levels due to weathering. A better understanding of phosphorus source, transport, and biological effect in these watersheds would help determine potential management actions, including the possibility of reclassifying or providing site-specific classifications for water bodies based on natural conditions.

Both the Colorado and Green rivers had phosphorus levels above the indication for impairment of unknown origin. An evaluation of phosphorus exceedances on the Green River indicated that the number of historical exceedances increased

markedly near Jensen, Utah (Figure 11). The source of phosphorus there is unknown and could be investigated to provide insight to the contributing sources of phosphorus measured downstream in CANY.

3.4.11 Management implications

The source of phosphorus could be investigated through literature review and evaluation of current and past human land-use practices in the watersheds, geologic formations, and nonpoint source distribution. If a likely source or sources cannot be identified in the current literature, the NPS could advance a regional study by partnering with academic institutions or the USGS. When park managers understand the source and mechanisms of pollutant transport to water bodies—and their potential biological impact—then management actions can be developed in cases where the pollutant has a human-caused source. If the source is outside the park, then managers can advocate for the resource when opportunities arise. Additionally, when investigations of the source and cause of pollutants determine that the pollutants are naturally occurring, the NPS can work with the state to reclassify water bodies or develop site-specific standards to better reflect natural conditions.

3.5 Capitol Reef National Park

Both sites sampled during the period covered in this report had State of Utah water-quality exceedances (Table 3.5, Figure 3.5). NCPN staff sampled Halls Creek, while the UDWQ sampled the Fremont River at the Utah Highway 12 (U12) crossing.

3.5.1 Halls Creek

Halls Creek below the Narrows had exceedances for dissolved oxygen for 6% of site visits. Dissolved oxygen was below the standard for warm-water game fish.

3.5.2 Fremont River at U12 crossing

The Fremont River at the Utah Highway 12 crossing had exceedances for phosphorus and pH for 17% and 8% of site visits, respectively. Total phosphorus exceeded the indication for impairment for domestic use, secondary-contact recreation, cold-water game fish, and agricultural use. The standard for pH was exceeded for the same designated uses.

Table 3.5. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Capitol Reef National Park, 2005–2007.

Site	Exceedances	Visits	% visits exceeded standard	Constituent	Use code ¹	Standard	Units
Halls Creek	1	18	6%	Dissolved oxygen	3B	6	mg/l
Fremont River at U12 crossing	2	12	17%	Phosphorus, Total (as P) - SW	1C, 2B, 3A, 4	0.05	mg/l
Fremont River at U12 crossing	1	12	8%	pH, High	1C, 2B, 3A, 4	9	Standard units

¹ Use codes: 1C = domestic use; 2B = secondary-contact recreation; 3A = cold-water game fish; 3B = warm-water game fish; 4 = agricultural uses

3.5.3 Discussion

At Halls Creek, the DO exceedance occurred after a flood of historic proportion in October 2006, when turbidity and temperature were both high. These conditions, perhaps in concert with organic-matter enrichment and decomposition (an oxygen-consuming metabolic activity), created conditions that temporarily led to the depletion. While rare, these large floods are a natural occurrence on this watershed, and the anoxic conditions following the flood were probably a natural occurrence. The following site visit, in November, showed a rebound to more normal conditions.

The elevated phosphorus levels in the Fremont River due to agricultural activities upstream from Capitol Reef National Park (CARE) have been well documented by the State of Utah, and the UDWQ has written a total maximum daily load (TMDL) plan approved by the EPA (UDWQ 2002). The TMDL plan for the Fremont River watershed upstream from CARE identifies the most likely sources of pollution and potential solutions. Thus far, approximately three miles of streambank stabilization have been completed between Bicknell and Grover, Utah, immediately upstream from the park. All management actions on private land are voluntary, with an opportunity for cost-sharing with the state. There are still many opportunities for implementing best management practices in the watershed that will improve water quality in CARE.

Human impact in the Halls Creek Narrows is limited, and visitors were present in the Narrows only a few times during site visits. A more

effective sampling strategy for capturing episodic human impacts to water chemistry would be to conduct continuous monitoring for bacteria or to evaluate future measurements against data collected thus far when human impacts may be more common and extensive. Generally speaking, human impacts would be difficult to detect via water chemistry alone. Turbidity caused by hikers in the stream clears in a few hours, and bacteria exceedances may be more associated with beaver activity than humans.

3.5.4 Management implications

When writing backcountry permits, visitor-center staff members have used monthly reports of temperature (Figure 3.5.4-1) and wading depths to inform the public about expected conditions. If concerns over visitor impact to the Halls Creek Narrows continue, continuous water chemistry monitoring could be implemented to detect transient impacts and bio-monitoring could be implemented to detect chronic impacts to biological resources.

In June 2007, the non-profit Wild Utah Project conducted a riparian-area assessment workshop upstream from Loa, Utah, and on two sections of the Fremont River in CARE. Participants included Wayne County commissioners, NPS staff, and local landowners. Bringing together entities with a common interest in shared water resources had a positive outcome. Participants evaluated the riparian areas using an objective set of criteria, and could see for themselves the state of the resource, which provided an incentive for working together (Stacey et al. 2007). The riparian-area assessment

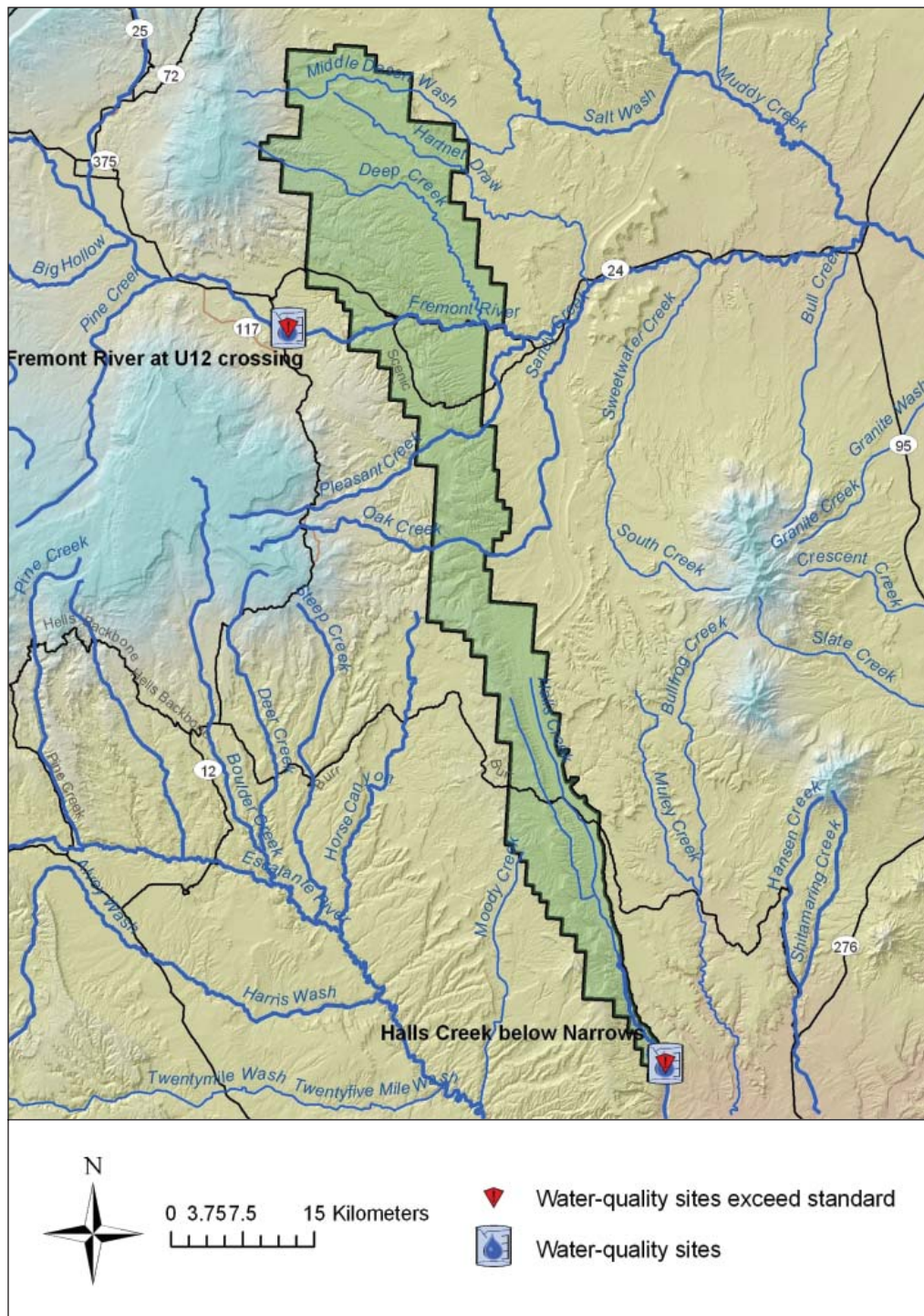


Figure 3.5. Water-quality sites sampled in Capitol Reef National Park, 2005–2007.

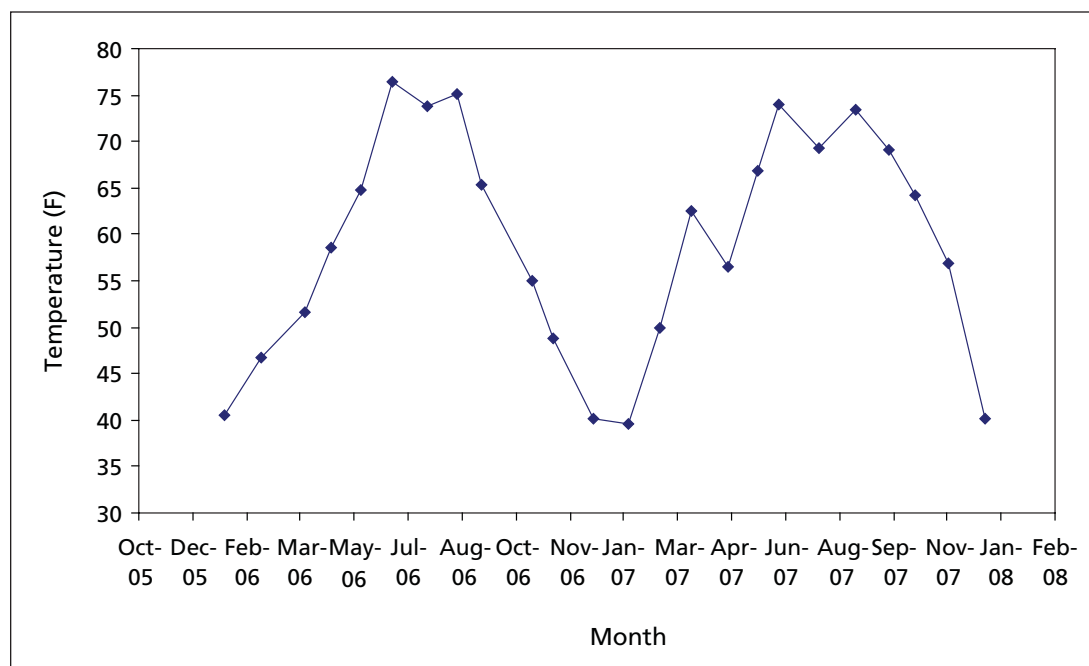


Figure 3.5.4-1. Time-series water temperature profile created for interpretive staff at Capitol Reef National Park to inform hikers entering the Halls Creek Narrows.

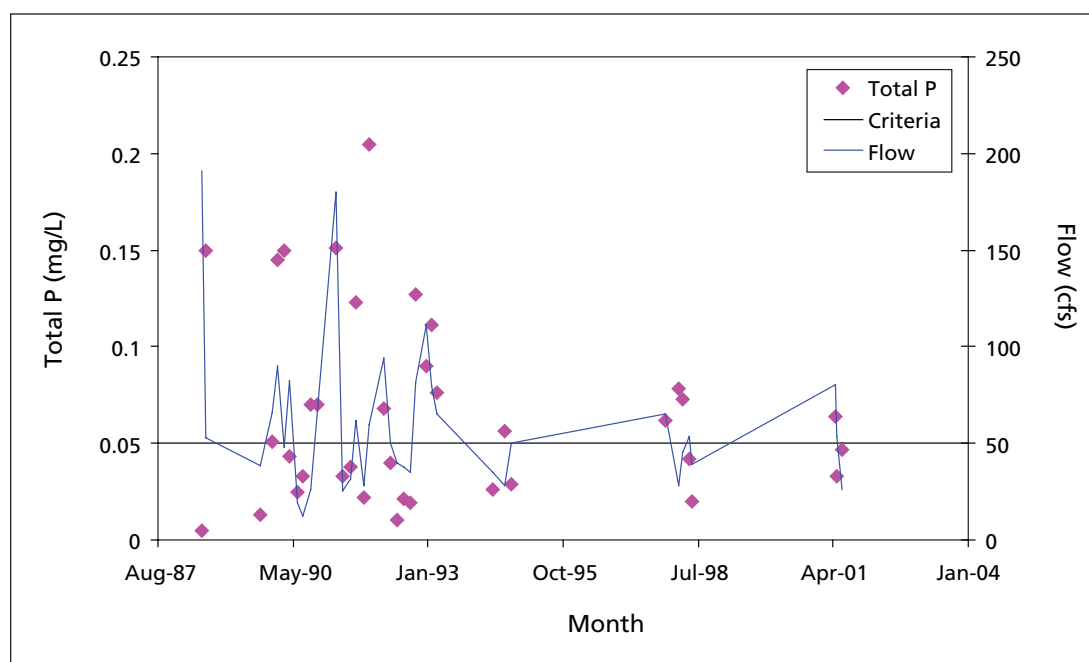


Figure 3.5.4-2. Total phosphorus concentration, Fremont River at U12 crossing sample site, October 1986–June 2001. Values above the horizontal black line exceed State of Utah water-quality standards for secondary contact and cold-water game fish species.

could become a starting point for continued co-operation and interaction between landowners, the state, and the NPS in the Fremont River watershed.

As best management practices are encouraged and implemented, changes in water quality may become apparent as fewer exceedances are detected during site visits (Figure 3.5.4-2). A weak positive relationship between total phosphorus concentration and flow ($r^2 = 0.09$) indicates generally higher pollutant loads with higher flows, which may indicate diffuse overland flow and redistribution in channels as a potential source.

3.6 Curecanti National Recreation Area

Eight of 13 sites monitored in Curecanti National Recreation Area (CURE) during the time period covered by this report did not have State of Colorado water-quality exceedances. These sites included the Gunnison River at County Road 32, Beaver Creek at U.S. Highway 50, West Elk Creek, Soap Creek above Chance Creek, Pine Creek at U.S. Highway 50, Lake Fork Gunnison River, and Cebolla Creek at Powderhorn. Five of 13 sites sampled during the period covered in this report had State of Colorado water-quality exceedances (Table 3.6, Figure 3.6). The following discussion focuses only on sites that had exceedances.

In most cases, the number of samples collected during the sampling period was not sufficient to evaluate chronic conditions or demonstrate a significant management issue. For some sites, data from as few as four visits were available. Sample frequency for most sites for this time period was inordinately low due to contracting difficulties, and may result in a higher percentage of exceedances than in most years. However, some episodic water-quality issues described in the following paragraphs have been noted previously. If those same conditions persist or worsen, management action may be warranted.

3.6.1 East Elk Creek near mouth (near Sapinero, CO)

East Elk Creek near its mouth, near Sapinero, Colorado, had exceedances for manganese greater than the chronic standard for drinking-water supply for 50% of site visits. There are no drinking-water supplies drawn from East Elk Creek within or outside CURE.

3.6.2 Red Creek near mouth (Sapinero, CO)

At the mouth of Red Creek, near Sapinero, exceedances were observed for dissolved manganese and *E. coli* for 50% and 16% of site visits, respectively. Dissolved manganese exceeded the standard for drinking-water supply. There are no

Table 3.6. Exceedances of water-quality standards established by the State of Colorado for surface water-quality sites sampled in Curecanti National Recreation Area, 2005–2007.

Site	Exceedances	Visits	% visits exceeded standard	Constituent	Use code ¹	Standard	Units
East Elk Creek near mouth (near Sapinero, CO)	6	12	50%	Manganese, Dissolved	50	50	ug/l
Red Creek near mouth (Sapinero, CO)	2	4	50%	Manganese, Dissolved	50	50	ug/l
	1	6	16%	<i>E. coli</i>	primary contact	126	cfu/100 mL
Blue Creek at Hwy 50 (near Sapinero, CO)	3	11	27%	<i>E. coli</i>	primary contact	126	cfu/100 mL
Cimarron River below Squaw Creek	3	11	20%	<i>E. coli</i>	primary contact	126	cfu/100 mL
Curecanti Creek near Sapinero, CO	1	4	25%	<i>E. coli</i>	primary contact	126	cfu/100 mL

¹ Use codes: 50 = drinking-water supply

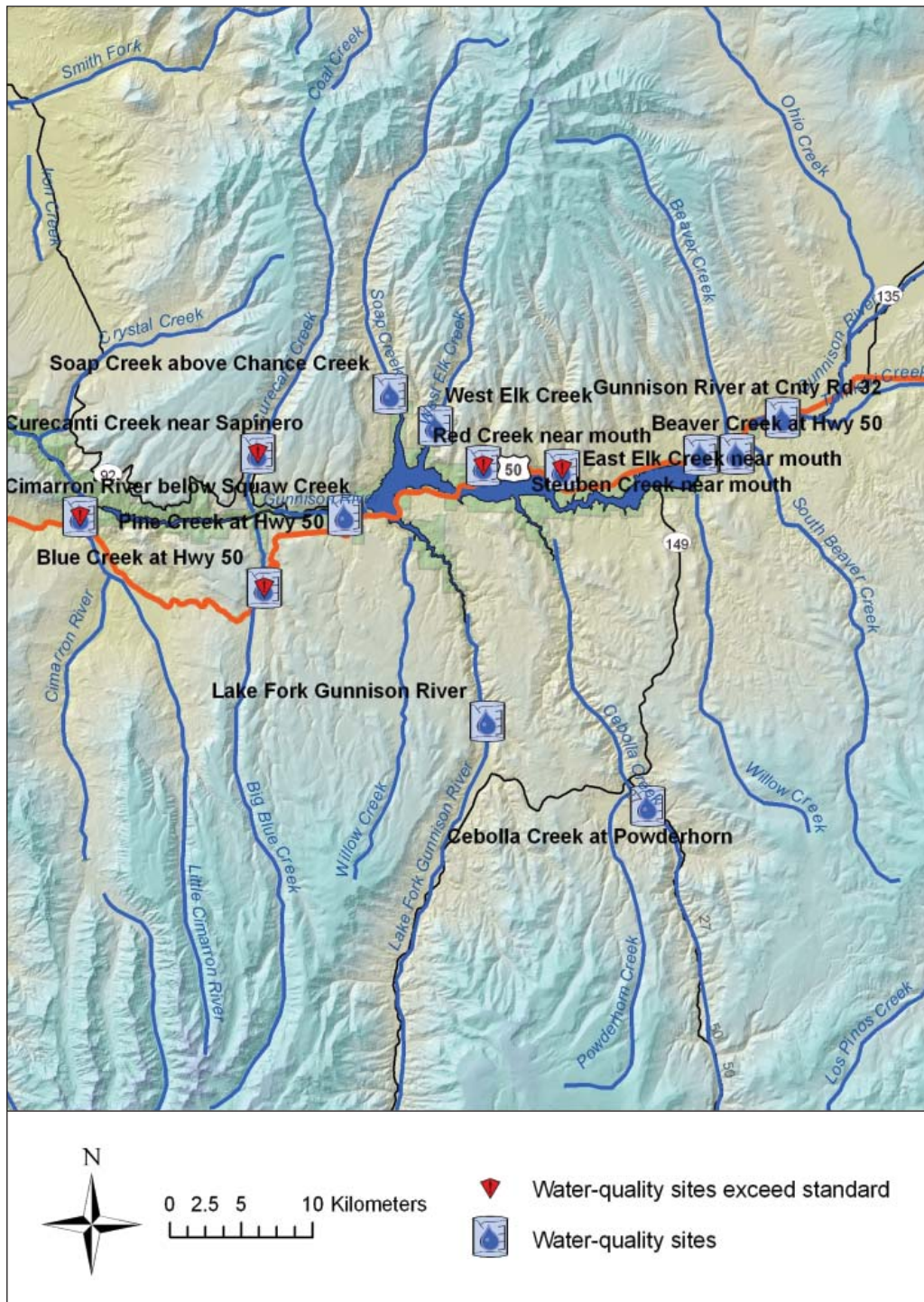


Figure 3.6. Water-quality sites sampled in Curecanti National Recreation Area, 2005–2007.

drinking water supplies drawn from Red Creek within or outside CURE. *E. coli* exceeded the standard for primary-contact recreation.

3.6.3 Blue Creek at Hwy 50 (near Sapinero)

Blue Creek, at U.S. Highway 50 near Sapinero, had exceedances for *E. coli* for 25% of site visits. The *E. coli* concentration exceeded the standard for primary-contact recreation.

3.6.4 Cimarron River below Squaw Creek

The Cimarron River below Squaw Creek had exceedances for *E. coli* for 20% of site visits. The *E. coli* concentration exceeded the standard for primary-contact recreation.

3.6.5 Curecanti Creek near Sapinero, Colorado

Curecanti Creek near Sapinero had exceedances for *E. coli* for 25% of site visits. The *E. coli* concentration exceeded the standard for primary-contact recreation.

3.6.6 Discussion

The chronic manganese standard for drinking-water supply was exceeded for half of the site visits at East Elk and Red creeks. These exceedances did not raise significant concerns, because there are no direct drinking-water intakes on these streams. These tributaries drain areas of public land (including the West Elk Wilderness) that are minimally impacted by human activities, and it is assumed that the source of manganese may be natural. It should also be noted that the concentration of manganese in these and other water bodies did not exceed criteria for aquatic life, and that the drinking water standard of 50 ug/L is for color and staining, not human health.

The primary-contact recreation criteria for *E. coli* was occasionally exceeded on Blue Creek, Red Creek, the Cimarron River below Squaw Creek, and Curecanti Creek near Sapinero. The source of *E. coli* contamination is unknown and could be from wildlife, domestic animals, or human sources.

Overall, water quality is better than the standards set for the beneficial designated uses. Manganese in Red Creek was the only parameter in the 85th percentile (in 2006) that exceeded the drinking-water standard. It should be noted that of the four samples collected and analyzed for this site during

this period, three were below the drinking-water standard. Generally, water quality of all streams in Curecanti NRA is excellent, with occasional exceedances due to naturally occurring conditions in the watersheds. A monitoring record of more than 10 years supports the findings in this report. Furthermore, overall stream water quality is sufficient to warrant consideration as Outstanding Natural Resource Waters (ONRW), which would result in the establishment of source-specific criteria more stringent than typical water-quality criteria. An ONRW designation is a means of preventing deterioration of high-quality waters to the level of existing criteria.

3.6.7 Management implications

It may be possible and logical to request exemptions or site-specific manganese criteria if sufficient evidence exists to make a strong case for naturally occurring conditions that exceed criteria, and no drinking-water source exists on the water bodies. Such a change would not improve water quality, but would make accounting for exceedances more straightforward, especially if these conditions are already recognized by the Colorado State Water Board. Given the heterogeneity of naturally occurring *E. coli* in aquatic systems, the frequency of monitoring and number of exceedances for the time period does not warrant management action, but continued monitoring at these sites is justified. Continued discussions with watershed stakeholders and the state water board will be necessary to gain ONRW status.

3.7 Dinosaur National Monument

Both Colorado sites sampled in Dinosaur National Monument (DINO) during the period covered in this report had State of Colorado water-quality exceedances (Table 3.7, Figure 3.7). Also, the one site sampled in Utah had State of Utah water-quality exceedances. Between eight and 22 visits occurred at these three sites between January 2005 and July 2007.

3.7.1 Green River above Gates of Lodore, Colorado

The Green River above the Gates of Lodore had State of Colorado water-temperature exceedances for cold-water aquatic life Class 1 for 27% of site visits. This is the more stringent of two aquatic-life classifications.

Table 3.7. Exceedances of water-quality standards established by the states of Colorado and Utah for surface water-quality sites sampled in Dinosaur National Monument, 2005–2007.

Site	Exceedances Visits % visits exceeded standard			Constituent	Use code ¹	Standard	Units
Green River above Gates of Lodore, CO	3	11	27%	Temperature, Water	16	20	deg C
Yampa River at Deerlodge Park, CO	8	8	100%	Iron, Total rec.	16, 17, 18, 19	1000	ug/l
Green River near Jensen, UT	4	22	18%	Temperature, Water	2B, 3B	20	deg C

¹ Use codes: 16 = Aquatic Life Cold 1; 17 = Aquatic Life Cold 2; 18 = Aquatic Life Warm 1; 19 = Aquatic Life Warm 2; 2B = secondary-contact recreation; 3B = warm-water game fish

3.7.2 Yampa River at Deerlodge Park, Colorado

The Yampa River at Deerlodge Park had State of Colorado exceedances for total recoverable iron for 100% of site visits. Recoverable iron exceeded the criteria for all forms of aquatic life.

3.7.3 Green River near Jensen, Utah

The Green River near Jensen, Utah, had State of Utah exceedances for water temperature for 22% of site visits. The water temperature occasionally exceeded the criteria for secondary-contact recreation and warm-water game fish (temperature criteria for secondary contact are determined for biotic effect, not comfort).

Analyses of historical phosphorus data indicate frequent concentrations above the indication for impairment for total phosphorus at the Jensen, Utah, monitoring station (Figure 3.7.4). There were no total phosphorus results available for evaluation at the site at the time this report was compiled. However, for the same time period, total phosphorus was above the indication for impairment for all site visits on the Green River in Canyonlands National Park. A re-evaluation of total phosphorus and dissolved oxygen at this site is needed when the data become available, to determine eutrophication status.

3.7.4 Discussion

The source of iron, the duration of exceedance, and degree of impairment caused in the Yampa River is unknown, and could be evaluated more thoroughly. The sampling location is near the point where the Yampa River flows into DINO;

thus, the source of iron is most likely upstream, outside the boundary. It may have geologic origin or be elevated due to human activities upstream. This is a large watershed, draining a significant portion of northwest Colorado, so there is a wide diversity of human activities that might be a source of the iron.

The temperature exceedances on the Green and Yampa Rivers all occurred in June, July, and August. Elevated water temperatures may result from unusually warm conditions or changes in river-bank shading. The maximum water temperatures exceeded the criteria by 1–5° Celsius. An evaluation of water temperatures on these rivers, and their possible negative biological effects, is recommended to determine if summertime water temperatures are increasing due to changes in climate or in flow regime, or if riparian vegetation is decreasing, resulting in reduced shading in the watershed.

A preliminary evaluation of total phosphorus between 1977 and 2002 indicated a frequent and persistent elevated phosphorus level near Jensen, Utah (Figure 3.7.4). A close examination of historical total phosphorus concentrations at all sites in and upstream from DINO is warranted to determine seasonality, magnitude, and direction of trend, as well as the source of total phosphorus in the Green River. This issue was brought to the attention of the Utah Division of Water Quality in November 2007.

3.7.5 Management implications

Understanding the long-term exceedance history and sources of iron in the Yampa River watershed,

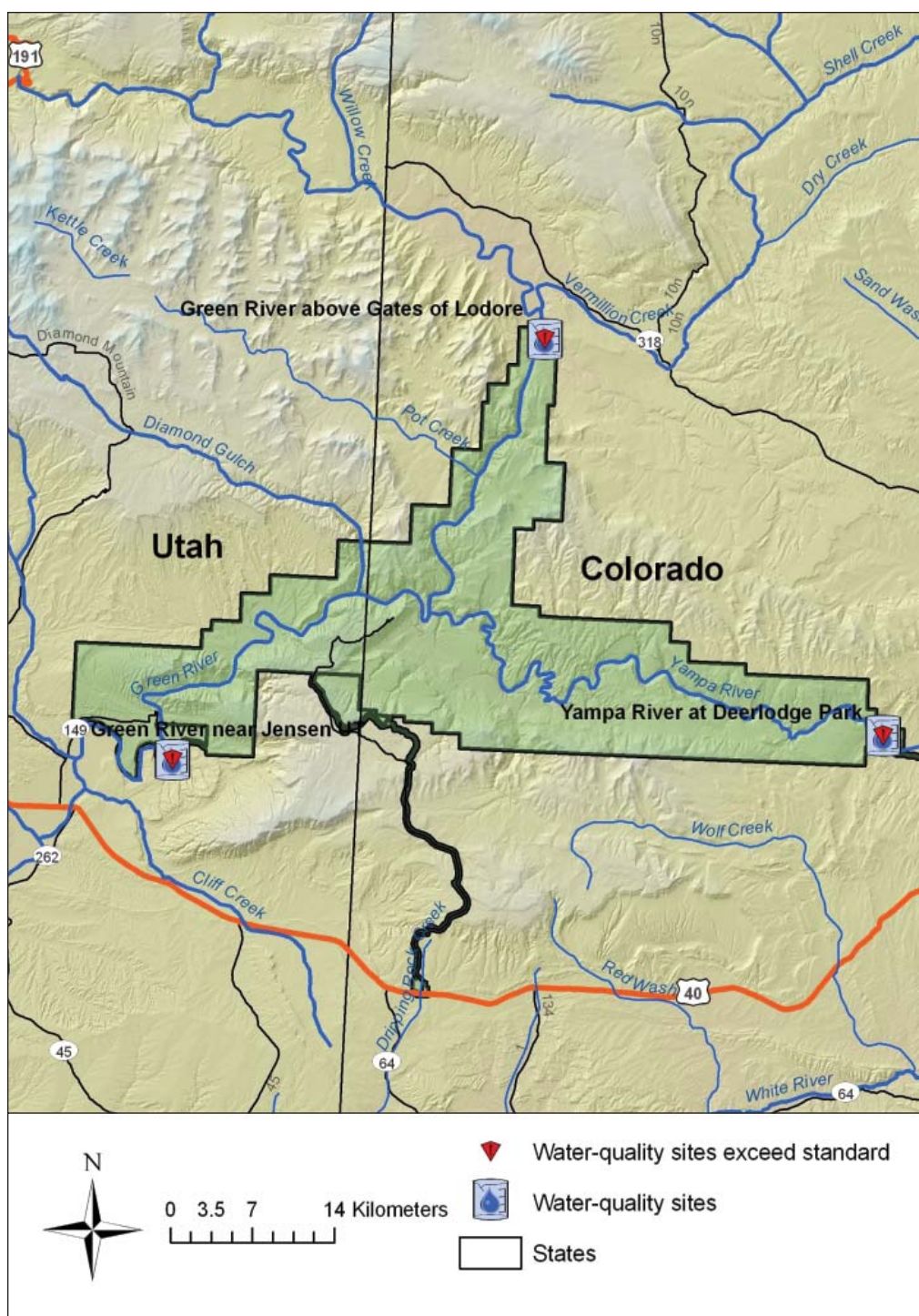


Figure 3.7. Water-quality sites sampled in Dinosaur National Monument, 2005–2007.

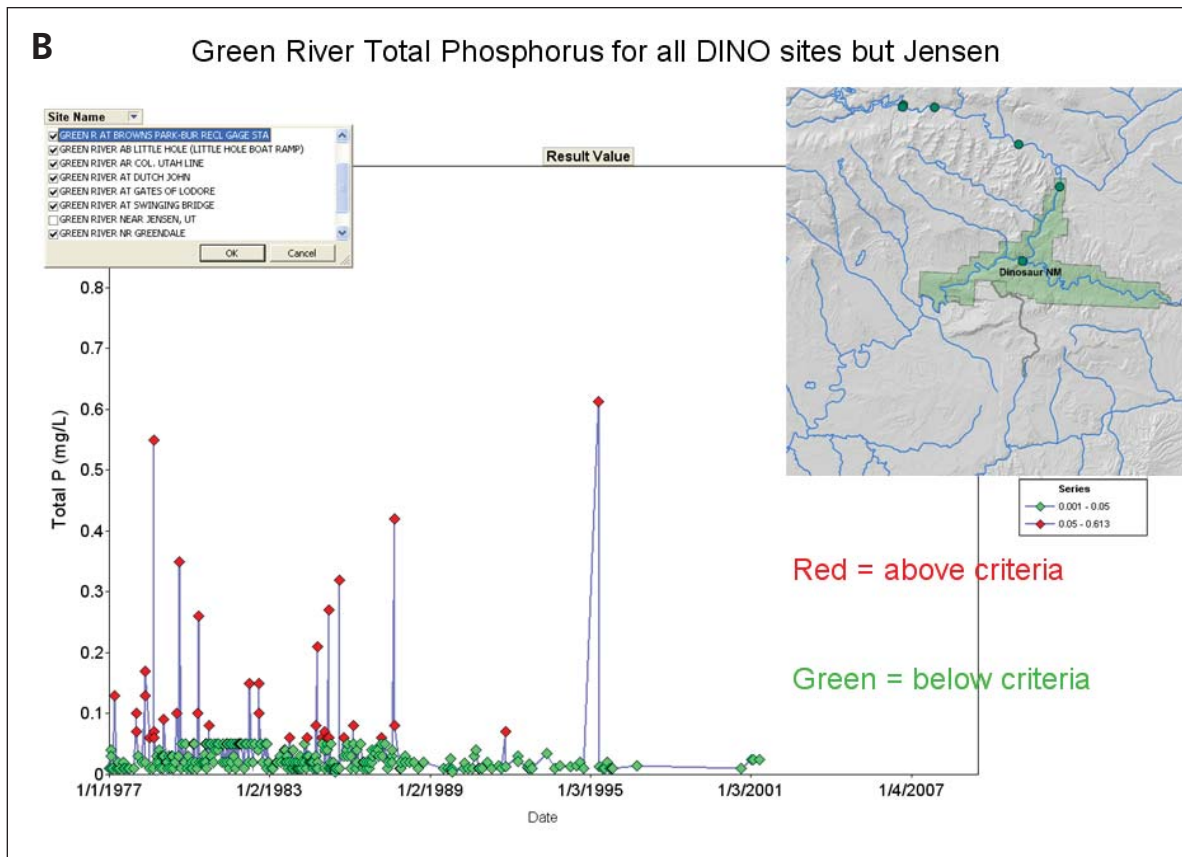
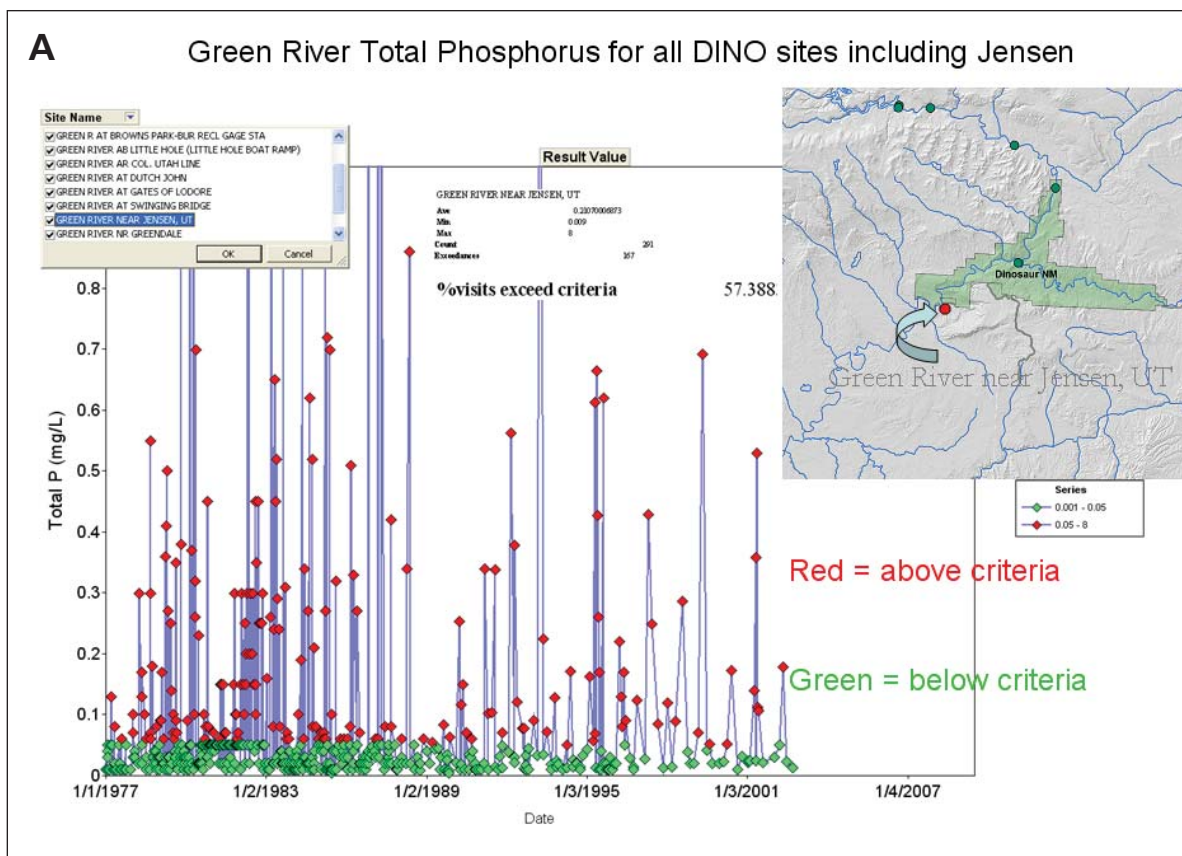


Figure 3.7.4. Historical total phosphorus concentrations (1977–2002) on the Green River (A), including and (B) excluding water-quality data from the monitoring station at Green River near Jensen, Utah.

and trends in summer water temperatures in the Green and Yampa rivers, will allow managers to advocate for the resource when opportunities arise. Also, a better understanding of total phosphorus source and impact on biological processes is needed to determine if management action or advocacy can improve water-quality conditions. If the source of phosphorus is natural or not of biological concern, then site-specific water-quality standards may be needed.

3.8 Zion National Park

The East Fork Virgin River, monitored by UDWQ, was the only one of four sites monitored that did not have water-quality exceedances for the period covered in this report. The remaining three sites, monitored by the NCPN, had State of Utah water-quality exceedances or indication of impairment (Table 3.8, Figure 3.8). Between two and 19 analyses were available for evaluation of these sites. The following discussion focuses only on sites that had exceedances.

3.8.1 La Verkin Creek

La Verkin Creek at Lee Pass Trail, in the Kolob Canyons area of the park, had State of Utah exceedances for total phosphorus for 38% of site visits. Total phosphorus exceeded the indication of impairment for secondary-contact recreation.

3.8.2 North Creek at NPS boundary

North Creek near the park boundary had State of Utah exceedances for dissolved oxygen and

pH, and an indication of impairment due to total phosphorus for 21%, 32%, and 50% of site visits, respectively. Dissolved oxygen exceeded the criteria for cold-water game fish. The pH occasionally exceeded criteria for domestic use, secondary-contact recreation, cold-water game fish, and agricultural uses. Total phosphorus exceeded the indication of impairment for secondary-contact and cold-water game fish species. Cattle trespass occurs occasionally at this site, and recreational use occurs upstream in the park.

3.8.3 North Fork Virgin at North Fork Road

The North Fork Virgin River at the North Fork Road, upstream from the Zion park boundary, had a State of Utah indication of impairment due to total phosphorus for 25% of site visits. Total phosphorus exceeded the indication of impairment for secondary-contact recreation and cold-water game fish species one time in four visits. Cattle grazing in the riparian area are common during summer months.

3.8.4 Discussion

Total phosphorus levels on La Verkin Creek and the North Fork Virgin River may be naturally occurring or could be due to accelerated erosion from human activities or grazing in the watersheds. Although this frequency of exceedance does not cause alarm, an analysis of a longer data record for total phosphorus, and attention to DO trends over time, is warranted.

The number and frequency of parameter exceed-

Table 3.8. Exceedances of water-quality standards established by the State of Utah for surface water-quality sites sampled in Zion National Park, 2005–2007.

Site	Exceedances Visits % visits exceeded standard			Constituent	Use code ¹	Standard	Units
La Verkin Creek	3	8	38%	Phosphorus, Total (as P) - SW	2B	0.05	mg/l
North Creek at NPS boundary	4	19	21%	Dissolved oxygen	3A	8	mg/l
	6	19	32%	pH, High	1C, 2B, 3A, 4	9	Standard units
	1	2	50%	Phosphorus, Total (as P) - SW	2B, 3A	0.05	mg/l
North Fork Virgin at North Fork Road	1	4	25%	Phosphorus, Total (as P) - SW	2B, 3A	0.05	mg/l

¹ Use codes: 1C = domestic use; 2B = secondary-contact recreation; 3A = cold-water game fish; 4 = agricultural uses

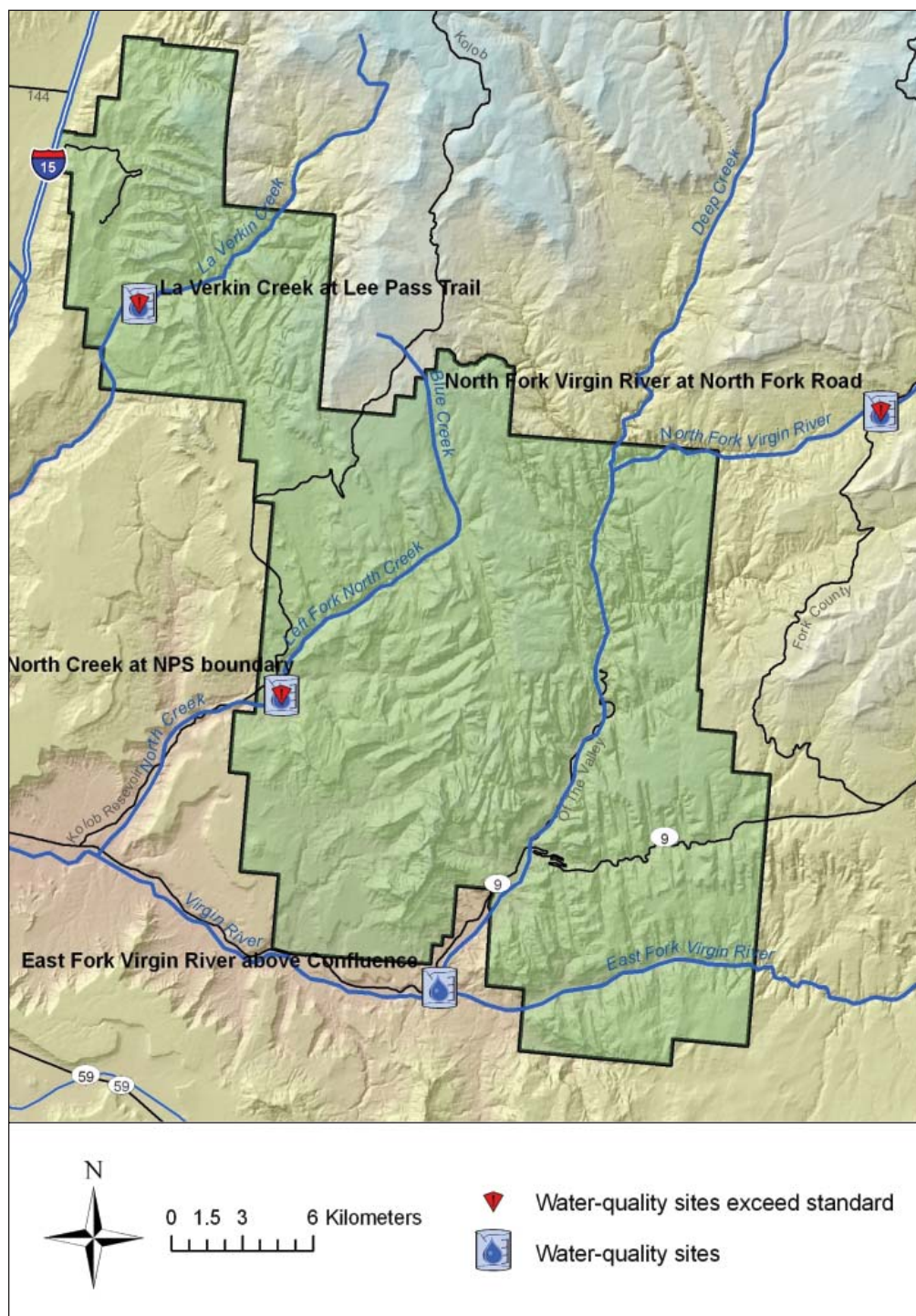


Figure 3.8. Water-quality sites sampled in and near Zion National Park, 2005–2007.

ances on North Creek near the park boundary may be related to after-effects of the Kolob fire that burned much of the watershed in June 2006. After the fire, heavy precipitation eroded much topsoil in two subsequent storms, in June 2006 and August 2007. Nutrient flushes are common occurrences following fires, and in August 2006, an algal bloom was observed in North Creek, when a DO concentration of 123% saturation was measured. Presumably, a crash in DO occurred shortly thereafter, when the algae decomposed. Fish have been noticeably absent from the site since the fire and floods. Over time, it is expected that fish from upstream, unburned portions of the watershed will recolonize the sampled reach. Continued monitoring of this site will help determine the duration of time necessary for the water chemistry and biology to recover to a normal range in conditions.

In February 2007, the NPS petitioned the UDWQ to upgrade the North Fork Virgin River from 2B (secondary-contact recreation) to 2A (primary-contact recreation) (Appendix B). Recent discussions with UDWQ personnel indicate that the status is still pending with the Water-Quality Standards Working Group, and that a decision should be made by February 2008. The change will lower the bacteria standard and reflect how the North Fork Virgin River is actually being used by park visitors during the summer season. The reclassification will also apply to all tributaries of the North Fork Virgin River.

3.8.5 Management implications

To develop post-fire management actions and responses that favor survival of native flora and fauna, it is critical to understand the potential range in conditions that result post-fire. The response of North Creek to the Kolob fires demonstrates the extreme conditions under which native flora and fauna survive. Such information could help managers to design prescribed fires—or, in the case of wildfires, to mitigate the potential range in post-fire conditions—in a manner that limits unintended consequences. The Kolob fire and North Creek response could be used as a learning tool for managing prescribed fire or wildland fire response and recovery.

In 2007, the State of Utah assigned North Creek a site-specific standard for total dissolved solids that raised its standard from 1,200 to 2,035 mg/L. This change was made due to persistently high TDS readings downstream from the park at Virgin, Utah. The cause was determined to be contact with marine bedrock downstream from the park. Although the previous TDS standard in the park was not violated above the park boundary, the new standard reaches into the headwaters of North Creek, thus removing the entire stream from the 303(d) list of impaired waters. Removal of a stream segment from the 303(d) list by changing a standard is an important accomplishment for the state but, in effect, reduces protection for that portion of the stream in the park. The NCPN will continue to evaluate measurements against the more stringent standard and, if deterioration in TDS is observed, propose to UDWQ that the stream be divided into upper and lower reaches for water-quality regulation.

Reclassification of the North Fork Virgin River to a higher standard for recreation may justify a more comprehensive monitoring of bacteria concentrations in the main stem and tributaries. New methods of analysis make bacteria enumeration quite simple. Over time, such monitoring will help protect public health, and the data could be used to help maintain or improve water quality in the North Fork Virgin River.

A management question facing both the park and state is whether the higher 2A classification will require a monitoring frequency (5 times/month) and incident response comparable to that used for public swimming beaches. Neither the park nor the NCPN currently has the resources to undertake such a monitoring program, nor is the Zion Narrows setting conducive to management with temporary closures when exceedances occur.

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Appendix A. NCPN Sites Sampled 2005–2007, with Location and Date of Last Site Visit Used in this Report

Park_Code	Site_Name	Last_site_visit ¹	Latitude_DD	Longitude_DD
ARCH	(D-23-22)17CAB-S1	15-Jun-05	38.804	-109.514
ARCH	(D-24-21)20CAD-S1	9-Jun-05	38.700	-109.628
ARCH	Courthouse Wash near Moab, UT	25-Oct-06	38.613	-109.580
ARCH	Freshwater Spring	9-Jun-05	38.742	-109.528
ARCH	Salt Wash at Wolfe Ranch	25-Oct-06	38.737	-109.519
ARCH	Sleepy Hollow Spring	13-Jun-05	38.671	-109.639
ARCH	Upper Courthouse Wash at NPS boundary	6-Jul-05	38.688	-109.654
BLCA	Gunnison River below Tunnel	5-Feb-07	38.529	-107.649
BLCA	Red Rock Canyon at mouth	27-Jul-06	38.594	-107.788
BLCA	Red Rock Canyon near NPS boundary	13-Dec-06	38.572	-107.787
BRCA	Sheep Creek at NPS boundary	17-Oct-06	37.566	-112.199
BRCA	Yellow Creek at NPS boundary	18-Oct-06	37.573	-112.129
CANY	Cave Spring	21-Jun-06	38.157	-109.753
CANY	Chocolate Drops Spring	26-Jun-06	38.226	-110.002
CANY	Colorado River above Confluence	26-Sep-06	38.193	-109.884
CANY	Colorado River at Potash	26-Sep-06	38.467	-109.666
CANY	Colorado River below Big Drop 3	27-Sep-06	38.071	-110.046
CANY	Green River above Confluence	26-Sep-06	38.190	-109.889
CANY	Green River at Mineral Bottoms	10-Aug-06	38.527	-109.993
CANY	Horseshoe Canyon Spring	25-May-06	38.454	-110.198
CANY	Little Spring Canyon Creek	22-Jun-06	38.201	-109.801
CANY	Loop Spring	22-Jun-06	38.125	-109.822
CANY	Maze Overlook Spring	26-Jun-06	38.229	-109.998
CANY	Salt Creek near Crescent Arch	23-Oct-06	38.085	-109.766
CANY	Salt Creek near Peekaboo Springs	22-Jun-06	38.085	-109.766
CARE	Fremont River at U12 crossing	28-Jun-07	38.270	-111.375
CARE	Halls Creek below Narrows	25-Oct-06	37.615	-110.871
CURE	Beaver Creek at Hwy 50	4-Dec-06	38.495	-107.031
CURE	Blue Creek at Hwy 50	26-Sep-06	38.405	-107.407
CURE	Cebolla Creek at Powderhorn	13-Sep-06	38.276	-107.096
CURE	Cimarron River below Squaw Creek	7-Feb-07	38.446	-107.556
CURE	Curecanti Creek near Sapinero	18-Dec-06	38.488	-107.415
CURE	East Elk Creek near mouth	6-Dec-06	38.483	-107.171
CURE	Gunnison River at Cnty Rd 32	20-Sep-06	38.518	-106.995
CURE	Pine Creek at Hwy 50	25-Mar-06	38.451	-107.344
CURE	Red Creek near mouth	6-Dec-06	38.484	-107.234
CURE	Soap Creek above Chance Creek	5-Dec-06	38.527	-107.310
CURE	Steuben Creek near mouth	4-Dec-06	38.494	-107.060
CURE	West Elk Creek	12-Dec-06	38.508	-107.273
CURE	Lake Fork Gunnison River	3-Mar-06	38.326	-107.226
DINO	Green River above Gates of Lodore	26-Dec-06	40.738	-108.880
DINO	Green River near Jensen UT	19-Sep-06	40.409	-109.235
DINO	Yampa River at Deerlodge Park	31-Jan-07	40.451	-108.523
ZION	East Fork Virgin River above Confluence	2-Oct-07	37.163	-113.011
ZION	La Verkin Creek at Lee Pass Trail	7-Nov-06	37.406	-113.180
ZION	North Creek at NPS boundary	23-Oct-06	37.266	-113.097
ZION	North Fork Virgin River at North Fork Road	23-Oct-06	37.390	-112.825

¹The start date for data used in this report is 1-Jan-2005.

Appendix B. Petition to Change Use Classification of North Fork Virgin River

Request to change classification of North Fork Virgin River and tributaries from 2B to 2A.

The North Fork Virgin River is currently classified 2B by the State of Utah which is a stream capable of supporting secondary-contact recreation such as boating wading and other similar uses (Utah administrative code R317-2. Standards of Quality for Waters of the State). In addition to assigned use classes, the North Fork Virgin River and its tributaries above the confluence with East Fork Virgin River are designated as High Quality Waters - Category 1 (see box).

In Zion National Park this river is used by 100's of visitors each summer day for wading and swimming. Though the water is shallow, visitors seek out deeper pools for swimming and water play wherever there is convenient access to the river. At the Temple of Sinawava shuttle buses drop off thousands of visitors who take the riverside walk to the lower end of the Zion Narrows. Many visitors enter the water there to wade and swim upstream. Actual counts of visitors at this point have often been over 1,500 people per day, and sometimes exceed 2,000 people per day. Significant but fewer numbers of visitors swim in the Virgin River between the lower end of the Narrows and the southern park boundary at Springdale, UT. Kayakers also occasionally use this stretch of river. In the City of Springdale there are businesses that rent inner tubes for floating the river outside the park during summer months (this activity is not permitted in the park due to damage to the stream bed and banks associated with tubers).

The National Park Service takes seriously its responsibility for maintaining high quality water in this stretch of the river by limiting the number of overnight hikers traveling through the Narrows and by providing bags for solid waste disposal that hikers must carry out. Permits are issued for up to 80 hikers per day traveling all the way through the narrows, and an additional 70 people per day to camp at the 12 designated campsites. Actual use is typically about 100 per day on summer days where flood hazards are low.

Zion is a world-class canyoneering destination, a sport which is growing annually. Many of the tributary canyons that drain to the North Fork

3.2 High Quality Waters - Category 1

Waters of high quality which have been determined by the Board to be of exceptional recreational or ecological significance or have been determined to be a State or National resource requiring protection, shall be maintained at existing high quality through designation, by the Board after public hearing, as High Quality Waters - Category 1. New point source discharges of wastewater, treated or otherwise, are prohibited in such segments after the effective date of designation. Protection of such segments from pathogens in diffuse, underground sources is covered in R317-5 and R317-7 and the Regulations for Individual Wastewater Disposal Systems (R317-501 through R317-515). Other diffuse sources (nonpoint sources) of wastes shall be controlled to the extent feasible through implementation of best management practices or regulatory programs.

Projects such as, but not limited to, construction of dams or roads will be considered where pollution will result only during the actual construction activity, and where best management practices will be employed to minimize pollution effects.

Waters of the state designated as High Quality Waters - Category 1 are listed in R317-2-12.1.

Virgin River are extreme descents that require swimming through deep plunge pools. Canyons with higher use levels in the north fork Drainage include Pine Creek (3,000 people/year), Keyhole (2,300 people/year) and Orderville Gulch (1,600 people/year).

It is clear that rivers and streams in Zion are being used by visitors for activities that include full-body immersion, and thus the NPS requests the designated use be upgraded from 2B to 2A consistent with how these waters are being used for recreation.

Zion National Park has no Point source discharges that would be affected by this change in designation, and no new discharges are planned. Issues of concern that could affect or be affected by this new designation are cattle grazing and septic systems upstream from the north park boundary. Limited data collected by the Northern Colorado Plateau Inventory and Monitoring program in-

dicade occasional spikes in *E. coli* bacteria during summer months that may be issues of potential public health concern. Fecal Coliform sampling during 2000 and 2001 found a geometric mean of 560 and 63 cfu/100 ml respectively (combined n=23) upstream of the Narrows, and 23 and 290 cfu/100 ml respectively (combined n=46) downstream of the Narrows.

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Appendix C. Parameter Summary for Sites in NCPN Park Units Monitored January 2005–July 2007

Appendix C is included as a separate pdf file in the pdf package that contains this report. If you are viewing the report as a pdf file, you will need to open Appendix C separately. Results are sorted by park code, site name, and then parameter. The pdf is bookmarked to provide easy access to each park's information. Open the document, then click the bookmark icon to navigate. Appendix C can also be downloaded from the NCPN website, http://science.nature.nps.gov/im/units/ncpn/Monitoring_Reports.cfm#WQ2007M.

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NPS D-81, August 2008

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