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Natural Resource Stewardship and Science

Water Quality Vital Signs Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Version 1.03

Natural Resource Report NPS/NCPN/NRR—2017/1499



ON THE COVER

Monitoring water quality on Oak Creek, Capitol Reef National Park. NPS photo.

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Acronyms and Abbreviations

General acronyms

303(d)	Section 303(d) of Clean Water Act requiring a reporting of waters not meeting standards
as N	as Nitrogen
as P	as Phosphorus
AWQMS	Ambient Water Quality Monitoring System
AZ	Arizona
B	fecal indicator bacteria
CDPHE	Colorado Department of Public Health and Environment
cfs	cubic feet per second
CO	Colorado
CP	core parameters
Cr.	creek
CWA	Clean Water Act
DFC	desired future conditions
DO	dissolved oxygen
DOC	dissolved organic carbon
EPA	U.S. Environmental Protection Agency
FIB	fecal indicator bacteria
GPRA	Government Productivity and Results Act
H2S	hydrogen sulfide
I&M	Inventory and Monitoring Program
MI	major ions
Mg	magnesium
mg/L	milligrams per liter
Nut	nutrients
NPS	National Park Service
NTU	nephelometric turbidity units [turbidity]
NWIS	National Water Information System (USGS)
ONRW	outstanding natural resource waters
pci/L	picocuries per liter
Q	discharge (in cubic feet per second)
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
R.	river
Res.	reservoir
SC	specific conductance
Secchi	Secchi disk for measuring light penetration
SOP	standard operating procedure
STORET	USEPA Storage and Retrieval System database
T	temperature
TDS	total dissolved solids
TMDL	total maximum daily load
TOC	total organic carbon
TSS	total suspended solids
TU	turbidity
WRD	National Park Service Water Resources Division
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter [specific conductance]
UT	Utah
UDEQ	Utah Division of Environmental Quality

UDWQ	Utah Division of Water Quality
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WY	Wyoming

Acronyms for NPS Units

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
CEBR	Cedar Breaks National Monument
COLM	Colorado National Monument
CURE	Curecanti National Recreation Area
DINO	Dinosaur National Monument
FOBU	Fossil Butte National Monument
GOSP	Golden Spike National Historic Site
HOVE	Hovenweep National Monument
NABR	Natural Bridges National Monument
NCPN	Northern Colorado Plateau Network
PISP	Pipe Spring National Monument
SCPN	Southern Colorado Plateau Network
SEUG	Southeast Utah Group (includes ARCH, CANY, HOVE and NABR)
TICA	Timpanogos Cave National Monument
ZION	Zion National Park

Protocol Narrative

Revision History Log

Previous version #	Revision date	Author	Change(s) made	Reason for change	New version #
1.00	5/27/2009	D. Thoma	Updated WQ standards	Mistake in previous version	1.01
1.01	9/2011	R. Weissinger	Reduced to 10 month sampling in Utah; update to current standards and methods	Safety and budget concerns; revisions to Utah and Colorado standards; new equipment	1.02
1.02	10/2013	R. Weissinger	Include field blanks for bacteria and lab samples	Improve data quality assurances	1.03

1 Background and Objectives

This water quality monitoring protocol consists of this protocol narrative and the following standard operating procedures (SOPs), available at https://irma.nps.gov/DataStore/Reference/Profile/2243275:

- SOP 1: Field Safety for Water Quality Sampling
- SOP 2: Staff Training, NCPN Units in Colorado
- SOP 3: Staff Training and Coordination with Utah Division of Water Quality, Utah Units
- SOP 4: Site Selection, Conditions, and Documentation
- SOP 5: Preparations, Equipment Calibration, Handling and Storage
- SOP 6: Cumulative Bias Control
- SOP 7: Quality Assurance Project Plan (QAPP) for Water Quality Monitoring
- SOP 8: Field Methods for Core Parameters, Turbidity and Discharge, All Units
- SOP 9: Field Sample Collection and Processing for Water Chemistry, Nutrients and TSS, Colorado Units
- SOP 10: Field Sample Collection and Processing for Water Chemistry, Nutrients and TSS, Utah Units
- SOP 11: Fecal Indicator Bacteria, All Units
- SOP 12: Laboratory Analysis Methods for Water Quality, Colorado Units
- SOP 13: Laboratory Analysis Methods for Water Quality, Utah Units
- SOP 14: Data Management
- SOP 15: Data Analysis and Reporting, All Units
- SOP 16: Protocol Revision
- SOP 17: Annual Project Review

1.1 Introduction

The Northern Colorado Plateau Network (NCPN) comprises 16 National Park Service (NPS) units. Eight are located exclusively in the state of Utah, three are located in the state of Colorado, one unit each is located in Wyoming and Arizona, and two straddle the Utah–Colorado border (Figure 1). Most of the units are in the Colorado River Basin. Exceptions are the parks along the northern and western margins of the network that drain to the Great Basin: Fossil Butte National Monument (FOBU), Golden Spike National Historic Site (GOSP), Timpanogos Cave National Monument (TICA), and Cedar Breaks National Monument (CEBR).

1.1.1 Hydrologic setting and influences on water quality

On the Colorado Plateau, the relatively arid climate and geology strongly influence water resources and water quality. Segments of the Colorado River and its major tributaries are protected within Dinosaur National Monument (DINO), Curecanti National

Northern Colorado Plateau Network Parks

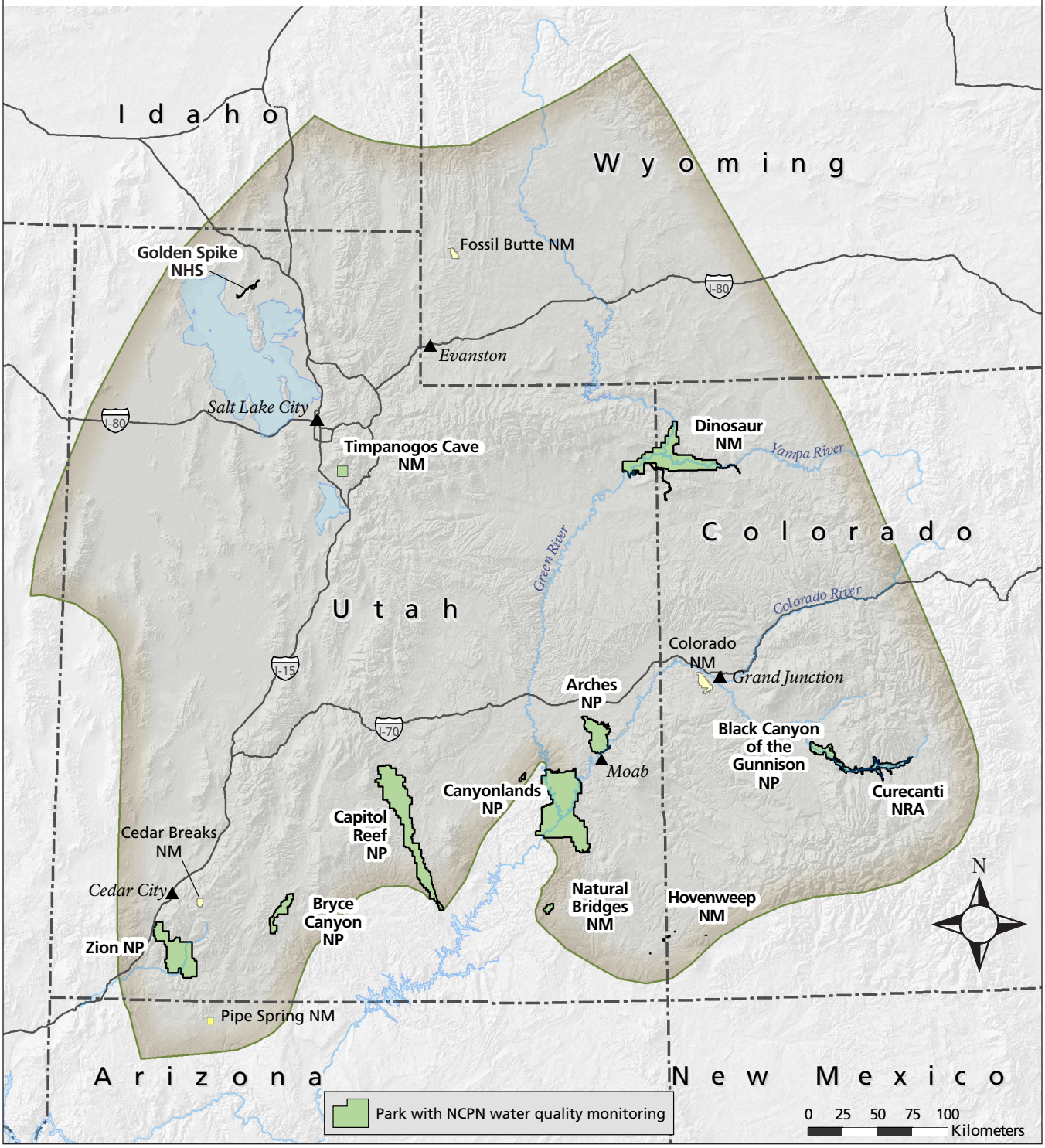


Figure 1-1. Northern Colorado Plateau Network parks. Parks where water quality is monitored are bolded and outlined in white.

Recreation Area (CURE), Black Canyon of the Gunnison National Park (BLCA), and Canyonlands National Park (CANY). These are large rivers with mean annual discharges of 5.6–56 m^3/s. In some cases, the large rivers are nearly free-flowing, while other segments are entirely controlled by large reservoirs upstream. CURE contains three large reservoirs and CANY includes the upstream end of Lake Powell, the majority of which is managed by Glen Canyon National Recreation Area, in the Southern Colorado Plateau Network. Tributaries with mean annual discharges of 1.1–2.8 m^3/s are major rivers in Capitol Reef National Park (CARE) and Zion National Park (ZION). Smaller streams with seasonal and perennial discharges of less than 0.03 m^3/s, though not abundant, are found in many parks.

Springs are significant resources in the network because they are the only water sources in many areas. A type of spring characteristic of the Colorado Plateau is the hanging garden, where groundwater seeps or trickles from a saturated vertical sandstone face, creating a large area of wetted rock. These vertical oases are habitat for wetland species and some endemics in Arches National Park (ARCH), CARE, CANY, Colorado National Monument (COLM), DINO, Natural Bridges National Monument (NABR), and ZION. Other water sources in the NCPN include tinajas (small water catchments eroded into bedrock that hold water for a few weeks or months) and other small reservoirs developed for livestock, wildlife, or NPS water supply.

Precipitation is strongly correlated with elevation across the Colorado Plateau and surrounding mountains. As a result, the park units, or portions of larger park units, with the greatest amounts of precipitation are those with the highest elevations; CEBR, CURE, and TICA receive 50–100 cm of annual precipitation. Parks at lower elevations—particularly those in rain shadows of higher terrain, such as ARCH, CARE, Hovenweep National Monument (HOVE), and Pipe Spring National Monument (PISP)—receive 20–40 cm annually. The result of this distribution is that perennial water in park units either originates at high elevation and flows (sometimes for long distances) to the park or travels as groundwater and arises in the vicinity of the park. It also means that perennial water sources in low- and mid-elevation parks are often separated by wide expanses of arid terrain.

Two other climatic characteristics that strongly influence water flow and quality are snowmelt and monsoonal rains. At higher elevations, a large part of the annual precipitation occurs as snow, building a substantial snowpack resulting in a spring runoff for any rivers with headwaters that reach these higher elevations. For larger watersheds, the greatest discharge of the year is usually the spring snowmelt. Spring floods are associated with lower concentrations of most dissolved constituents, but higher suspended loads. The NCPN is at the northern limits of the Southwest Monsoon, a moist southerly airflow that contributes to thunderstorm downpours from mid-July to mid-August. Runoff from these intense storms often results in flood events with extraordinarily high sediment loads.

1.1.2 Uses of water and ecological significance of water quality

Water in NCPN units controls much of the abundance, distribution, and diversity of floral and faunal assemblages. Additionally, it continues the inexorable sculpting of landscape features that are synonymous with many NCPN parks. Flowing water on the surface or underground is a major mechanism of nutrient and ion transport in natural systems. Water quality can also have a substantial influence on human uses of the water, both inside and outside parks. The water-dependent ecosystems in these unique landscapes, and the other natural and cultural resources found therein, are protected by the National Park Service Organic Act and the enabling acts or proclamations for each unit.

River water in NCPN parks can generally be characterized as moderate to high in dissolved solids, turbid at higher flows, slightly basic in pH, well-buffered, and dominated by calcium, magnesium, and sodium cations and carbonate, sulfate, and chloride anions. Notable exceptions are the higher-elevation streams draining into CURE from water-

sheds dominated by metamorphic rocks that are very low in dissolved solids. Seasonal precipitation, snowmelt runoff, and monsoonal floods combine with a landscape where water infiltration and groundwater storage are generally low to create a high degree of spatial and temporal variation in discharge, temperature, and dissolved solids. Rivers in the NCPN also tend to be very turbid much of the year because the landscape is highly erodible and lacks a dense vegetative cover. The majority of sediment washed from the landscape is transported during floods, but the fine sediment that contributes to turbidity can cloud the water for months after a flood event. Endemic aquatic organisms are adapted to the natural high sediment loading and turbidity of the rivers.

Uses of water include domestic supply for park employee residences, park operations, and visitor facilities, such as concessionaire-run lodges and campgrounds. Reservoirs and larger rivers are used for water-based recreation, including boating, swimming, and fishing. The NPS diverts water from some streams for irrigation of landscape plantings in several units, and irrigation of historic orchards in CARE. Wildlife and domestic livestock use water at its source or from spring developments or diversions.

In addition to NPS use of water, water is diverted from sources in parks for private and public uses outside park boundaries. These diversions for domestic and municipal use, stock watering, and irrigation generally predate establishment of the parks. The large dams in BLCA and CURE are significant sources of hydroelectric power generation by the U.S. Bureau of Reclamation.

1.1.3 State standards and protected uses

NCPN water quality monitoring emphasizes the support of protected uses through water quality standards as developed by the states of Arizona, Colorado, Utah, and Wyoming. These states have developed a regulatory system under the Clean Water Act and Environmental Protection Agency (EPA) guidance that provides for specific standard concentrations or measures for water quality constituents that are desired to protect a class of uses. The specific protected uses vary somewhat state by state, but generally include irrigated agriculture, domestic water supply, cold-water aquatic life, warm-water aquatic life, water-based recreation, and livestock watering. A detailed listing of protected uses for each water source and segment in all NCPN parks is provided in Appendix A. Current sources for water quality standards for each state are listed in Table 1-1. Quantitative standards are established for several parameters that the states and EPA believe are necessary to protect each of these uses. Standards are typically of two types. Most are fixed quantities. Others vary in response to another water quality value, typically hardness or temperature. In some cases, qualitative standards or recommended levels are used.

1.2 Waters on the 303(d) list in NCPN park units

Under the Clean Water Act (CWA), states must identify all waters that do not meet or are not expected to meet water quality standards. The identification and public notification of water quality-limited waters

Table 1-1. Sources for water quality standards for NCPN states.

State	Regulation
Arizona	Arizona Administrative Code, Title 18. Environmental Quality, Chapter 11.
Colorado	Water Quality Control Commission Regulations: 5 CCR 1002, Regulations 21 through 94
Utah	Standards of Quality for Waters of the State, R317-2, Utah Administrative Code (Utah Department of Environmental Quality, Division of Water Quality).
Wyoming	Wyoming Surface Water Quality Standards, Water Quality Rules and Regulations.

is accomplished through what has become known as "303(d) Lists" after the CWA section that contains the requirement (EPA 2006). States are required to analyze the cause(s) of non-attainment of standards and develop a plan for bringing the problem water body into compliance. These plans analyze the total maximum daily loading of contaminants to the water and are therefore referred to as "TMDL" plans. States can consider a wide variety of remedies, including reducing the contaminant loading, changing the designated protected uses (such as from Cold Water Fishery to Warm Water Fishery) to more accurately reflect ambient conditions, or documenting that the "poor" quality of the water is due to natural causes and is not correctable.

Several water sources in NCPN parks have been reported on the non-attainment or 303(d) list (Table 1-2).

Selenium at ARCH, BLCA, and CANY—Selenium is a widespread problem in the upper Colorado River Basin, particularly in streams that drain Mancos Shale geology. Agricultural runoff from irrigated lands increases the contribution of selenium. The completed total maximum daily load (TMDL) plan for the Gunnison and Uncompahgre River basins indicates that nonpoint sources in Red Rock Creek must be decreased by over 90% to attain Colorado selenium standards. Selenium exceedances in the Colorado River in Utah are a result of non-attainment in Colorado.

Fremont River in CARE—The reason for non-attainment for benthic macroinvertebrates and *E. coli* is not known. Upstream of the park, a completed TMDL for total phosphorus, organic enrichment, and low dissolved oxygen identified numerous livestock feeding operations and other agricultural practices as contributors to the nutrient loading. The upstream segment is listed for *E. coli*, benthic macroinvertebrates, total dissolved solids (TDS), and water temperature. State monitoring found the river to routinely exceed the standard for total phosphorus at Hickman Bridge inside the park. Additionally, the Fremont River segment immediately downstream of the park is listed for TDS. A TMDL report has been completed for the Fremont River segment immediately downstream of the park for high salinity and chlorides. A TMDL for *E. coli* is scheduled in 2017.

Yampa River in DINO is listed for iron. Upstream of the park there are few exceedances for iron at Craig, Colorado, and iron concentrations are consistently higher at Deerlodge Park (in DINO) than near Craig. Exceedances are most common from April through June, corresponding to higher flows from snowmelt, but the highest iron concentrations do not always correspond to the highest flows. A tributary to the Yampa

Table 1-2. Water bodies within NCPN park boundaries put on the 303(d) list since the NCPN monitoring program began in 2006.

Park	Water body	Criteria	Listed	Delisted	Reason delisted
ARCH	Colorado River	Selenium	2006	-	-
BLCA	Red Rock Creek	Selenium	2006	2012	TMDL completed – agricultural sources
CANY	Colorado River	Selenium	2006	-	-
CARE	Fremont River	Benthic macroinvertebrates	2008	-	-
		E. coli	2014	-	-
DINO	Yampa River	*E. coli*	<2006	2010	Improved WQ
		Fe (total recoverable)	2010	-	-
ZION	North Creek	TDS (total dissolved solids)	<2006	2006	TMDL completed – natural sources
		pH	2014	-	-
	North Fork Virgin River	Water temperature	2010	-	-
		E. coli	2010	-	-

River, Milk Creek near Lay, Colorado, is also listed as impaired for iron and is downstream of Craig. Geologic sources of iron are abundant in the area, but iron concentrations in the river may be exacerbated by run-off from coal-mining operations.

North Creek in ZION was listed for total dissolved solids, primarily from natural sources. A TMDL plan was completed and the State of Utah established source-specific standards that recognize the naturally high TDS. A large fire burned the North Creek watershed in summer 2006. Eutrophication was observed in the stream for several summers after the fire. Although algal levels have improved, pH still regularly exceeds state standards in the summer.

North Fork Virgin River in ZION is listed for water temperature and *E. coli*. Increased monitoring by the NCPN, ZION, and the State determined that *E. coli* exceedances were due to the combined presence of livestock grazing and overland irrigation return flows. Attempts to address this issue are ongoing. The North Fork Virgin River is currently designated a cold-water stream, and the State of Utah is evaluating water-temperature data to determine whether it should be re-classified as a warm-water stream. A TMDL for *E. coli* is scheduled in 2019.

Additional waters of concern near NCPN units are listed in Table 1-3.

Kolob Reservoir upstream of ZION is sometimes out of compliance for low dissolved oxygen. It has been assigned category 5D by the Utah Department of Environmental Quality (DEQ), meaning that it has been intermittently out of compliance for dissolved oxygen during some monitoring cycles, but not others.

Blue Creek upstream of GOSP is subject of a TMDL review of industrial discharges upstream of the park. The State of Utah categorizes it as a "5C" water, meaning that the permitted discharge loading to the stream is significant and requires TMDL analysis.

1.3 Qualitative desired future conditions

The following desired future conditions (DFCs) represent what National Park Service policies and federal law allow. It is expected that the DFCs for individual water bodies will differ and evolve depending on current status, changing conditions, and management objectives. The DFCs can be used as a starting point to develop quantitative performance measures.

Listed here is a summary of the DFCs and how they will be achieved, followed by more detailed rationale and explanation.

1. Achieve water quality standards for designated beneficial use.
2. Keep impairments to minor or negligible levels.
3. Meet anti-degradation provisions of the CWA.

DFCs require that this program develop quantitative performance measures that allow managers to

1. Quantitatively evaluate achievement of water quality standards.
2. Quantitatively evaluate change relative to definitions of impairment and anti-degradation.
3. Do this in an adaptive-management context that allows detection of a true change outside of natural variability.

Table 1-3. Water bodies near NCPN park boundaries with impairments of concern.

Park	Water body	Location	Criteria	Listed	Delisted	Reason delisted
CARE	Fremont River	Upstream	*E. coli*, temperature, TDS	2014		TMDL completed – agricultural sources
		Downstream	TDS	<2006		
GOSP	Blue Creek	Upstream	Industrial waste	<2006		
ZION	Kolob Reservoir	Upstream	DO (dissolved oxygen)	<2006		

This in turn might initiate a management action.

It is instructive to review policies and concepts outlined in guidance documents for water quality that help establish a starting point for DFCs.

The National Park Service Management Policies, Chapter 4 (NPS 2006) state:

> *The National Park Service will strive to understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the parks while providing meaningful and appropriate opportunities to enjoy them. The Service recognizes that natural processes and species are evolving, and . . . will allow this evolution to continue, minimally influenced by human actions. . . .*
>
> *The Service manages the natural resources of parks to maintain them in an unimpaired condition for future generations in accordance with NPS-specific statutes, including the NPS Organic Act and the National Parks Omnibus Management Act of 1998; general environmental laws such as the Clean Air Act, the Clean Water Act, the Endangered Species Act of 1973, the National Environmental Policy Act, and the Wilderness Act; executive orders; and applicable regulations.*

Thus, the integrity and character of pristine water bodies should be maintained in accordance with the anti-degradation provision of the CWA to ensure sustainable ecological function and enjoyment by park visitors. The highest level of water quality protection under standards associated with the CWA applies to certain waters that constitute an outstanding state or national resource. These waters, designated as outstanding natural resource waters (ONRWs), shall be maintained and protected at their existing quality. The anti-degradation provision states that existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected. The Clean Water Act specifically mentions national parks and the special status of waters therein:

> *Where high quality waters constitute an outstanding national resource, such as waters of national and state parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected (Title 40 CFR 131.12).*

The anti-degradation provision is interpreted differently by states, but in general has two or three classes or tiers that represent degrees of anti-degradation, ranging from none whatsoever to short-term impairment with no long-term consequences. A good summary of the anti-degradation provision as interpreted by the states can be found at http://www.blm.gov/nstc/WaterLaws/abstract2.html.

Variability is large within and across water bodies in NCPN parks, making defined standards difficult to identify. For this reason, managers should evaluate water quality data relative to water quality standards and long-term natural variability to the extent that "natural" can be separated from anthropogenic-induced change, with careful consideration of proposed changes in watersheds that may result in anthropogenic-induced impairment.

For waters that originate or lie wholly within park units, anthropogenic activities should be managed so that they have *minor or negligible* impacts on water quality according to defined levels of impact under the National Environmental Policy Act (NEPA) (NPS 2003):

- Negligible: Impacts are effects that are not detectable, well below water quality standards, and within historical baseline water quality conditions.
- Minor: Impacts are effects that are detectable but well within or below water quality standards and within historical baseline water quality conditions.
- Moderate: For most waters, impacts are effects that are detectable, within or below water quality standards, but historical baseline water quality conditions are being altered on a short-term basis. However, in outstanding natural resource waters (ONRWs), this thresh-

old may approach the requirements for statutory impairment.

- Major: For most waters, impacts are effects that are detectable and significantly and persistently alter historical baseline water quality conditions. Water quality standards are locally approached, equaled, or slightly and singularly exceeded on a short-term and temporary basis. However, in ONRWs this threshold would probably constitute statutory impairment.

1.3.1 Utah parks

Due to the high standard of protection outlined in the NPS Management Policies, it is expected that park managers will manage waters that originate or lie wholly within Utah parks as Category 1 and 2 waters, defined as follows (Utah Administrative Code R317-2-3.2), regardless of designated beneficial use established by the state.

- Category 1–Waters of high quality that have been determined by the [Water Quality] 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. The North Fork and East Fork of the Virgin River in ZION have Category 1 status.
- Category 2—Water segments treated as High Quality Waters–Category 1 except that a point-source discharge may be permitted provided that the discharge does not degrade existing water quality.

1.3.2 Colorado parks

In 2012, the State of Colorado designated tributaries at BLCA and CURE as Outstanding Waters. The Outstanding Waters designation extends from North Beaver Creek to Meyer's Gulch (except Steuben, Soap, and Willow creeks), draining the West Elk Wilderness area to Blue Mesa and Morrow Point reservoirs. These parks have collected water quality data since the 1980s as part of a baseline water quality monitoring program, and the data were used to characterize existing water quality conditions. The Outstanding Waters designation will protect the waters of BLCA and CURE beyond current standards, consistent with servicewide and park guidelines.

1.3.3 Other parks

No continuous monitoring of water bodies in Wyoming or Arizona parks is being implemented at present. However, if park waters in those states are monitored by NCPN personnel or resources in the future, it is expected they will be monitored and managed in the spirit of the CWA anti-degradation provision as interpreted by the states of Wyoming and Arizona.

1.3.4 Thresholds of concern

Thresholds of concern for NCPN waters will be the same as water quality standards used by states to evaluate compliance with CWA. Water quality standards can be found in state administrative codes (see Table 1-1). These standards will be used to warn of potential problems because they are quantitative and have built-in margins of safety. The number of site visits necessary to detect a true change outside of natural variability that might initiate a management action is discussed in Section 1.5, below.

States have narrative standards that protect water bodies against pollutants for which quantitative standards do not exist, as well as quantitative numeric standards for acute and chronic exceedances. In practice, consultation with state water quality professionals will be necessary to determine if acute and chronic exceedances warrant action on the part of park managers. In some cases, acute exceedances may result from natural causes that cannot reasonably be controlled by management.

1.4 Water quality vital signs

Prior to the initiation of NCPN monitoring, a description of water quality vital signs for each park unit was prepared by the U.S.

Geological Survey–Water Resources Division (O'Dell et al. 2005, Appendix F). This analysis was the primary basis for developing the initial NCPN sampling design. It provides the 2005 status of 303(d) listed waters, streamflow gauges, and monitoring activities within each park, along with a detailed summary of existing water quality data, screening of those data against standards and threat levels, and a discussion of findings from the analysis. The analysis was conducted for each important water body identified in NCPN parks with available water quality data. Results are discussed in the following sections.

1.4.1 Historic observations and existing conditions

The number of water quality samples and constituents measured varied considerably between and within parks. Of the 161 water sources identified by NCPN park resource managers as being of interest, approximately 110 (or 68%) were data-deficient (where generally fewer than 10 water quality samples were collected in the last 15 years), and approximately half of these water sources had essentially no water quality data in the record.

Overall, there were relatively few violations of water quality standards. The most common violations were for dissolved oxygen, water temperature, nutrients (phosphorus and un-ionized ammonia), aluminum (dissolved), selenium (dissolved), total dissolved solids, and total suspended solids. Some water quality constituents of widespread concern across the network are discussed below.

1.4.2 Nutrients

Nutrients, in particular total phosphorus and un-ionized ammonia, are a concern for many NCPN parks. Possible sources of these elevated nutrients include upstream activities (grazing, irrigation return flows and other agricultural activities, residential development, wastewater discharges) within-park activities (waste disposal facilities, leaking septic systems, visitor activities, campgrounds, trespass or permitted grazing), and wildlife. It is also possible that the natural geology contributes to elevated levels, a conclusion at least partly supported by the widespread occurrence of high nutrient levels combined with the low occurrence of algal blooms and other nutrient-related problems.

1.4.3 Trace elements (Metals)

Trace elements, including metals, were identified as a potential water quality concern in several NCPN parks. Activities or sources that could be contributing to elevated metals and/or water quality exceedances include historic and current mining and gas development activities adjacent and upstream of the park, nearby coal-fired power plants and waste incinerators, the underlying geology, and upstream wastewater discharges. Very limited trace-element data were collected at BLCA, Bryce Canyon National Park (BRCA), CANY (springs), CARE (seeps and springs), COLM, FOBU, and PISP. No data were collected at CEBR or cave sites at TICA.

1.4.4 Selenium

Selenium is a trace element of particular concern throughout much of the Colorado River basin with elevated levels due to irrigation practices and development (Butler and Lieb 2002). Natural background levels are high and associated with particular soil types and geological features, such as Mancos Shale. Of the 16 NCPN parks, ARCH, BLCA, CANY (surface water only), CURE, DINO, HOVE, and ZION had water bodies with selenium exceedances. CEBR had no selenium data available for evaluation.

1.4.5 Total dissolved solids and total suspended solids

Elevated TDS and TSS are a water quality concern throughout the network. Activities contributing to elevated TDS and/or TSS concentrations occur upstream and within parks. These include natural geologic sources, visitor activities in and around water sources; off-road recreational vehicle use; grazing and other agricultural activities; road development and repair; and upstream residential development. Six parks (BLCA,

CEBR, COLM, CURE, PISP, and ZION) had little to no TDS and/or TSS data. Exceedances occurred in all of the remaining 10 parks with recent TDS and TSS data.

1.4.6 Pesticides

ARCH, CARE, CEBR, DINO, and NABR identified pesticides as a management concern. Pesticide (or herbicide) applications are used within ARCH, NABR, and ZION for *Tamarix* control, within park orchards at CARE, and are used on lands adjacent to CEBR and DINO. Only GOSP had any pesticide exceedances identified (for phenol); however, water sources located in Colorado were not evaluated for pesticide exceedances. Four parks had conducted very limited pesticide sampling:

- CANY (1 site, 40 samples; 4 sites, 1 sample)
- DINO (1 site, 1–5 samples)
- GOSP (2 sites, 1–3 samples)
- ZION (1 site, 1 sample)

Pesticide monitoring is of interest to several parks. However, this concern must be addressed outside the basic NCPN monitoring program due to the very high laboratory costs of pesticide analyses. The NCPN has partnered with the Region 8 EPA laboratory to conduct additional pesticide testing at ARCH, BLCA, BRCA, CANY, CARE, CURE, DINO, HOVE, NABR, PISP, TICA, and ZION.

1.4.7 Springs, seeps, hanging gardens, and tinajas

Springs, seeps, hanging gardens, and tinajas are common water features in NCPN parks. These water sources are critical to flora and fauna, and are aesthetically appealing to park visitors. Monitoring is sometimes difficult because individual water sources, though often diminutive, can be numerous and can have diffuse discharge points that are difficult to sample. A network approach applicable to many springs is to rotate sampling among several springs from year to year.

The amount of data for identified springs and seeps varies considerably between parks and is usually minimal. Some spring sites are included in the proposed NCPN water quality monitoring program. NCPN-supported, springs-specific monitoring with limited water quality data is occurring at ARCH, CANY, HOVE, and NABR (Weissinger et al. in prep).

1.4.8 Chlorophyll and carbon

Chlorophyll and carbon were listed as vital signs that may be considered for inclusion in a monitoring program. Chlorophyll is monitored only at CURE, in Blue Mesa Reservoir. This parameter is effective in relaying information about eutrophication levels in reservoirs, lakes, ponds, and even streams. At present, chlorophyll monitoring at other parks is not recommended in flowing waters because few eutrophication problems have been observed, and state standards do not exist.

Monitoring carbon in its various forms (e.g., benthic organic matter, total organic matter, coarse organic matter, dissolved organic matter) is useful in describing structure and function of lotic systems, and can relay information about changes in an aquatic system. Limited data are available for NCPN parks. These measurements are difficult and expensive. Measurement of this parameter is left to special studies.

1.5 Power analysis

An evaluation of historic parameter variability is useful in determining the expected sample size required to detect a significant change beyond natural variability. This analysis helps determine realistic timeframes for the duration of data collection and the number of site visits necessary to detect a significant change that may be of concern to park managers. An analysis of historic data in 2006 found that monthly sampling would detect a 30% mean change for core parameters of pH, dissolved oxygen, and specific conductance—and for un-ionized ammonia—within two years (Thoma et al. 2009). Monthly visits were initiated at sampling locations in Utah in 2007.

After several years of data collection, safety concerns about winter sampling and a reduction in budget prompted a review of NCPN's sampling design. A power analysis of data collected since 2006 indicated that reducing winter sampling would not reduce the ability to detect trend in core parameters (Thoma unpublished data). In October 2011, the NCPN reduced Utah sampling to 10 months of the year, with only one sample collected during December–February.

Scheduled site visits may not always be possible, given weather and road conditions. Furthermore, there will be data that must be censored for reasons not yet known or encountered. Sampling frequency should be periodically re-evaluated for the ability to detect trends in parameters of interest.

1.6 Monitoring questions

The purpose of the water quality program can be framed in a series of general questions that can be answered quantitatively via measurable objectives.

1. What are the existing chemical and biological ranges in water quality parameters within selected waters of NCPN parks?
2. What are the long-term status and trends in selected water quality parameters at selected sites on selected NCPN water bodies?
3. Are selected NCPN water bodies in compliance with designated beneficial uses?
4. Are the existing chemical and biological ranges at selected times and sites consistent with establishment of outstanding natural resource waters (ONRW) designation?
5. What are point and non-point pollution sources within the watersheds?

1.7 Measurable objectives

The measurable objectives are related to water quality criteria presented in applicable state water quality standards (see Table 1-1). These criteria provide the framework for developing specific questions, a sampling plan, and data analysis techniques that will answer the questions. Answering the questions posed will be a tangible result of the monitoring effort. The amount of data collected, variability of results due to natural conditions, and variability due to analysis technique will introduce a level of uncertainty that can be quantified in order to aid interpretation of results.

1. Establish range and variability of water quality parameters under base flow conditions as they vary with seasonal and climatic conditions using descriptive statistics discussed in SOP 15. *It is recognized that insufficient data are collected on a monthly basis to fully understand diel and seasonal trends in parameters.*
2. Determine status and trends in selected water quality parameters as a function of flow, season and climatic conditions, using trend analysis techniques outlined in SOP 15.
3. Compare water quality data against state standards for chronic exceedance on a monthly and annual basis. *Multiple exceedances in a year typically indicate non-compliance, but this evaluation is made formal in conjunction with state officials.*
4. Analyze long-term data for designation as ONRW. *Descriptive statistics and long-term trends will help determine if a water body has the potential to be designated an ONRW. This will be possible after many years of monitoring and through cooperation with the state water boards.*
5. Determine point and non-point sources of pollution within watershed via association. *Some pollutants have unique or typical causes and thus can be assigned a source through association or by evaluation of ancillary data, such as geology or land use using GIS or remote sensing resources coupled with field evaluation.*

1.8 Management use of monitoring data

The knowledge gained by answering the monitoring questions and measurable objectives 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:

1. Maintain waters that vary within their existing 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*.
2. Improve water quality of impaired waters. *Justification: The NPS GPRA goal is that 99.3% of streams and rivers managed by NPS will meet state and federal water quality standards. Several water bodies within NCPN are impaired or flow into an impaired water body. This falls under effectiveness monitoring, but will be useful in some situations if management activities occur in monitored watersheds*.
3. Demonstrate and maintain high water quality where it exists. *Justification: The anti-degradation policy of the Clean Water Act specifies that high quality waters will be maintained (EPA 2006; section 303)*.

2 Sampling Design

2.1 Target population

The goals for water quality monitoring are to determine status and trends at specific sites, not to make inference to other sites. Thus, the target population is a subset of potential daytime water quality measurements in perennial waters selected through a judgmental process involving the participation of park resource managers, NCPN staff, and U.S. Geological Survey (USGS) and other water quality specialists. The process included on-site interviews of staff from parks and other nearby agencies, a review of existing formal and informal literature, and an extensive compilation and analysis of existing water quality data. The results of this process are summarized in Appendix F of the NCPN Plan for Natural Resource Monitoring (O'Dell et al. 2004).

Perennial waters were selected over ephemeral or seasonal water sources because the larger perennial sources are most likely to transport contaminants (natural or anthropogenic) long distances across park boundaries. This holds true primarily for rivers and larger reservoirs, but also can be applied to larger perennial springs where the recharge basin can extend many miles. Perennial waters are the sources for which standards are commonly established and are most frequently monitored for compliance with CWA-based standards.

Specific water sources were selected based on the following hierarchy:

1. **303(d) listed waters**—where previous sampling indicates one or more parameters regularly approach or exceed standards or recommended levels.
2. **Waters with demonstrated threat levels**—where an analysis of existing data indicate that measured conditions regularly approach or exceed standards or recommended levels, but where the frequency of exceedance, or the quality of the database do not support a 303(d) listing.
3. **Data gaps**—Waters identified as important, but where little or no water quality information exists.
4. **Waters of management concern**—where past sampling may not indicate constituent values of concern, but where anthropogenic activities indicate that contamination is a significant threat.
5. **Other perennial waters** with no specific threat.

2.2 Rationale for sampling design

Given the number of network parks with water resources, water resource diversity, and limited funding, making broader inference is not achievable. However, it is recognized that sampling will represent conditions in the watershed above the point of sample collection. A judgmental design will continue to be used in the long-term NCPN monitoring, both in the selection of water sources to be monitored, and in the selection of specific sample sites. A split-panel temporal sampling design is used, in which some sites are visited at every sampling event, while others are sampled only in some years. This will allow tracking long-term trends while expanding the number of sites that can be monitored with limited financial resources.

2.3 Influences on sampling design

2.3.1 Partnerships

A primary goal is to capture a long-term record of water quality conditions across the parks and track the status of individual sites of high interest. To achieve this goal, the NCPN partners with the Utah Division of Water Quality (UDWQ). NCPN staff collect samples in parks and the state runs laboratory analysis as part of its EPA-funded Clean Water Act monitoring program. In Colorado parks, NCPN relies on data collected by individual parks, or pays the USGS to collect and analyze samples in parks where ongoing water quality monitoring has not been established. The primary influences on sampling design beyond monitoring objectives are the need for adequate temporal representa-

tion of water conditions, and requirements associated with partner (UDWQ) analysis of samples.

The resulting program includes partnerships with the State of Utah, USGS-Colorado, and NPS units. The sampling design is not complex, but the logistics and data management are. While relying on so many partners introduces the potential for inconsistency, the existence of relatively uniform methods for water quality sample collection and analysis by EPA-certified laboratories permits collection of reliable, high-quality data. Guidelines for sample collection, analysis, and quality assurance are presented in the SOPs. Table 2-1 depicts the framework that will be used with partners as well as responsibilities for various aspects of the monitoring.

2.3.2 Monitoring by others that supports NCPN goals

Water quality monitoring that directly meets NCPN vital signs goals is currently conducted by the State of Utah, NPS, and the USGS for several significant water sources throughout the network. As a result, NCPN water quality monitoring benefits from the data collected by others in and near several parks, thus freeing NCPN resources to be directed toward monitoring gaps. For a more detailed description of the scope and utility of these monitoring efforts, see Appendix R in O'Dell and others (2004). Where current monitoring meets NCPN needs, the design assumption is that the NCPN will, where feasible, compile the data from the current collecting agency rather than incurring the expense of sample collection.

2.3.3 Other design considerations

Myriad other factors affected the sampling design (Table 2-2). The result is that it is primarily judgmental in nature and consists of a set of long-term, fixed station sites. Building a more robust database for specific sites and water bodies was favored over a design that would provide a stronger picture of regional conditions. This approach was based on objectives that gave highest priority to determining compliance with the Clean Water Act—and the fact that the State of Utah, a major partner, requires 10 monthly samples per year under its monitoring protocols in order to ensure a robust database when determining if protected uses are supported.

2.3.3 Boundary of monitoring effort

Monitoring is primarily conducted within NCPN units. In some cases, sample sites are located on waters that flow through the park but are a short distance upstream or downstream of the park. This is usually done (1) where physical access to the water source in the park is impractical, and (2) where another agency is already monitoring a site nearby a park, so additional sampling inside the park would be redundant. In both instances, these nearby sites are considered appropriate because we can make educated guesses about some of the intervening sections, but no definitive statistical inferences can be made. Representativeness in this instance will be based on professional judgment that considers amount of flow, size of tributaries between the park and the gauge site (if any), proximity of gauge site to park boundary, and changes in geology and land

Table 2-1. Overview of partnerships and approaches to sampling and analysis.

Park unit*	Number of NCPN-supported monitoring sites	Partner	Sample collection	Laboratory analysis	Data quality assessment	Data screening, storage, and analysis
ARCH, BRCA, CANY, CARE, ZION	16	Utah DWQ	NCPN/Park staff	Utah State Lab	NCPN	Utah DWQ/NCPN
BLCA, CURE	4	USGS	Park staff	USGS	Park staff	Park staff/NCPN
DINO	2	USGS	USGS	USGS	USGS	USGS

*For GOSP, HOVE, and TICA, see Section 2.3.2.

use between gauge and park. Additional verification could be made by evaluating range and variability of over-sampled core parameters at a gauged site and a site thought to be similar within the park. With long-term data from sites at various levels of the watershed, including a reference or upper watershed site and a site at the bottom of a watershed, we can make educated guesses about some of the intervening sections, but no definitive statistical inferences can be made.

Table 2-2. Planning considerations that influenced the sampling design for NCPN water quality monitoring.

Planning consideration	Influences on sampling design
Objectives	Water sources that are included on the state 303(d) list or have frequent exceedances for state standards are a high priority for monitoring. Waters that can provide a representative indicator of the status and trends of water quality conditions for important water resources in the parks are also considered important.
Funding is very limited, considering the number of parks and water resources that could potentially be monitored.	• NCPN must take advantage of existing monitoring conducted by the states, other federal agencies, and current monitoring by parks, and not duplicate these efforts. • Measures will generally be selected where the laboratory analysis is relatively inexpensive. For this reason, analysis for organic compounds (including pesticides) and radionuclides is not considered practical. • In most cases, even a major water body has only one sample site in a park. • Some sites will be monitored on a rotating schedule where annual monitoring will be rotated among 2–3 sites.
The State of Utah has offered to cover the cost of laboratory analysis for as many as 15 sites in Utah parks.	Taking advantage of this valuable service will require adopting State of Utah schedules and techniques for sampling and sample handling and developing a compatible process for data management.
NCPN parks are widely separated and some are very large, requiring several hours of travel to reach some of the more remote water sources.	• Accessible sample locations are often selected over those with difficult access. Most sample sites will be accessible by vehicle. Of the sites that require access by foot, most hikes will be short, and the longest would not exceed about 2 hours one-way. • In some cases, water sources that are considered important will not be monitored due to the difficulty of access. In other cases where access by NCPN monitoring staff is impractical (such as at DINO), agreements with other agencies will be developed to accomplish sampling and analysis. • Monitoring staff will be located so that they can service groups of 3–6 parks, because it would be impractical to monitor the entire network based from one central location.
Water quality data exist for many water resources in network parks.	• Existing data were used to identify where water quality approaches or exceeds standards. These sites are a high priority for monitoring. • It will be advantageous to select vital sign monitoring locations where data exist in order to build on the existing information base.
Water quality data are absent for some high-priority waters.	Filling these data gaps is a high priority.
Some parks currently conduct some water quality monitoring.	Having experienced staff, equipment, and facilities in place will facilitate NCPN monitoring at reduced cost, and in some instances NCPN can enhance park programs.

Table 2-2. Planning considerations that influenced the sampling design for NCPN water quality monitoring, cont.

Planning consideration	Influences on sampling design
Laboratory analyses for water quality parameters are traditionally performed for groups of parameters.	Measures will often be selected as groups of parameters, such as "major ions" and "nutrients" or "trace elements."
Core parameters have been mandated for water quality vital signs monitoring because they are useful basic indicators and are typically necessary for analyzing the findings for other parameters.	Core parameters consisting of discharge, pH, dissolved oxygen, temperature, and specific conductance will be measured in the field with every sample collected.
Some sources in the NCPN, such as seeps, springs, and wetlands, do not occur in well-defined channels, making discharge measurements difficult.	Techniques for discharge measurement and the quality of the resulting measurement will vary depending on the site. An attempt will be made to obtain the best practical discharge measurement given limitations on time, equipment, and the nature of the flow.
There is a high degree of natural variability in some water quality characteristics due to seasonal variation and response to storm events.	Sampling will occur 8–12 times per year to capture seasonal and flow variation. Flow measurements will accompany sampling.
Groundwater in this setting generally has less variability in discharge and chemistry.	Spring sampling may be less frequent.
Many of the sources of high levels of ions or trace elements are believed to be natural.	The NPS generally does not wish to modify these natural conditions but is interested in monitoring these sources so that conditions can be determined with greater certainty and tracked over time for effective use in any 303(d) listing or TMDL planning.
Sample timing	Samples will typically be collected during periods of low/base flow. This is for the practical reason that wet backcountry roads in NCPN are impassable and waiting for dry travel conditions will result in base flow sampling conditions in most instances.
Sample variability	Due to high variability and the need for large sample sizes for statistical analysis, the most efficient sampling will occur when flow conditions are similar. This will be most easily achieved by targeting base flow conditions.

3 Site Selection

Twenty-two sites were selected for NCPN-supported water quality monitoring (Table 3-1). For these sites, the network supports fieldwork and/or laboratory analysis in addition to data compilation and reporting. An additional 67 sites relevant to NCPN park units are currently monitored by other entities or as part of other NCPN protocols (Table 3-2).

In addition to monitoring locations, quality assurance samples, including field replicates and field blanks, are collected and reported under STORET numbers listed in Table 3-3.

Table 3-1. NCPN-supported sampling locations.

Park	Storet/NWIS ID	Station name	Sampling	Laboratory	Panel*	Active	Comment
Arches NP	5995220	SALT WASH AT WOLFE RANCH RD XING SW-3	SEUG	UTDEQ	C	Y	
	5995240	COURTHOUSE WASH .5MI AB COLORADO R AT USGS CW-1	SEUG	UTDEQ	C	Y	
Black Canyon of the Gunnison NP	383418107471401	RED ROCK CANYON NEAR NPS BOUNDARY NEAR MONTROSE,CO	CURE	USGS	C	Y	
Bryce Canyon NP	-9999	TROPIC DITCH	NCPN	N/A	R	Y	field parameters only
	4951855	SHEEP CK BL SPRING IN BRYCE CYN NP	NCPN	UTDEQ	C	Y	
	4951857	YELLOW CK BL SPRING IN BRYCE CYN NP	NCPN	UTDEQ	R	Y	
	4951915	MOSSY CAVE SPRING NW OF TROPIC	NCPN	UTDEQ	R	Y	
Canyonlands NP	5995150	SALT CK NR CRESCENT ARCH SC-10	SEUG	UTDEQ		N	discontinued 10/2013
Capitol Reef NP	4954770	SULPHUR CK AB CNFL/ FREMONT R IN PICNIC AREA	NCPN	UTDEQ	R	Y	
	4954775	SULPHUR CK BL ROAD TO GOOSENECKS OVERLOOK IN CRNP	NCPN	UTDEQ	R	Y	
	4954780	PLEASANT CK S OF SLEEPING RAINBOW RANCH	NCPN	UTDEQ	R	Y	
	4954795	OAK CREEK ABOVE SANDS RANCH DAM	NCPN	UTDEQ	R	Y	
	4954812	HALLS CK BL NARROWS	NCPN	UTDEQ	R	Y	
Curecanti NRA	09127000	CIMARRON RIVER BL SQUAW CREEK, NR CIMARRON, CO.	CURE	USGS	R	Y	
	382831107172600	BLUE MESA RESERVOIR ABV SOAP CR NEAR SAPINERO, CO	CURE	USGS	C	Y	
	383028107162200	WEST ELK CR BELOW FOREST BOUNDARY NR SAPINERO, CO	CURE	USGS	R	Y	
Dinosaur NM	09260050	YAMPA RIVER AT DEERLODGE PARK, CO	USGS-CO	USGS	C	Y	
	404417108524900	GREEN RIVER ABOVE GATES OF LODORE, CO	USGS-CO	USGS	C	Y	
Zion NP	4950800	LA VERKIN CK AT LEE PASS TRAIL	NCPN	UTDEQ	C	Y	
	4950920	NORTH CK AT PLANNED GAGE IN PARK	NCPN	UTDEQ	C	Y	
	4951260	NORTH FK VIRGIN R AT NORTH FORK RD	NCPN	UTDEQ		N	site upstream of development - replaced by 4951265 downstream of private land
	4951265	N FK VIRGIN R AT WSA BNDRY	NCPN	UTDEQ	C	Y	

*Indicates continuous (C) or 2-year rotation (R). See Chapter 4.

Table 3-2. NCPN-relevant sampling locations monitored by other entities or as part of other NCPN protocols.

Park unit	Storet/NWIS ID	Station name	Priority	Sampling	Data	Active	Comment
Arches NP	09163500	COLORADO RIVER NEAR COLORADO-UTAH STATE LINE		USGS - CO	NWIS	Y	
	09180000	DOLORES RIVER NEAR CISCO, UT		USGS - UT	NWIS	Y	
	09180500	COLORADO RIVER NEAR CISCO, UT		USGS - UT	NWIS	Y	
	5995200	FRESHWATER SPG IN SALT WASH .5MI AB RD XING SW-1		SEUG	Storet	N	discontinued 10/2013
	5995245	UPPER COURTHOUSE WASH @ NPS BNDY		SEUG	Storet	N	unstable sampling location, on hold until stable location re-emerges; part of NCPN springs monitoring
	5995246	COURTHOUSE WASH AT SPRING APPROX. 75M INSIDE NPS WEST BOUNDARY		SEUG	Storet	Y	part of NCPN springs monitoring
	5995250	SLEEPY HOLLOW SPRING IN UPPER COURTHOUSE WASH SH-1		SEUG	Storet	N	part of NCPN springs monitoring
	5995270	WILLOW SPRING WS-1		SEUG	Storet	N	discontinued 10/2013
	5995290	LOST SPRING		SEUG	Storet	N	discontinued 10/2013
Black Canyon of the Gunnison NP	09128000	GUNNISON RIVER BELOW GUNNISON TUNNEL, CO	x	CURE	NWIS	Y	
	383537107471500	RED ROCK CANYON AT MOUTH NEAR MONTROSE, CO		CURE	NWIS	Y	

Table 3-2. NCPN-relevant sampling locations monitored by other entities or as part of other NCPN protocols, cont.

Park unit	Storet/NWIS ID	Station name	Priority	Sampling	Data	Active	Comment
Canyonlands NP	09272400	GREEN RIVER AT OURAY, UTAH		USGS - UT	NWIS	Y	
	09315000	GREEN RIVER AT GREEN RIVER, UT		USGS - UT	NWIS	Y	
	4930010	GREEN R AB CNFL / COLORADO R	x	SEUG	Storet	Y	
	4930150	GREEN R AT MINERAL BOTTOMS	x	SEUG	Storet	Y	
	09328920	GREEN RIVER AT MINERAL BOTTOM NR CANYONLANDS NTL PARK		USGS - UT	NWIS	Y	
	4952380	COLORADO R. BL BIG DROP #3 RAPIDS	x	SEUG	Storet	Y	
	4952400	COLORADO R AB CNFL / GREEN R	x	SEUG	Storet	Y	
	4956290	COLORADO RIVER AT POTASH BOAT RAMP	x	SEUG	Storet	Y	
	5995020	2.4 MILE LOOP SPRING BS-2		SEUG	Storet	N	discontinued 10/2013
	5995050	CAVE SPRING SQ-3		SEUG	Storet	N	discontinued 10/2013
	5995120	LITTLE SPRING CANYON CREEK LS2		SEUG	Storet	N	part of NCPN springs monitoring
	5995160	SALT CREEK NR PEEKABOO SPRING SC-12		SEUG	Storet	N	discontinued 10/2013
	5995420	CHOCOLATE DROPS SPG .5 MI S OF MAZE OVERLOOK SF-4		SEUG	Storet	N	discontinued 10/2013
	5995500	MAZE OVERLOOK SPG .25MI SE OF MAZE OVERLOOK SF-2		SEUG	Storet	N	discontinued 10/2013
	5995540	HORSESHOE CYN SPG .3MI AB CNFL/ WATER CYN LOWER HSC-2		SEUG	Storet	N	discontinued 10/2013
Capitol Reef NP	09330000	FREMONT RIVER NEAR BICKNELL, UT		USGS-UT	NWIS	Y	
	09330230	FREMONT RIVER NEAR CAINEVILLE, UT		USGS-UT	NWIS	N	discontinued 12/2011
	4954330	FREMONT R AT OLD U24 XING	x	UTDEQ	Storet	Y	
	4954380	FREMONT R NEAR BICKNELL		UTDEQ	Storet	Y	
	4954390	FREMONT RIVER AT U12 XING		UTDEQ	Storet	Y	
	4954550	FREMONT R AB MILL MEADOW RES		UTDEQ	Storet	Y	

Table 3-2. NCPN-relevant sampling locations monitored by other entities or as part of other NCPN protocols, cont.

Park unit	Storet/NWIS ID	Station name	Priority	Sampling	Data	Active	Comment
Curecanti NRA	09125000	CURECANTI CREEK NEAR SAPINERO, CO.		CURE	NWIS	Y	
	381633107054700	CEBOLLA CREEK AT POWDERHORN, CO	x	CURE	NWIS	Y	
	381934107133500	LAKE FORK GUNNISON RIVER BELOW GATEVIEW, CO	x	CURE	NWIS	Y	
	382418107242600	BLUE CREEK AT HWY 50 NEAR SAPINERO, CO		CURE	NWIS	Y	
	382702107203900	PINE CREEK AT HWY 50 NEAR SAPINERO, CO		CURE	NWIS	Y	
	382900107101600	EAST ELK CREEK NEAR MOUTH NEAR SAPINERO, CO		CURE	NWIS	Y	
	382902107140400	RED CREEK NEAR MOUTH NEAR SAPINERO, CO		CURE	NWIS	Y	
	382937107033500	STEUBEN CREEK NEAR MOUTH NEAR GUNNISON, CO	x	CURE	NWIS	Y	
	382943107015300	BEAVER CREEK AT HWY 50 NEAR GUNNISON, CO		CURE	NWIS	Y	
	383103106594200	GUNNISON RIVER AT CNTY RD 32 BELOW GUNNISON, CO	x	CURE	NWIS	Y	
	383137107183600	SOAP CREEK ABOVE CHANCE CREEK NEAR SAPINERO, CO		CURE	NWIS	Y	
	382644107271000	MORROW PT RESERVOIR BELOW BLUE CR NR SAPINERO, CO		CURE	NWIS	Y	
	382702107315400	MORROW PT RES ABV MORROW PT DAM NEAR CIMARRON, CO		CURE	NWIS	Y	
	382829107122200	BLUE MESA RES. ABOVE CEBOLLA CR NEAR SAPINERO, CO		CURE	NWIS	Y	
	382856107050000	BLUE MESA RES. BELOW HWY 149 NEAR GUNNISON, CO		CURE	NWIS	Y	
	382924107352300	CRYSTAL RESERVOIR AT CRYSTAL CREEK NR CIMARRON, CO		CURE	NWIS	Y	
	383024107371800	CRYSTAL RESERVOIR AT CRYSTAL DAM NEAR CIMARRON, CO	x	CURE	NWIS	Y	
Dinosaur NM	09247600	YAMPA RIVER BELOW CRAIG, CO.		USGS-CO	NWIS	Y	
	09251000	YAMPA RIVER NEAR MAYBELL, CO		USGS-CO	NWIS	Y	
	09261000	GREEN RIVER NEAR JENSEN, UT	x	USGS-UT	NWIS	Y	
	4937760	BRUSH CK AT U149 XING		UTDEQ	Storet	Y	
	5937810	POT CREEK AB CALDER RES		UTDEQ	Storet	Y	
	5937880	POT CREEK AB MATT WARNER RES		UTDEQ	Storet	Y	
Golden Spike NHS	4960760	BLUE CK AT CR504 XING E OF GOLDEN SPIKE MONUMENT		UTDEQ	Storet	Y	

Table 3-2. NCPN-relevant sampling locations monitored by other entities or as part of other NCPN protocols, cont.

Park unit	Storet/NWIS ID	Station name	Priority	Sampling	Data	Active	Comment
Hovenweep NM	5995700	SQUARE TOWER SPRING		SEUG	Storet	Y	part of NCPN springs monitoring
	5995710	CAJON SPRING		SEUG	Storet	Y	part of NCPN springs monitoring
	5995720	HACKBERRY HOUSE SPRING		SEUG	Storet	N	part of NCPN springs monitoring
Natural Bridges NM	5995310	ARMSTRONG CANYON CK AT KACHINA NATURAL BRIDGE KB-1		SEUG	Storet	N	discontinued 10/2013
	5995320	OWACHOMO BRIDGE SPRING IN TUWA CYN AB CNFL OB-1		SEUG	Storet	N	discontinued 10/2013
	5995330	SIPAPU BRIDGE SPRING .25 MI AB BRIDGE SB-1		SEUG	Storet	N	discontinued 10/2013
Timpanogos Cave NM	-999	HIDDEN LAKE AT TIMPANOGOS CAVE		TICA	Private	Y	
	4994970	HANSEN CAVE SPRING IN TIMPANOGOS CAVE NM		TICA	Storet	Y	
Zion NP	09405500	NORTH FORK VIRGIN RIVER NEAR SPRINGDALE, UT		USGS-UT	NWIS	Y	
	09406000	VIRGIN RIVER AT VIRGIN, UT		USGS-UT	NWIS	Y	
	4950890	NORTH CK AB CNFL/ VIRGIN R		UTDEQ	Storet	Y	
	4950950	N FK VIRGIN R AB CNFL / E FK VIRGIN R	x	UTDEQ	Storet	Y	
	4951400	E FK VIRGIN R AB CNFL / N FK VIRGIN R	x	UTDEQ	Storet	Y	

NCPN may support priority sites in the future if other monitoring efforts are reduced or eliminated.

Table 3-3. Quality assurance sample STORET numbers.

Park	Storet/ NWIS ID	Station name	Sampling	Data	Active	Comment
-	5995202	NPSETAL FIELD BLANK	NCPN	Storet	Y	Lab field blank at random sampling site
ARCH	5995222	SALT WASH ABOVE WINTER CAMP WASH AT ROAD CROSSING	SEUG	Storet	Y	dummy site for duplicate lab QAQC for 5995220
CANY	4956291	COLORADO RIVER AT POTASH BOAT RAMP	SEUG	Storet	Y	dummy site for duplicate lab QAQC for 4956290
ZION	4951261	NORTH FK VIRGIN AB SCENIC NARROWS	NCPN	Storet	N	dummy site for duplicate lab QAQC for 4951260
ZION	4951266	N FK VIRGIN R AB CNFL/ BAPTISM RIVER	NCPN	Storet	Y	dummy site for duplicate lab QAQC for 4951265

4 Revisit Design

Sampling implementation uses a split-panel design, in which some sites are visited at every sampling event while others are sampled in rotation. The split-panel design balances the need to sample every site with budget constraints that limit the number of sites that can be sampled each year. In Table 3-1, the "Panel" column indicates whether each site is sampled continuously (as indicated by a "C" for long-term continuous sampling) or on a rotational (R) basis, occurring monthly when possible for two years, then off for two years. Once activated, each rotation site should be sampled for at least two consecutive years, with the goal of collecting data representative of a broad range of hydrologic and other environmental conditions.

To balance the requirement to minimize the annual cost of the program with the need for repeated data collection at each site, recommended sample frequencies range from four to 12 samples per year, depending on site characteristics, known water quality conditions/issues, and other site-specific considerations. To use the Utah public laboratory for no-cost analytical work, all sites in Utah must be sampled 10 times in a year. However, it is understood that some sites are not accessible year-round.

5 Site Locations

Sampling site locations are presented in the figures below.

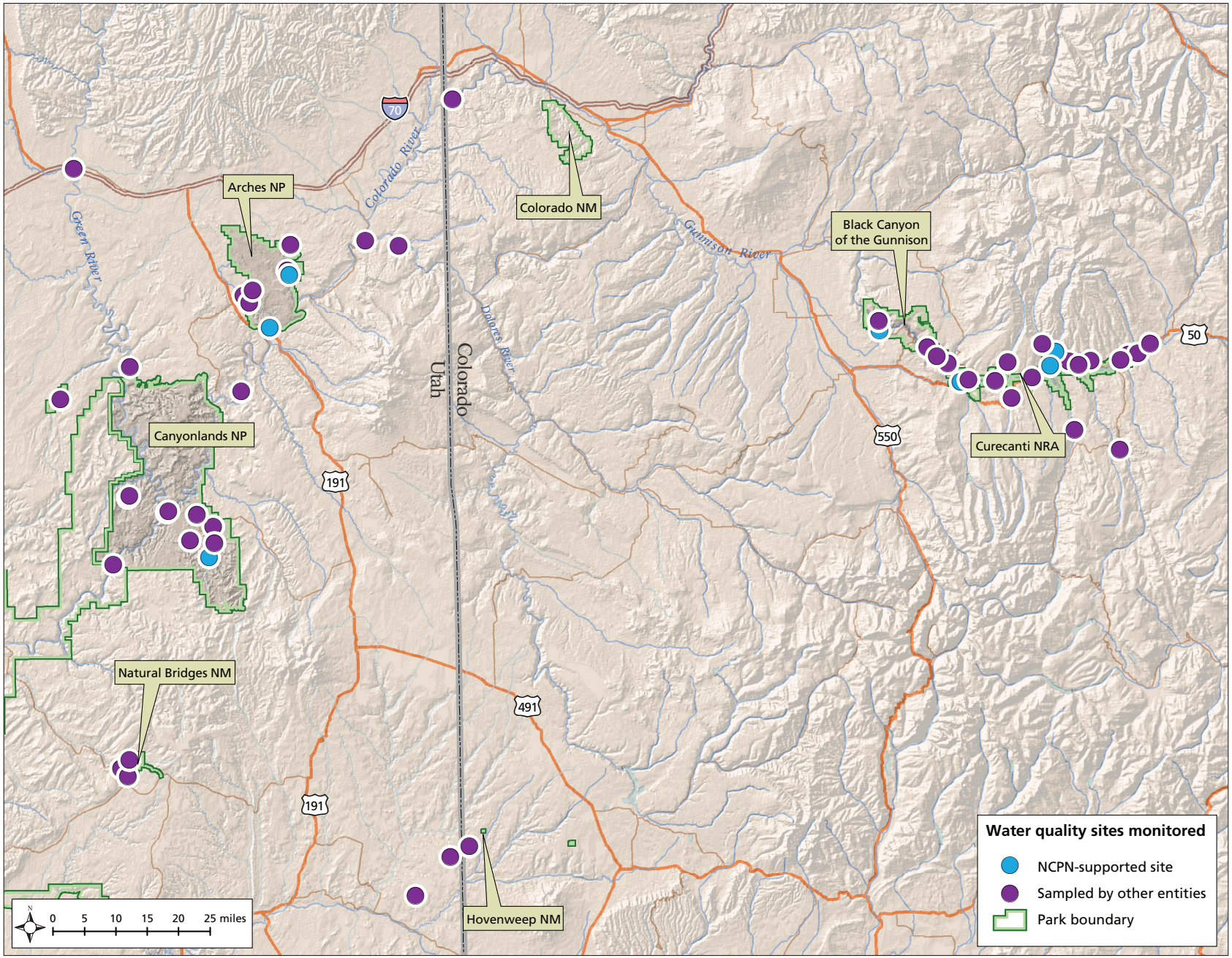


Figure 5-1. Sampling locations associated with parks in the southeastern portion of the Northern Colorado Plateau Network.

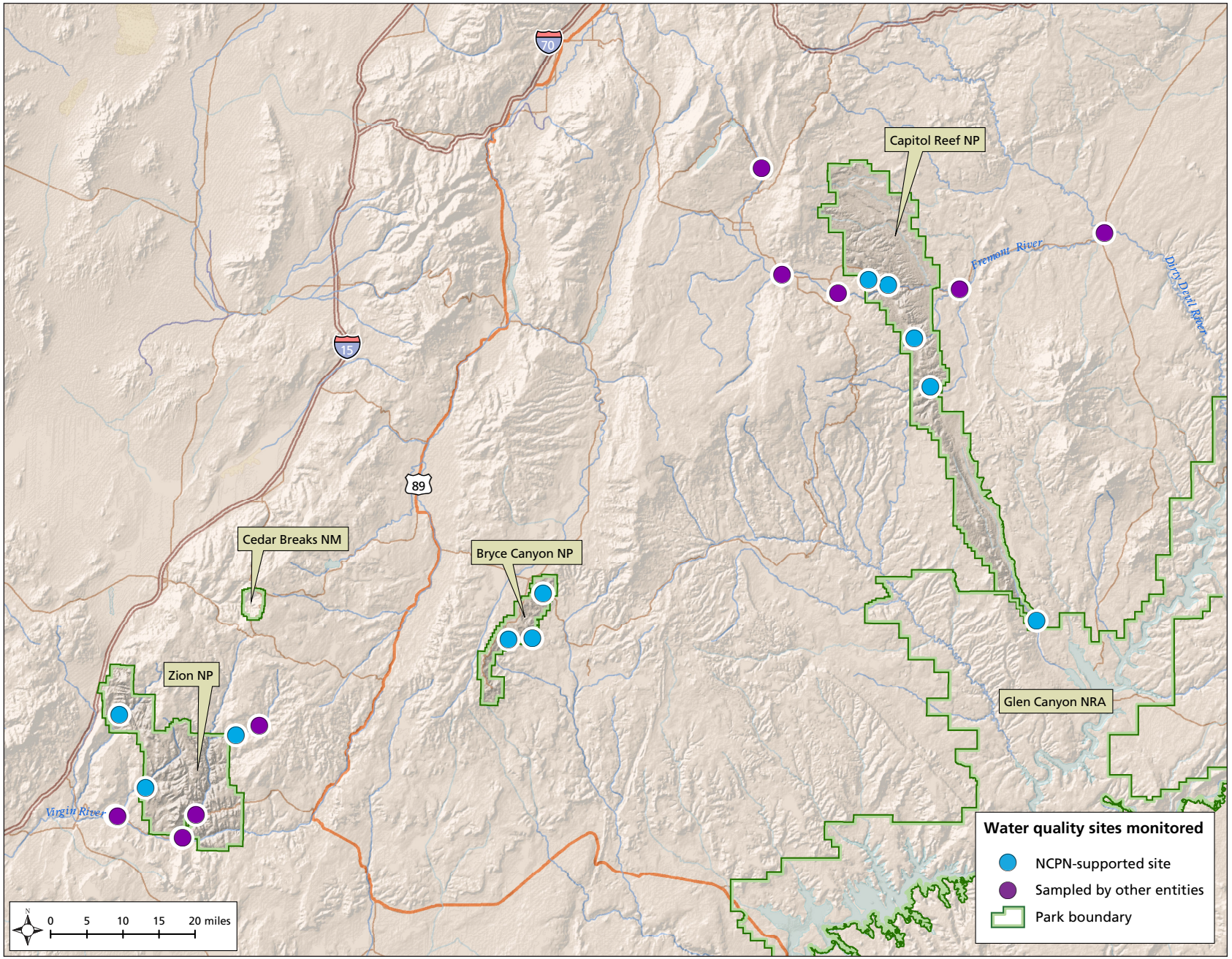


Figure 5-2. Sampling locations associated with parks in the southwestern portion of the Northern Colorado Plateau Network.

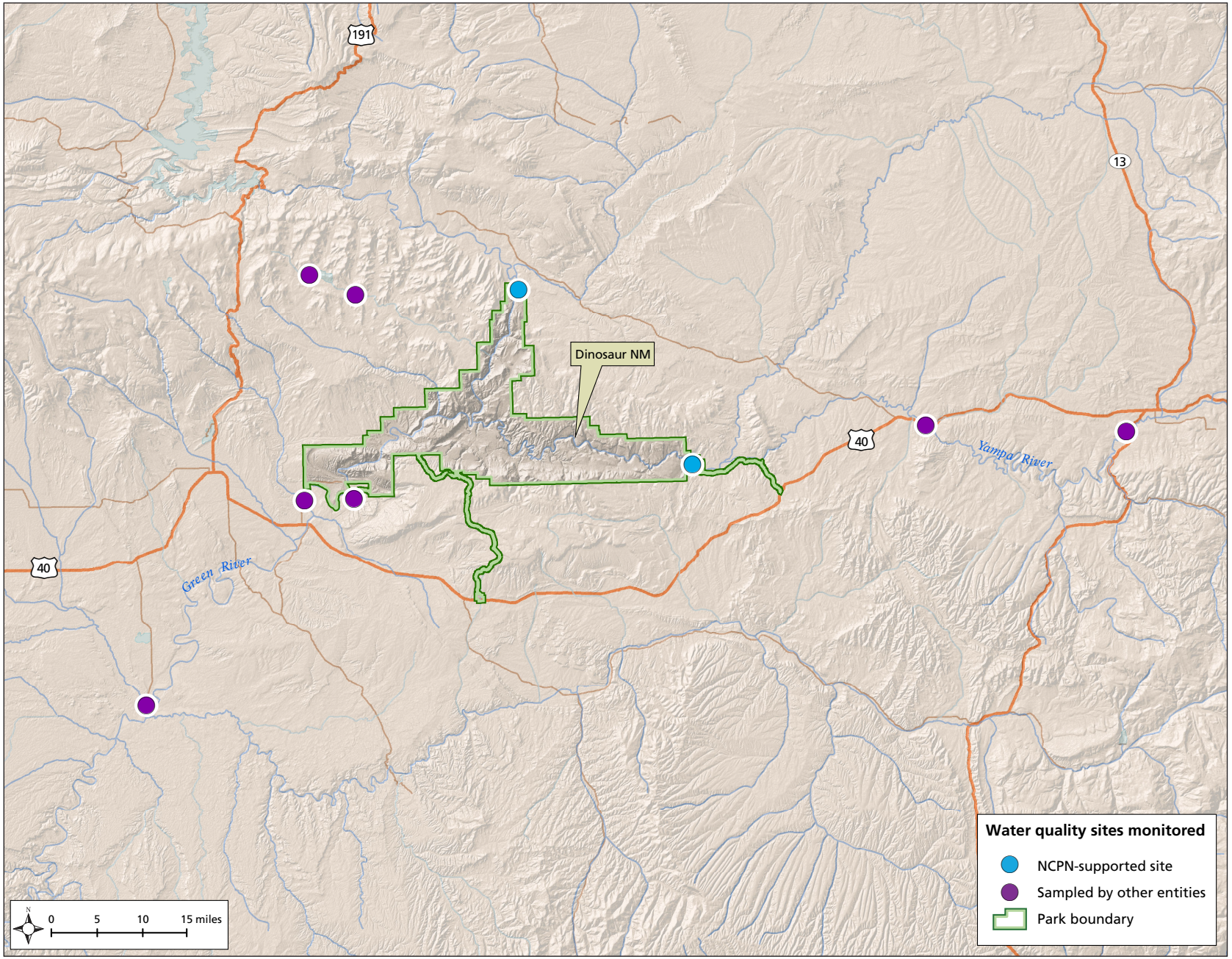


Figure 5-3. Sampling locations associated with Dinosaur National Monument.

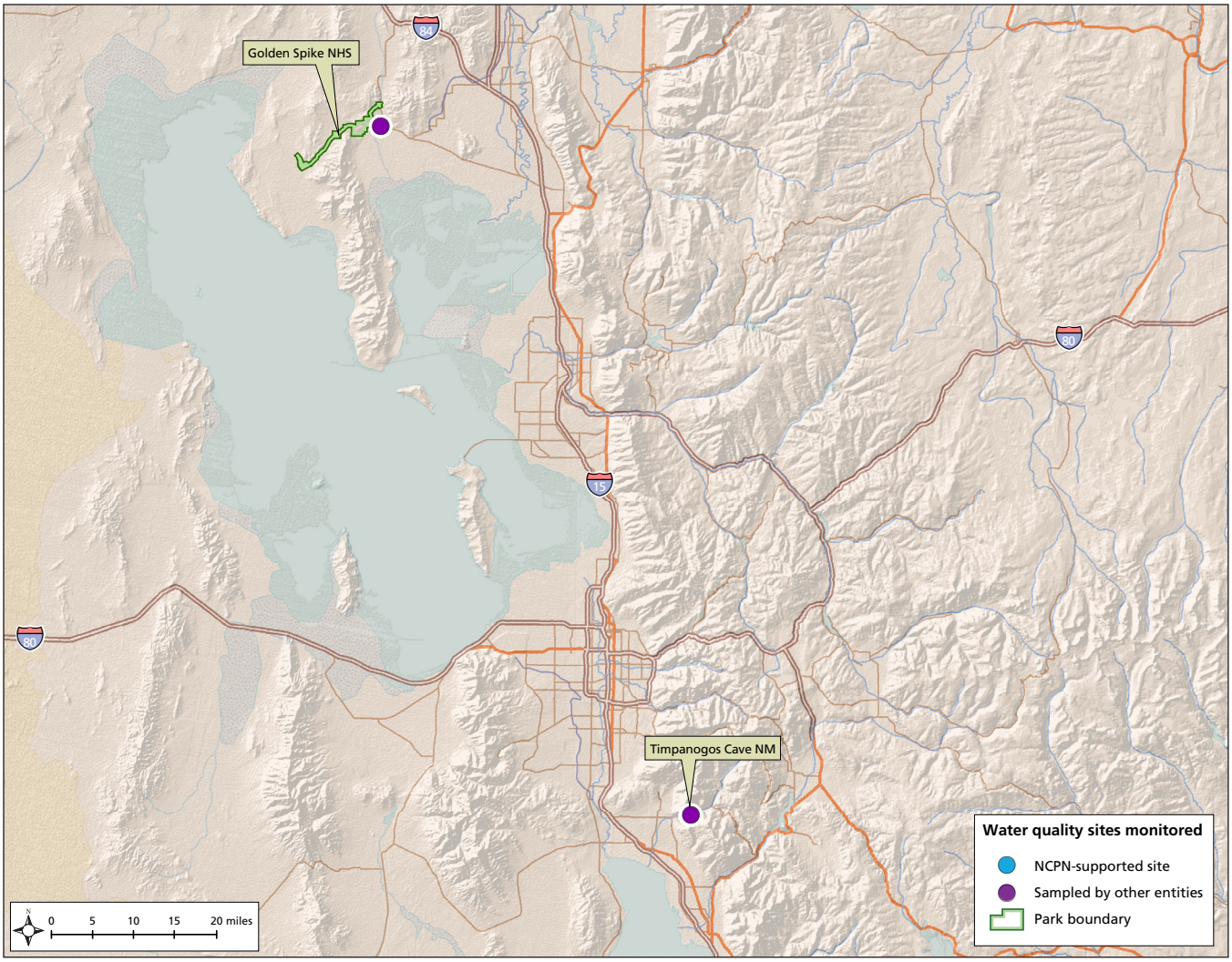


Figure 5-4. Sampling locations associated with parks in the northern portion of the Northern Colorado Plateau Network.

6 Strengths and Limitations of Monitoring Design

The approach selected provides several benefits to the NCPN, network parks, and regulatory agencies. It will create a long-term record with consistent methodologies and thus provide high-quality information for some key water resources. This record will be valuable for understanding long-term trends and identifying both chronic contamination and the extent of natural variability. It can document some larger-scale, interannual changes and smaller-scale changes that show some consistency or periodicity over periods of several years. By following state-accepted protocols, the approach will be effective in determining compliance with state water quality standards (except bacteria, which require a higher sampling frequency). It will contrast with data from short-term studies and many monitoring efforts that end after a few years, making analysis of long-term trends problematic.

The sampling frequency (4–12 samples per year) will capture conditions that occur over relatively long periods, such as base flow, spring runoff, and warm-season and cool-season conditions. It will be somewhat less effective for capturing individual episodic events, such as flood conditions that occur several times each year but are of relatively short duration.

Primary among the limitations of the program is that it is not nearly comprehensive. The number of water sources is a small portion of the total, and is biased toward perennial streams. Additionally, the waters sampled are represented by a single sample location, so drawing conclusions about the larger water system requires some assumptions about spatial consistency.

Water quality characteristics that fluctuate diurnally or otherwise change rapidly will not be well-characterized. The monthly measure of water chemistry, while useful for comparison against standards, will not fully characterize the patterns of parameters. Stream discharge measurements will be useful primarily for understanding hydrologic conditions at the time of sampling, which is necessary to interpret laboratory data. Springs, which have more consistent flow, will be well-represented. For some springs, the discharge measurements made under this program will be the only flow data available. For bacterial monitoring, the frequency will be sufficient for a "screening" level of analysis, but will not be sufficient as a basis for regulatory action. Winter conditions will be missed at sites with poor winter access.

Importantly, this monitoring is not expected to capture short-duration episodic events, such as spills or floods. It will, however, provide a well-documented baseline of background conditions.

7 Field and Laboratory Methods

7.1 Standard Operating Procedures

Field and laboratory methods will employ standard methods of water quality sampling and analysis. Standard operating procedures (SOPs) cover field-season preparations and equipment, sequence of events in the field, details of taking measurements (including field forms and electronic data entry), post-collection processing of samples, lab analysis, data verification, and end-of-season procedures. A quality assurance project plan (QAPP) describes quality assurance (QA) and quality control (QC) procedures.

Procedures described in the SOPs are developed from several sources, primarily:

- Utah Division of Water Quality, Manual for Water Quality Monitoring, 1993
- Standard Methods for the Examination for Water and Wastewater, 20th ed., Clesceri 1998
- USGS National Field Manual for the Collection of Water quality Data, variously dated U.S.
- Manuals provided by equipment manufacturers

Monitoring is subdivided into 17 categories. A detailed Standard Operating Procedure (SOP) details activities for each. Table 7-1 provides a brief overview of SOPs used in this monitoring program.

7.2 Measurable attributes

The water quality attributes measured or sampled at each site are grouped by sample type (Table 7-2) for convenience in discussion and reporting. Core parameters are required by the NPS Water Resources Division (WRD) as the minimum suite of parameter measurements that could be used as indicators of water quality. They are closely related to the speciation and concentration of other water quality constituents as well as determinants of biological activity. Major ions are used to determine alkalinity, and are useful in toxicity and transport models. Sulfate can drive mercury methylation to very high levels and is a good general indicator of water quality in small western streams. Some of these ions are nutrients and trace elements necessary for biological activity and may be correlated with other water quality parameters.

7.3 Site-specific attributes and protocols

Park-specific management issues and the receiving laboratory determine which sample types are reported for each site. Table 7-3 summarizes the sampling done at each NCPN site, the personnel who will collect the data, and the protocols they will follow.

Table 7-1. Standard operating procedures (SOPs) for water quality monitoring.

SOP #	Title	Summary
SOP 1	Field Safety for Water Quality Sampling	Each NPS employee performing field inventory and monitoring activities in the NCPN will, in conjunction with their supervisor (and, if appropriate, other knowledgeable persons), develop a Job Hazard Analysis of the task to be performed. The Job Hazard Analysis will identify real and potential hazards associated with inventory and monitoring activities, and develop approaches that minimize or eliminate the hazards.
SOP 2	Staff Training, NCPN Units in Colorado	Annual training will be provided by NPS staff that has attended USGS training in water quality field techniques. As a partner, USGS will provide quality reviews of NPS field and laboratory techniques.
SOP 3	Staff Training and Coordination with Utah Division of Water Quality, Utah Units	Annual training is conducted by the state and required for all field staff. If possible, then back-up staff will also attend this training. If new staff come on board outside of the regular training season (spring), then arrangements will be made with UDWQ for a special training session.
SOP 4	Site Selection, Conditions, and Documentation	A description of the criteria used to select sample sites. A process for documenting each site as part of the permanent record. In addition to location information, this will include access information, such as road conditions and land ownership, known hazards, park contacts, special equipment requirements, the source of streamflow data, and parameters and parameter groups to be measured.
SOP 5	Preparations, Equipment Calibration, Handling and Storage	This SOP will follow guidelines provided by the manufacturers (e.g., Oakton, In-SITU, Inc., Marsh-McBirney, Rickly Hydrologic, etc.) for equipment operation and maintenance as well as common sense. This includes calibration methods and frequency, and equipment cleaning and maintenance. An equipment log will be established for each major piece of equipment where calibrations, servicing, problems, and other notable events are recorded. In addition, a field equipment checklist is included in the protocol. This lists all required and optional equipment and supplies to be carried with the field crew (or in the field vehicle) at all times. The checklist is provided for review before leaving the base park/office for each sampling event.
SOP 6	Cumulative Bias Control	Following guidance from Irwin (2004), the QAPP or QC SOP includes QC objectives for (1) measurement certainty (detection limits such as MDL (method detection limit) and ML (minimum quantitation limit), (2) measurement precision, (3) measurement systematic error (bias as percent recovery), (4) data completeness (including adequacy of planned sample sizes and statistical power), and (5) blank controls for lab measurements. Individual SOPs for parameters also include discussion related to data comparability and selection of laboratories and protocols. SOP is detailed (e.g., indicating how many duplicate samples will be collected for QC) so that other agencies can determine whether they can utilize NCPN data in conjunction with their own data.
SOP 7	Quality Assurance Project Plan (QAPP) for Water Quality Monitoring	

Table 7-1. Standard operating procedures (SOPs) for water quality monitoring.

SOP #	Title	Summary
SOP 8	Field Methods for Core Parameters, Turbidity and Discharge, All Units	This focuses primarily on the use of multiparameter probes for measuring basic physical and chemical characteristics of the water. Several alternative methods for measuring discharge are presented. The particular method used will vary by site and depend on the quantity of flow, channel characteristics, and accessibility. For moderate to large streams, the preferred method is to use a nearby stream gauge as a source of flow data. • Colorado - Specifically, the Hydrolab Minisonde 4a with a Surveyor 4 display will be used for determining dissolved oxygen concentration and percent saturation, specific conductance, pH and temperature in CO units. Details of this field SOP will focus on the actual in-situ measurement (e.g., location of probe within sample site, location of probe in water column, proximity to streambank, differences in measurement techniques in pools versus riffles.) • Utah - Same except for use of TROLL 9500 with a Rugged Reader display. The Hach 2100 P Turbidimeter will be used to measure turbidity.
SOP 9	Field Sample Collection and Processing for Water Chemistry, Nutrients and TSS, Colorado Units	This field SOP focuses on the actual in-situ collection of samples (e.g., clean and sterile technique to avoid contaminating a sample, location of sample in the water column, proximity to streambank, and the use of composite samples). Details of sample bottle labeling, storage, and transport to laboratories (including chain of custody forms) are discussed. Laboratory methods are also discussed.
SOP 10	Field Sample Collection and Processing for Water Chemistry, Nutrients and TSS, Utah Units	Similar to SOP 9, except specific to coordination with the Utah State Laboratory and UDWQ protocols.
SOP 11	Fecal Indicator Bacteria, All Units	Sampling frequency is at a screening level (monthly) as opposed to an enforcement level, such as for swimming beaches (5 samples/month).
SOP 12	Laboratory Analysis Methods for Water Quality, Colorado Units	Describes USGS National Water Quality Laboratory protocols. Lists EPA method number and reporting limit for each parameter.
SOP 13	Laboratory Analysis Methods for Water Quality, Utah Units	Describes Utah public laboratory protocols. Lists EPA method number and reporting limit for each parameter.
SOP 14	Data Management	Discusses the handling of data from multiple sources and repositories of data. Includes discussion of NPS-WRD requirement for use of WRD-STORET and cooperators requirement for storage in STORET (Utah) and NWIS (USGS).
SOP 15	Data Analysis and Reporting, All Units	Describes techniques for periodic reporting of results including notable hydrologic events, exceedances, and recommendations on modifications to the sampling network or protocols. Describes techniques for trend analysis.
SOP 16	Protocol Revision	Describes the procedure for updating this protocol narrative and the SOPs to maintain a relevant reference source that serves to maintain high integrity in data collection and archive. Older versions of SOPs are kept on file so that in the future changes in the program can be tracked.
SOP 17	Annual Project Review	An annual review of procedures and needs. Will provide a schedule and list of what will be reviewed, including: • Annual maintenance and upkeep • Equipment maintenance • Supplies and consumables • Review safety contact numbers • Review and update field folders • Update field forms • Equipment list / ownership / location / loan

Table 7-2. Water quality attributes grouped by sample type.

Sample type	Attributes
Core field parameters (CP)	discharge, water temperature, dissolved oxygen, specific conductance, pH, turbidity*, Secchi depth*
Major ion (MI)	alkalinity, bicarbonate, calcium, CO_2, carbonate, chloride, hardness, hydroxide*, magnesium, potassium, sodium, sulfate, and total dissolved solids
Nutrients (Nut)	ammonia*, un-ionized ammonia* (calculated), nitrite, nitrate, organic nitrogen*, total phosphorus
Trace elements (T)	aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver and zinc
Fecal indicator bacteria (FIB)	fecal coliform, *E. coli* in selected samples

*Parameter will not be measured at every site either due to site type (stream or lake) or depending on which laboratory receives samples (CO or UT laboratories).

Table 7-3. Target waters, parameters to be monitored, and protocols to be used at NCPN-supported sites.

Park	Storet/NWIS ID	Station name	Parameter groups[1]	Sample frequency	Field personnel	Protocol(s)
ARCH	5995220	SALT WASH AT WOLFE RANCH RD XING SW-3	CP, MI, Nut, T, TSS, FIB	10–12/yr	SEUG	Utah state protocols
ARCH	5995240	COURTHOUSE WASH .5MI AB COLORADO R AT USGS CW-1	CP, MI, Nut, T, TSS, FIB	10–12/yr	SEUG	Utah state protocols
BLCA	383418107471401	RED ROCK CANYON NEAR NPS BOUNDARY NEAR MONTROSE,CO	CP, MI, Nut, T	7/yr	BLCA/CURE	National Field Manual (USGS, variously dated)
BRCA	-9999	TROPIC DITCH	CP	10–12/yr	NCPN	Utah state protocols
BRCA	4951855	SHEEP CK BL SPRING IN BRYCE CYN NP	CP, MI, Nut, T, FIB, Tu	8–12/yr[2]	NCPN	Utah state protocols
BRCA	4951857	YELLOW CK BL SPRING IN BRYCE CYN NP	CP, MI, Nut, T, FIB, Tu	8–12/yr[2]	NCPN	Utah state protocols
BRCA	4951915	MOSSY CAVE SPRING NW OF TROPIC	CP, MI, Nut, T, FIB, Tu	8–12/yr	NCPN	Utah state protocols
CARE	4954770	SULPHUR CK AB CNFL/ FREMONT R IN PICNIC AREA	CP, MI, Nut, T, Tu	10–12/yr	NCPN	Utah state protocols
CARE	4954775	SULPHUR CK BL ROAD TO GOOSENECKS OVERLOOK IN CRNP	CP, MI, Nut, T, Tu	10–12/yr	NCPN	Utah state protocols
CARE	4954780	PLEASANT CK S OF SLEEPING RAINBOW RANCH	CP, MI, Nut, T, Tu	10–12/yr[2]	NCPN	Utah state protocols
CARE	4954795	OAK CREEK ABOVE SANDS RANCH DAM	CP, MI, Nut, T, Tu	10–12/yr[2]	NCPN	Utah state protocols
CARE	4954812	HALLS CK BL NARROWS	CP, MI, Nut, T, Tu	10–12/yr[2]	NCPN	Utah state protocols
CURE	9127000	CIMARRON RIVER BL SQUAW CREEK, NR CIMARRON, CO.	MI, Nut, T	7/yr	BLCA/CURE	National Field Manual (USGS, variously dated)
CURE	382831107172600	BLUE MESA RESERVOIR ABV SOAP CR NEAR SAPINERO, CO	CP, MI, Nut, T, Secchi	7/yr	BLCA/CURE	National Field Manual (USGS, variously dated)
CURE	383028107162200	WEST ELK CR BELOW FOREST BOUNDARY NR SAPINERO, CO	MI, Nut, T	7/yr	BLCA/CURE	National Field Manual (USGS, variously dated)
DINO	09260050	YAMPA RIVER AT DEERLODGE PARK, CO	CP, MI, Nut, T, TSS	4–12/yr	USGS	National Field Manual (USGS, variously dated)
DINO	404417108524900	GREEN RIVER ABOVE GATES OF LODORE, CO	CP, MI, Nut, T	4–12/yr	USGS	Utah state protocols
ZION	4950800	LA VERKIN CK AT LEE PASS TRAIL	CP, MI, Nut, T	10–12/yr	NCPN	Utah state protocols
ZION	4950920	NORTH CK AT PLANNED GAGE IN PARK	CP, MI, Nut, T	10–12/yr	NCPN	Utah state protocols
ZION	4951265	N FK VIRGIN R AT WSA BNDRY	CP, MI, Nut, T, Tu	10–12/yr[2]	NCPN	Utah state protocols

[1] See Table 7-2 for abbreviations.

[2] Collection of 10 samples per year will be attempted, but it is recognized that this site will be inaccessible during some periods due to snow or muddy roads or trails.

8 Data Management

The custody requirements of the organizations involved in water quality monitoring result in NCPN data being temporarily distributed among several water quality databases. Data acquired by USGS cooperators reside permanently in the National Water Information System (NWIS) database. Data acquired through the State of Utah reside in EPA-STORET, and field data collected by NCPN staff reside in NPSTORET, a Microsoft Access database that consolidates water quality data collected in and near the 16 NCPN park units. Although data initially reside in disparate databases, they are periodically reconciled such that all data from NCPN activities are eventually uploaded to WRD-STORET, as required by the water quality component of the Natural Resource Challenge. WRD-STORET is a database maintained by the Water Resources Division (WRD) that stores water quality data collected as part of the Vital Signs Monitoring Program.

These databases have been developed by water data specialists to document the multiple layers of attributes describing each datum (e.g., the sample was filtered or not, was acid stabilized or not, was at the limit of detection, or documents the specific laboratory method used). NCPN data will be most useful to a wider audience when it is included in these national databases.

NPSTORET, developed by WRD, has built-in water quality standards assessment tools that allow comparisons of historical and current data with applicable state standards. NCPN will maintain the data in this database and integrate new data so it can serve as an ongoing tool for the network's long-term water quality monitoring and analysis needs. On a regular basis (usually annually), the NCPN will export new water quality data from NPSTORET and submit it to WRD for upload to WRD-STORET. WRD will ensure that data in WRD-STORET is transferred to EPA-STORET. Table 8-1 summarizes the data management duties associated with each of the NCPN water quality monitoring partnerships, with details provided in the following sections.

8.1 Data management in Utah parks in partnership with UDWQ

For parks in Utah, samples are collected by NPS staff and sent to the UDWQ laboratory for analysis. Field measurements and notes

Table 8-1. Data management duties associated with each NCPN water quality monitoring partnership.

Partner	Park(s)	Duties
Utah Department of Water Quality	ARCH, BRCA, CARE, CANY, NABR, ZION	• NPS does sample collection • UDWQ does analysis • UDWQ enters data into local AWQMS and uploads to EPA-STORET, transfers data to NCPN. • NCPN uploads data to NPSTORET, submits to WRD for upload to WRD-STORET. • UDWQ reviews lab results as soon as possible and requests reruns if necessary.
USGS	BLCA, CURE	• NPS does sample collection • USGS does analysis • BLCA/CURE hydrologist performs QC checks, transfers data to NCPN. • NCPN uploads data to NPSTORET, submits to WRD for upload to WRD-STORET.
USGS	DINO	• USGS does sample collection and analysis • USGS enters data into NWIS • USGS does QC checks • NCPN pulls data from NWIS for upload to NPSTORET, submits to WRD for upload to WRD-STORET.

are electronically transferred to the state using their template. The state enters the data into their local Ambient Water Quality Monitoring System (AWQMS), and then transfers it to EPA-STORET and to NCPN. NCPN uploads this lab data, along with the field data, to NPSTORET. On a regular basis (usually annually), NCPN exports the data from NPSTORET and submits it to WRD for upload to WRD-STORET.

8.2 Data management in Colorado NCPN parks

For parks in Colorado, samples are collected by NPS staff and sent to the USGS National Water Quality Laboratory (NWQL) for analysis. The BLCA/CURE hydrologist quality checks the data and then transfers it to NCPN in a spreadsheet format. NCPN uploads the data to NPSTORET. On a regular basis (usually annually), NCPN exports the data from NPSTORET and submits it to WRD for upload to WRD-STORET.

8.3 Data management for sites with a USGS partner

Field and laboratory data from DINO sites monitored by USGS through a cooperative agreement with NCPN are collected by USGS staff, sent to NWQL for analysis, entered into the NWIS database, and quality checked by USGS. On a regular basis (usually annually), NCPN downloads the data from NWIS and uploads it to NPSTORET. NCPN also exports the data from NPSTORET and submits it to WRD for upload to WRD-STORET.

9 Data Analysis and Reporting

Analyzing the information gained through water quality monitoring and reporting is essential for the short- and long-term utility of the monitoring program. It will permit network staff to assess the condition of the resources and share that information with other interested parties. Specifically, it will permit the NCPN to meet the monitoring objectives stated in Section 2.5 and to:

- Provide written documentation of the condition of water resources in a form that can be shared with others,
- Identify areas of water quality concern,
- Present supporting information (metadata) essential for the understanding and utility of the data,
- Document accomplishments of the monitoring program, and
- Assess and document the effectiveness of the monitoring program and recommend improvements.

Two types of formal reports are prepared regularly: triennial comparison reports to state water quality standards and longer-term trend reports of water quality conditions.

9.1 Standards comparison report

Standards comparison reports include an accounting of the number of samples taken and analyses conducted, observations of notable events, and a listing of exceedances relative to state water quality standards. Target audiences include park managers, resource managers in the park and network, and state water quality managers. An explanation of the significance of the results will be provided along with recommendations for changes in park operations or state actions where warranted, for modifications in the monitoring program, and where special studies are indicated. These reports are intended to provide park managers with early warning of any potential state impairments but do not meet regulatory requirements for declaring a site in exceedance of state water quality standards.

9.2 Trend report

Trend reports will summarize longer-term trends with five years or more of data. These reports will include comprehensive analysis and synthesis of site-level trends adjusted for season and flow for individual constituents. Statistical tests include Seasonal Kendall tests for monotonic trends and Seasonal Rank Sum tests for step trends.

10 Roles and Responsibilities

The NCPN hydrologist/aquatic ecologist is the water quality project leader. This individual oversees field work, QA/QC measures, data management (in conjunction with the network data manager), data analysis, and reporting, and is supervised by the network program manager. Additional field staff (with position titles including aquatic ecologist, biologist, hydrologist, biological technician, and hydrologic technician) conduct fieldwork for groups of parks within the network, and are stationed at central locations for accessing those parks. At time of writing, these locations are the Southeast Utah Group office in Moab, Utah, and CURE, in Gunnison, Colorado. Their responsibilities parallel those of the water quality program leader, with the exception of program oversight and the preparation of consolidated reports. The location of these personnel is based on the location of existing personnel with expertise in water quality sampling and suitable facilities.

11 Operational Requirements

11.1 Annual workload and field schedule

The fieldwork load will be somewhat heavier in summer, when more sites are accessible. Year-round monitoring is planned in Utah parks, though it is recognized that some sites will not be accessible in the winter due to mud or snow. Sampling in Colorado parks is planned for seven months per year, excluding the winter and early spring. Data entry and validation checks will be ongoing. The time commitment per site will vary with accessibility, from Halls Creek in CARE (which may require 1.5–2 days), to places where 2–3 sites can be sampled in one day. On average, each sample is estimated to require one half-day for preparation, one day for access, sample collection, and processing, and one half-day for data management, for a total of two workdays per sample.

11.2 Facility and equipment needs

The large geographic area covered by the NCPN requires that monitoring personnel and equipment be at multiple dispersed locations, referred to here as nodes. These will be at CURE, SEUG, and NCPN. Each node will need laboratory facilities and the equipment listed in Table 11-1.

11.3 Startup costs and budget considerations

Categorized annual program costs in 2005 dollars are estimated in Table 11-2. A per site-visit cost estimate of $720–780 per sample is derived by dividing total program budget (FY2005) by estimated sample number (136–148 samples per year, contingent on access). This includes supplies and equipment, field sampling, NPS laboratory analysis, outside laboratory analysis, data validation, data management, report preparation, and coordination with other park and NCPN activities. This represents an underestimate of actual costs because some equipment and supplies were already purchased by parks and by the NCPN in previous years. Some support is provided to cooperating parks (SEUG), where staff helps with water sample collection and data handling. Average sample costs for parks in Utah will be somewhat lower than for parks in Colorado, typically $200–300, because UDWQ is contributing laboratory analysis costs.

Table 11-1. Equipment requirements for each sampling node.

Activity	Equipment required	CURE	SEUG	NCPN
Discharge measurement	Flow meter, wading rod, and associated equipment	X	X	X
	Portable flume (optional)	-	X	X
	Portable weir (optional)	-	X	X
Sample collection	Compositing churn	X	-	-
Field parameters	Multi-parameter meter for pH, water temperature, specific conductance, dissolved oxygen	X	X	X
	Turbidity meter (optional)	Lab	-	Field
Sample processing	Peristaltic pump and tubing	X	X	X
Bacteria enumeration	Membrane filtration apparatus or IDEXX system and incubator	X	X	X
Laboratory operations and calibration	DI water generation or storage	X	X	X
	Acid storage	X	X	X
	Sink and counter space	X	X	X
	Supply storage	X	X	X
Transportation	Vehicle	X	X	X

X = Equipment serviceable

- = Equipment not present & not needed

Table 11-2. Projected annual budget for NCPN water quality monitoring in 2005 dollars.

Category	Item	Estimated annual expense
Personnel	Hydrologist, GS-11, ½-time	$52,000
	Technician at SEUG	$7,500
	subtotal	*$59,500*
Equipment and Supplies	Field & Lab Equipment and Supplies	$5,000
	Major Equip. Replacement and Service	$5,000
	subtotal	*$10,000*
Park and Other Agency Support for WQ	Facility Support to BRCA	$2,000
	Laboratory Analysis (CO parks)	$7,500
	IA cooperation for Sampling at DINO	$19,000
	subtotal	*$28,500*
Travel and Transportation		$5,500
Maintain IT Hardware/ Software		$1,000
General supplies and Misc.		$2,000
Total		**$106,500**

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*See Table 12-1 for chapter-by-chapter citation information.

Table 12-1. Chapter-by-chapter citation information for the U.S. Geological Survey National Field Manual for the Collection of Water-quality Data, Techniques and Methods, Book 9, Handbooks for Water-resources Investigations

Chapter	Citation
A1	Wilde, F. D., D. B. Radtke, J. Gibs, and R. T. Iwatsubo. 1998. Chapter A1: Preparations for water sampling. http://pubs.water.usgs.gov/twri9A1/.
A2	Lane, S. L., S. Flanagan, and F. D. Wilde. 2003. Chapter A2: Selection of equipment for water sampling (v. 2.0). http://pubs.water.usgs.gov/twri9A2/.
A3	Wilde, F. D., D. B. Radtke, J. Gibs, and R. T. Iwatsubo, eds. 2003. Chapter A3: Cleaning of equipment for water sampling (v. 1.2). http://pubs.water.usgs.gov/twri9A3/.
A4	Wilde, F. D., D. B. Radtke, J. Gibs, and R. T. Iwatsubo, eds. 1999. Chapter A4: Collection of water samples: http://pubs.water.usgs.gov/twri9A4/.
A5	Wilde, F. D., D. B. Radtke, J. Gibs, and R. T. Iwatsubo, eds. 2004. Chapter A5: Processing of water samples (version 2.1). http://pubs.water.usgs.gov/twri9A5/. (Separate updates for 5.6.1.F, "Wastewater, pharmaceutical, and antibiotic compounds," and 5.6.4.A, "Arsenic speciation," are provided on the Web page.)
A6	Wilde, F. D., and D. B. Radtke, eds. Various dates. Chapter A6: Field measurements. http://pubs.water.usgs.gov/twri9A6/. (Chapter sections are cited by author and date.)
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A9	Lane, S. L., and R. G. Fay. 1997. Chapter A9: Safety in field activities. http://pubs.water.usgs.gov/twri9A9/.

Appendix A: Protected Uses for Northern Colorado Plateau Network Parks

The following tables summarize protected uses as identified by the states of Colorado, Utah, Wyoming, and Arizona for units of the Northern Colorado Plateau Network. Numeric standards for water quality are specific to these protected uses. Prepared by Dave Sharrow, Zion National Park, November 2003 (revised March 2009, November 2012).

Table A-1. Protected uses designated for Northern Colorado Plateau Network parks in Colorado (including portions of Dinosaur and Hovenweep National Monuments in Utah) (2012 regulation).

Park unit	Segment description[1]	Water body identification code (305b water body identification code)[2]	Miles (in park)	Shoreline miles[3]	Acres (in park)	State-designated uses applied to this segment (See Tables A-5 and A-6 for definitions of use codes)												
						Colorado							Utah					
						AG	ALCW1	ALCW2	ALWW1	ALWW2	DWS	Rec	1C	2A	2B	3A	3B	4
Dinosaur NM	CO Region 11, LY/G Basin, Segment 2: Mainstem of the Yampa R. from a point immediately below the confluence of Elkhead Cr. to the confluence with the Green R.	COLCLY02 (COLCLY02_8100)	48.23	-	2.92	X	-	-	X	-	X	E	-	-	-	-	-	-
	CO Region 11, LY/G Basin, Segment 19a: Mainstem of the Green R. within Colorado (Moffatt County) from its entry at the Utah/Colorado border to a point just above the confluence with the Yampa R.	COLCLY19 (COLCLY19_7800)	25.32	-	48.65	X	X	-	-	-	X	E	-	-	-	-	-	-
	CO Region 11, LY/G Basin, Segment 19b: Mainstem of the Green R. within Colorado (Moffatt County) from a point just above the confluence with the Yampa R. to its exit at the Utah/Colorado border.	-	-	-	-	X	-	-	X	-	X	E	-	-	-	-	-	-

Table A-1. Protected uses designated for Northern Colorado Plateau Network parks in Colorado (including portions of Dinosaur and Hovenweep National Monuments in Utah) (2012 regulation), cont.

Park unit	Segment description[1]	Water body identification code (305b water body identification code)[2]	Miles (in park)	Shoreline miles[3]	Acres (in park)	State-designated uses applied to this segment (See Tables A-5 and A-6 for definitions of use codes)												
						Colorado							Utah					
						AG	ALCW1	ALCW2	ALWW1	ALWW2	DWS	Rec	1C	2A	2B	3A	3B	4
Dinosaur NM, cont.	CO Region 11, LY/G Basin, Segment 20: All tributaries to the Green R. in Colorado, including all wetlands, except for the specific listings in segments 21 and 22; all tributaries to the Yampa R. from a point immediately below the confluence with the Little Snake R. to the confluence with the Green R., except for the specific listings in segments 15 through 18.	COLCLY20 (COLCLY20_7800)	74.28	-	-	X	-	X	-	-	-	E	-	-	-	-	-	-
	CO Region 11, White R. Basin, Segment 22: All Tributaries to the White R., including all wetlands, from a point immediately above the confluence with Douglas Cr. to the Colorado/Utah border, except for the specific listing in Segment 23.	COLCWH22 (COLCWH22_8500)	0.99	-	-	X	-	-	-	X	-	P	-	-	-	-	-	-
Dinosaur NM (Utah portions)	Green R. and tributaries, from the confluence with Colorado R. to state line, except for the two segments listed below.	UT-R-GREEN-0001 (UT14060001-001_00)	140.18	0.5	4.68	-	-	-	-	-	-	-	X	X	-	-	X	X
	Big Brush Cr. and tributaries, from confluence with Green R. to Tyzack (Red Fleet) Dam.	UT-R-GREEN-0034 (UT14060002-003_00)	0.95	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X
	Jones Hole Cr. and tributaries, from confluence with Green R. to headwaters. Utah as High Quality Category 1, which provides narrative standards for antidegradation.	UT-R-GREEN-0036 (UT14060001-002_00)	6.33	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-

Table A-1. Protected uses designated for Northern Colorado Plateau Network parks in Colorado (including portions of Dinosaur and Hovenweep National Monuments in Utah) (2012 regulation), cont.

Park unit	Segment description[1]	Water body identification code (305b water body identification code)[2]	Miles (in park)	Shoreline miles[3]	Acres (in park)	State-designated uses applied to this segment (See Tables A-5 and A-6 for definitions of use codes)												
						Colorado							Utah					
						AG	ALCW1	ALCW2	ALWW1	ALWW2	DWS	Rec	1C	2A	2B	3A	3B	4
Black Canyon of the Gunnison NP	CO Region 10, Basin–Lower Gunnison R., Segment 1: Mainstem of the Gunnison R. from the outlet of Crystal Reservoir to a point immediately above the confluence with the Uncompahgre R.	COGULG01 (COGULG01_6800)	11.93	-	-	X	X	-	-	-	X	E	-	-	-	-	-	-
	CO Region 10, Basin–Lower Gunnison R., Segment 4a: All tributaries to the Gunnison R., including all wetlands not on national forest lands, from the outlet of Crystal Res. to the confluence with the Colorado R.	COGULG04A (COGULG04_6800)	16.15	-	-	X	-	-	-	X	X	N	-	-	-	-	-	-
Curecanti NRA	CO Region 10, Basin–Lower Gunnison R., Segment 1: Mainstem of the Gunnison R. from the outlet of Crystal Res. to a point immediately above the confluence with the Uncompahgre R.	COGULG01 (COGULG01_6800)	2.26	-	-	X	X	-	-	-	X	E	-	-	-	-	-	-
	CO Region 10, Basin–Lower Gunnison R., Segment 4a: All tributaries to the Gunnison R., including all wetlands not on national forest lands, from the outlet of Crystal Reservoir to the confluence with the Colorado R.	COGULG04A (COGULG04A_6800)	0.60	-	-	X	-	-	-	X	X	N	-	-	-	-	-	-
	CO Region 10, Basin–Upper Gunnison R., Segment 14: Mainstem of the Gunnison R. from the confluence of the East R. and Taylor R. to the inlet of Blue Mesa Res.	COGUUG14 (COGUUG14_6800)	4.61	5.34	169.10	X	X	-	-	-	X	E	-	-	-	-	-	-

Table A-1. Protected uses designated for Northern Colorado Plateau Network parks in Colorado (including portions of Dinosaur and Hovenweep National Monuments in Utah) (2012 regulation), cont.

Park unit	Segment description[1]	Water body identification code (305b water body identification code)[2]	Miles (in park)	Shoreline miles[3]	Acres (in park)	State-designated uses applied to this segment (See Tables A-5 and A-6 for definitions of use codes)												
						Colorado							Utah					
						AG	ALCW1	ALCW2	ALWW1	ALWW2	DWS	Rec	1C	2A	2B	3A	3B	4
Curecanti NRA, cont.	CO Region 10, Basin–Upper Gunnison R., Segment 25: Blue Mesa Res., Morrow Point Res., and Crystal Res. and those segments of the Gunnison R. that interconnect reservoirs.	COGUUG25 (COGUUG25_6800)	64.05	100.30	9421.83	X	X	-	-	-	X	E	-	-	-	-	-	-
	CO Region 10, Basin–Upper Gunnison R., Segment 26: All tributaries, from the source, to those waters described in segment 25, including all lakes, reservoirs, and wetlands on Gunnison and Uncompahgre National Forest lands, or that flow into or are present within Curecanti NRA, with the exception of Segments 14 and 29.	COGUUG26 (COGUUG26_6800)	19.88	3.90	67.27	X	X	-	-	-	X	U	-	-	-	-	-	-
Colorado National Monument	CO Region 11, Basin–Lower Colorado R., Segment 13a: All tributaries to the Colorado R., including all wetlands, from a point immediately below the confluence of Roan Cr. to the Colorado/Utah border, except for the specific listings in segments 13b–19. (13b is a temporary standard for streams NE of park boundary, other exceptions are N/A)	COLCLC13A (COLCLC13A_6500)	54.46	-	-	X	-	-	-	X	-	P	-	-	-	-	-	-

Table A-1. Protected uses designated for Northern Colorado Plateau Network parks in Colorado (including portions of Dinosaur and Hovenweep National Monuments in Utah) (2012 regulation), cont.

Park unit	Segment description[1]	Water body identification code (305b water body identification code)[2]	Miles (in park)	Shoreline miles[3]	Acres (in park)	State-designated uses applied to this segment (See Tables A-5 and A-6 for definitions of use codes)												
						Colorado							Utah					
						AG	ALCW1	ALCW2	ALWW1	ALWW2	DWS	Rec	1C	2A	2B	3A	3B	4
Hovenweep National Monument	CO Region 9, Basin -La Plata R., Mancos R. McElmo Cr., and San Juan R. in Montezuma County and Delores County, Segment 7a: Mainstem of McElmo Cr. from the source to the Colorado/Utah border. Mainstem of Yellow Jacket Cr., including all tributaries, wetlands, lakes, and reservoirs from the source to the confluence with McElmo Cr.	-	-	-	-	X	-	-	X	-	-	E	-	-	-	-	-	-
	Utah units: all San Juan R. and its tributaries	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	X	X

[1] Segment descriptions are taken verbatim from the State of Colorado Stream Classifications and Water Quality Standards, except that references to exceptions that do not pertain to the park have been deleted (e.g., where the description says "except for the specific listings for segments 3a to 6," this text has been deleted if segments 3a to 6 are not located in or near the park).

[2] The water body identification (WBID) code is a state-assigned identifier for each reach. The water body identification codes used in 303(d) reports may include more than one WBID, or may include only a part of one WBID.

[3] Shoreline miles applies to adjacent lakes/ponds, seas/oceans, swamps/marshes, reservoirs, or estuaries.

Table A-2. Protected uses designated for Northern Colorado Plateau Network parks in Utah (2012 code).

Park unit	Waters in park	Reference to state segment	Utah high quality category 1	Utah protected uses (See Table A-6 for definitions of use codes)							
				1C	2A	2B	3A	3B	3C	3D	4
Arches NP	All	Colorado R. and tributaries, from Lake Powell to state line	-	X	X	-	-	X	-	-	X
Bryce Canyon NP	East	Paria R. and tributaries, from state line to headwaters	-	-	-	X	-	-	X	-	X
	West	Sevier R. and tributaries, Annabelle Diversion to headwaters	X	-	-	X	X	-	-	-	X
Canyonlands NP	Most of park	Colorado R. and tributaries, from Lake Powell to state line; Green R. and tributaries, from confluence with Colorado R. to state line	-	X	X	-	-	X	-	-	X
	Southwestern-most margin of park	All tributaries to Lake Powell, except as listed separately	-	-	-	X	-	X	-	-	X
Capitol Reef NP	Fremont R. downstream of the park (Harnet Draw, Sandy & Oak Cr. in park)	Fremont R. and tributaries, from confluence with Muddy Cr. to park	-	X	-	X	-	-	X	-	X
	Fremont R. in park and upstream	Fremont R. and tributaries, through park to headwaters	-	X	X	-	X	-	-	-	X
	Pleasant Cr. inside park	Pleasant Cr. and tributaries, from east boundary of park to headwaters	-	X	-	X	X	-	-	-	-
	Pleasant Cr. downstream of (outside) park	Pleasant Cr. and tributaries, from confluence with Fremont R. to east boundary of park	-	-	-	X	-	-	X	-	X
	Halls Cr. (Bitter Cr. Divide south in park)	All tributaries to Lake Powell, except as listed separately	-	-	-	X	-	X	-	-	X
Cedar Breaks NM	West Slope	Coal Cr. and tributaries	-	-	-	X	X	-	-	-	X
	East Slope	Duck Cr. and tributaries	-	X	-	X	X	-	-	-	X
Dinosaur NM	See Table A-1		-	X	-	X	-	X	-	-	X
Golden Spike NHS	Blue Cr.	Blue Cr. and tributaries, from Great Salt Lake to Blue Cr. Res.	-	-	-	X	-	-	-	X	X
Hovenweep NM	See Table A-1	San Juan R.	-	-	-	-	-	-	-	-	-
Natural Bridges NM	All (White Canyon)	All tributaries to Lake Powell, except as listed separately	-	-	-	X	-	X	-	-	X

Table A-2. Protected uses designated for Northern Colorado Plateau Network parks in Utah (2012 code), cont.

Park unit	Waters in park	Reference to state segment	Utah high quality category 1	Utah protected uses (See Table A-6 for definitions of use codes)							
				1C	2A	2B	3A	3B	3C	3D	4
Timpanogos Cave NM	All	American Fork Cr. and tributaries, from diversion at mouth of American Fork Canyon to headwaters	-	-	-	X	X	-	-	-	X
Zion NP	Kolob Area (Taylor Cr., Camp Cr.)	Ash Cr. and tributaries, from Ash Cr. Reservoir to headwaters	-	-	-	X	X	-	-	-	X
	North Fork Virgin R. and tributaries	North Fork Virgin R. and tributaries	X	X	X	-	X	-	-	-	X
	East Fork Virgin R.	East Fork Virgin R. from town of Glendale to headwaters	X	-	-	X	X	-	-	-	X
	Kolob Cr.	Kolob Cr. from confluence with Virgin R. to headwaters	-	-	-	X	X	-	-	-	X
	Kolob Reservoir & Navajo Lake (both outside Park)	Kolob Reservoir and Navajo Lake	-	-	-	X	X	-	-	-	X
	North Cr., Coalpits Wash	Virgin R. and tributaries, from Quail Cr. diversion to headwaters	-	X	-	X	-	-	X	-	X
	LaVerkin Cr.	Virgin R. and tributaries, from state line to Quail Cr. diversion	-	-	-	X	-	X	-	-	X

[1] High quality category 1 designation in Utah does not carry with it specific numeric criteria at this time.

Table A-3. Protected uses designated for Northern Colorado Plateau Network parks in Wyoming (2001 classification list).

Park unit	Waters in park	Reference to state segment	Use code[1]	Protected uses
Fossil Butte NM	Chicken Cr. watershed and northeast slopes draining to North Fork Twin Cr.	Chicken Cr., tributary to Twin Cr., and North Fork of Twin Cr. in Lincoln County	3B	Scenic Value, Industry, Agriculture, Wildlife, Recreation, Other Aquatic Life (NOT Protected are: Drinking Water, Game Fish, Non-Game Fish, and Fish Consumption)
	Western slopes draining to Rock Cr.; Southern slopes draining to Twin Cr., including Smallpox Cr.	Rock Cr., tributary to Twin Cr., Twin Cr., tributary to Bear R.	2AB	All (Drinking Water, Game Fish, Non-Game Fish, and Fish Consumption, Other Aquatic Life, Recreation, Wildlife, Agriculture, Industry, and Scenic Value)

[1]See table A-5 for definitions of Class

Table A-4. Protected uses designated for Northern Colorado Plateau Network parks in Arizona (2009 draft ruling).

Park unit	Waters in park	Reference to state segment	Protected uses
Pipe Spring NM	All	Kanab Cr.	Aquatic and Wildlife warm water, Full-body Contact, Domestic Water Source, Fish Consumption, Agricultural Livestock watering

Table A-5. Definitions of designated protected uses, State of Colorado.

State-designated use codes	State-designated use	Definition
AG	Agriculture	These surface waters are suitable or intended to become suitable for irrigation of crops usually grown in Colorado and which are not hazardous as drinking water for livestock.
ALCW1	Aquatic Life Cold Water-Class 1	These are waters that (1) currently are capable of sustaining a wide variety of cold water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. Waters shall be considered capable of sustaining such biota where physical habitat, water flows or levels, and water quality conditions result in no substantial impairment of abundance and diversity of species.
ALCW2	Aquatic Life Cold Water-Class 2	These waters are not capable of sustaining a wide variety of cold water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.
ALWW1	Aquatic Life Warm Water-Class 1	These are waters that (1) currently are capable of sustaining a wide variety of warm water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions. Waters shall be considered capable of sustaining such biota where physical habitat, water flows or levels, and water quality conditions result in no substantial impairment of abundance and diversity of species.
ALWW2	Aquatic Life Warm Water-Class 2	These waters are not capable of sustaining a wide variety of warm water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.
DWS	Water Supply	These surface waters are suitable or intended to become suitable for potable water supplies. After receiving standard treatment (defined as coagulation, flocculation, sedimentation, filtration and disinfection with chlorine or its equivalent) these waters will meet Colorado drinking water regulations and any revisions, amendments or supplements thereto.
RecE	Recreation E	Existing Primary Contact Use - These surface waters are used for primary contact recreation or have been used for such activities since November 28, 1975.
RecP	Recreation P	Potential Primary Contact Use - These surface waters have the potential to be used for primary contact recreation. This classification shall be assigned to water segments for which no use attainability analysis has been performed demonstrating that a recreation class N classification is appropriate, if a reasonable level of inquiry has failed to identify any existing primary contact uses of the water segment, or where the conclusion of a UAA is that primary contact uses may potentially occur in the segment, but there are no existing primary contact uses.
RecN	Recreation N	Not Primary Contact Use - These surface waters are not suitable or intended to become suitable for primary contact recreation uses. This classification shall be applied only where a use attainability analysis demonstrates that there is not a reasonable likelihood that primary contact uses will occur in the water segment(s) in question within the next 20-year period.
RecU	Recreation U	Undetermined Use - These are surface waters whose quality is to be protected at the same level as existing primary contact use waters, but for which there has not been a reasonable level of inquiry about existing recreational uses and no recreation use attainability analysis has been completed. This shall be the default classification until inquiry or analysis demonstrates that another classification is appropriate.

Table A-6. Definitions of designated protected uses, State of Utah.

State-designated use codes	State-designated use	Definition
1C	Drinking Water Supply	Protected for domestic purposes with prior treatment by processes as required by the Utah Department of Health.
2A	Primary Contact (Recreation)	Protected for primary contact recreation such as swimming.
2B	Secondary Contact (Recreation)	Protected for secondary contact recreation such as boating, wading, or similar uses.
3A	Cold Water Game Fish	Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
3B	Warm Water Game Fish	Protected for warm water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
3C	Nongame Fish	Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.
3D	Waterfowl	Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.
3E	Severely Habitat Limited	Severely habitat limited waters. Narrative standards will be applied to protect these waters for aquatic wildlife.
4	Agriculture	Protected for agricultural uses including crop irrigation and stock watering.
5	Great Salt Lake	Protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction.

Table A-7. Definitions of designated protected uses, State of Wyoming.

State-designated use codes	State-designated use	Definition
2AB	Spawning fish	Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2AB waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List." Unless it is shown otherwise, these waters are presumed to have both sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture and scenic value uses.
3B	Intermittent streams	Class 3B waters are tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. In general, 3B waters are characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length.

Sources: Adapted from National Park Service 2003a, 2003b, 2003c, and 2003d, which used Environmental Protection Agency WQSDB (Version 3), and State of Utah, 1997 as primary sources and State of Wyoming 2000.

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