

# Water Quality Monitoring for High-Priority Water Bodies in the Sonoran Desert Network

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***Abstract**—This paper describes a network monitoring program for “high priority” water bodies in the Sonoran Desert Network of the National Park Service. Protocols were developed for monitoring selected waters for ten of the eleven parks in the Network.*

*Park and network staff assisted in identifying potential locations of testing sites, local priorities, and how water quality sampling might be integrated into overall vital signs monitoring and park operations. Several criteria were used to determine the priority of these water bodies. These include ecological and perceptual threats to public and wildlife health, as well as adequacy of monitoring efforts.*

*In conjunction with selecting water bodies and sample sites, water quality monitoring parameters are also identified. These include five “core” parameters that will be sampled as part of the NPS Vital Signs monitoring program: temperature, dissolved oxygen (DO), conductivity, pH, and flow or water levels. Additional parameters were selected based on park-specific stressors or threats gathered from discussions with park and network staff, literature research, and ADEQ 303 (d) mandated reports on water quality.*

## Introduction

The National Park Service (NPS) is committed to significantly reducing the amount of pollution in park water bodies, and preserving the pristine water quality. Basic water quality and quantity data are a needed, yet lacking, component of management for many parks. The study described in this paper supports the above-stated NPS long-term water quality goal by developing a water quality and quantity monitoring program for the Sonoran Desert Network (SODEN) Parks of the National Parks Service.

This monitoring plan was developed as part of the Sonoran Desert Network’s Vital Signs Inventory and Monitoring Program. Managers need reliable data to maintain resources unimpaired for future generations, especially as conditions outside of parks rapidly change. For the area of water, the goal of the Inventory and Monitoring Program is to identify trends in water quality and quantity, which could be utilized to guide management actions, or to trigger further inquiries. This report represents the second phase of a study that examined water quality issues. The Phase I report, completed in May 2002, presented an overview of existing water quality and groundwater data. That report listed data that had previously been collected for each park and it identified where gaps in data existed. The Phase II report, utilizes data from the Phase I study to establish monitoring plans for each park. Results

from these reports can be integrated into park management decisions. Cooperation with similar agencies can allow for management of water resources on a larger scale.

The main objective of this study is the formulation of a network monitoring program for “high priority” water bodies, or those considered to be the most important for water monitoring purposes, in the Sonoran Desert Network. One high priority water body was selected for each park (table 1), in addition to other important water bodies. The monitoring design is grounded in historical and current water quality efforts.

## Receive Park Input

A dialogue was established with park staff via email, telephone and park visits to identify park-specific water quality issues that may not have been addressed by the Phase I effort. Park and network staff have assisted in identifying potential locations of testing sites, local priorities, and how water quality sampling might be integrated into overall vital signs monitoring and park operations.

In the fall of 2002 the study team made trips to “high priority” water bodies. The team was accompanied on the site visits by consultants Dr. Sam Kunkle and Dr. Richard Hawkins. Follow-up trips to the parks were made through September 2003.

**Table 1**—High priority surface water bodies by park.

Casa Grande	N/A	
Chiricahua	Unnamed Spring below King of Lead Mine Pond	CHIR*
Coronado	State of Texas Mine #11	CORO
Gila Cliff	West Fork of Gila River	GICH
Ft. Bowie	Apache Spring	FOBO
Mont. Castle	Montezuma's Well	MOCA
Organ Pipe	Quitobaquito Springs and Pond	ORPI
Saguaro East	The "Grotto" on Rincon Creek	SAGU
Saguaro West	King Canyon Mine Seep	SAGU
Tonto	Cave Canyon Creek	TONT
Tumacocori	Santa Cruz River	TUMA
Tuzigoot	Tavasci Marsh	TUZI

\* Name code

Several criteria were used to determine the priority of water bodies. These included ecological and perceived threats to public and wildlife health, adequacy of current monitoring efforts and ecological uniqueness. The ecological value of a site is determined by not only the presence of threatened and endangered species, but also the value of the riparian area to both the park unit and to the surrounding area. Secondly, the perceived value of the water resource carried a strong weight in selecting high priority water bodies and was determined by interviews with NPS staff in combination with survey results. High priority water bodies were also selected based on the degree of threat to public and wildlife health, and the short-term immediacy of the threat. Lastly, a third criterion for determining priority was based on whether or not particular water bodies and parameters were being adequately monitored by others at the time of the study.

## “High Priority” List

One “high priority” water body was selected from each park unit to monitor. In many cases, it was fairly easy to identify that water body. For example, in park such as Tonto National Monument, Fort Bowie National Historic Site, Tuzigoot National Monument and Tumacocori National Historic Park, there was only one major water body located in the unit. In other cases, where there are a variety of sites to choose from, such as Saguaro National Park, Coronado National Memorial and Gila Cliff Dwellings National Monument, the location of the water body, utilization by wildlife and humans, and presence of habitat for threatened and endangered species were factors considered.

## Review Database

A review of the existing water quality database was conducted to confirm that all relevant water quality issues were identified in the Phase I analysis. Hydrologists from the U. S. Geological Survey (USGS) and Arizona Department of Environmental Quality (ADEQ) reviewed the Phase I document. Both agencies stated that the Phase I document was thorough in its documentation of existing data. Hydrologists

from Colorado State University (CSU) and the University of Arizona (UA) also provided an external review of the database, and made suggestions as to other potential sources of water quality data. Recent provisional surface water quality data were received from USGS for some of the parks. The new data were analyzed and compared with the existing data which were previously assembled, to assure that the monitoring program was based on the most recent data available. USGS data for all of the parks was not available prior to publication of the Phase II report.

## Synthesis of Existing Protocols

To utilize existing protocols, a detailed review was done of existing water-quality testing procedures and equipment used by the USGS, ADEQ, and the NPS-Water Resource Division guidance documents on Long-Term Aquatic Monitoring Projects. We have incorporated these procedures into the Sonoran Desert Network protocols.

QA/QC testing protocols incorporated into the monitoring plan includes:

- Field note worksheets
- Equipment calibration guidelines
- Field blanks for quality control
- Proper sampling methodology
- Equipment troubleshooting
- Equipment maintenance
- Decontamination and cleaning of equipment
- Safety practices
- Proper disposal of calibration solutions
- Sample
  - preservation
  - holding time
  - tracking and labeling

## Sampling Design

The results generated from the review of the data base, park input and the synthesis of existing protocols were used to produce a water quality monitoring plan for the SODEN network. Specific protocols were developed for key water quality parameters at appropriate sampling locations (table 2). The protocols include an overview defining measurable objectives, sampling design, field techniques, data reporting, personnel requirements, training procedures, and operational requirements. We recommended that sufficient metadata be collected to fulfill the requirements of the EPA-STORET National Water Quality Database, where the data will be ultimately archived. Core parameters that will be collected are: temperature, specific conductivity, pH, dissolved oxygen and flow.

Other recommended parameters include: turbidity, nutrients, biological conditions, major ion balance, carcinogens, toxins and metals. Parameters were chosen on the basis of the Clean Water Act and other regulatory standards, as well as on the basis of network needs, and suggested criteria.

When sampling, NPS staff members need to be aware of specific conditions in each water body and park unit. One

**Table 2**—Parameters by Park (see table 1 for Park name codes).

Core Parameters	CHIR	CORO	FOBO	GICH	MOCA	ORPI	SAGU	TONT	TUZI	TUMA
pH	XX	XX	XX	XX	XX	X	XX	XX	XX	X
Conductivity	XX	XX	XX	XX	XX	X	XX	XX	XX	X
Dissolved Oxygen	XX	XX	XX	XX	XX	X	XX	XX	XX	X
Temperature	XX	XX	XX	XX	XX	X	XX	XX	XX	X
Streamflow or Water Level	XX	XX	XX	XX	X	X	XX	XX	XX	X
<b>Biological/Physical Conditions</b>										
E. coli	XX	X								
Biochemical Oxygen Demand										X
Narrative Water Quality Description	XX									
Turbidity				XX	XX				XX	X
<b>Acid-Base Equilibrium</b>										
Alkalinity	XX									
Major Ion Balance (K, Ca Mg, C. SO4, HCO3-CO3)	XX									
Bicarbonate					XX					
<b>Nutrients</b>										
Total Phosphorus				XX	XX				XX	XX
Nitrites + Nitrates				XX	XX				XX	XX
Ammonia										XX
<b>EPA Priority Pollutant Metals</b>										
Metals Suite (Be, Se, Pb, Hg, Ni, Cu, Fe, Tl, Zn, As, Ag, Cr, Cd)	XX									
<b>Carcinogens</b>										
Trihalomethane										XX
Residual Cl-										X
<b>Toxins</b>										
Cyanide										X
<b>Organic Chemicals</b>										
PCBs								XX		XX
VOCs								XX		XX

XX = Proposed; X = Previously monitored.

example is the incidence of amphibian epithelial chytridiomycosis in Saguaro National Park. Chytridiomycosis is a water-borne fungal disease that causes mortality in lowland leopard frogs as well as other amphibian species. In order to prevent spread of the disease from an infected water body to a non-infected one, NPS staff must disinfect sampling equipment between samples.

Sampling frequency and timing ideally depend upon the overall objectives of the water quality monitoring program. There are three basic objectives that can be satisfied by the combination of field and laboratory sampling that the NPS will conduct which will help managers to identify trends and guide future research. These objectives include:

- To understand a particular aquatic system, including the relationships between the geological, hydrological, and biological elements.
- To monitor current water quality status (trends, seasonal variation and flow).
- To anticipate future problems before they manifest themselves in a water body.

The sampling strategies address the aspects of these objectives, to include important water quality factors such as environmental or seasonal variations that NPS wants to understand. We therefore recommend utilizing the strategies in table 3 in order to capture the most relevant data for each parameter. While more frequently monitoring, such as each month, would be better than quarterly monitoring, the former was selected reflecting the limited resources, both financial and in personnel, that exist in the parks. More frequent monitoring can be done, and is recommended as additional resources become available.

## Research and Test Field Instrumentation

To simplify the water quality sampling process for the NPS personnel a multi-probe unit was selected which can monitor multiple parameters at one time rather than using a separate piece of equipment for each individual parameter. The multiprobe can monitor temperature, conductivity, dissolved

**Table 3**—Sampling strategy by category of parameters.

Category	Parameters	Method	Frequency
Hydrology	Flow and/or Water Level	Current Meter, Staff Gage, Field Inspection	Quarterly
General Water Conditions	Temperature, Dissolved Oxygen, pH, Conductivity, Barometric Pressure	YSI 6820 Instrument	Quarterly
Acid-base Equilibrium	Alkalinity, Major Ion Balance, Bicarbonate	Laboratory Sampling	Quarterly
Biological Conditions	Biochemical Oxygen Demand (BOD), E. coli, Narrative Water Quality	Laboratory Sampling, Field Inspection	Quarterly
Nutrients	Ammonia, Nitrogen (Nitrate+Nitrite), Total Phosphorus	Laboratory Sampling	Quarterly
Carcinogens	Free chlorine, Trihalomethane	Laboratory Sampling	Annually
Metals	Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Selenium, Thallium, Zinc	Laboratory Sampling	Annually / 5-year period
Toxins	Cyanide	Laboratory Sampling	Annually

oxygen, pH/ORP, barometric pressure, turbidity, chlorine, ammonia, and nitrate. After extensive research and field testing we concluded that a Yellow Springs Incorporated (YSI) 6820 Sonde Multiprobe best fit the water quality monitoring needs of the National Park Service. Other probes evaluated and tested were the Hydrolab Quanta Multiprobe, and the In-Situ 9000 Troll.

The Price Pygmy Meter was selected to measure water current. Most of the streams to be measured in SODEN are shallow with relatively low flows. Velocities in these streams are usually less than 2 feet per second for most of the year, and rarely reach velocities greater than 5 feet per second. Because of these low flows and shallow depths the Price Pygmy meter was selected. The Pygmy can be used for depths up to 1.5 feet, such as those in the Santa Cruz River at Tumacácori. For water depths between 1.5 ft. and 2.5 ft., the Price type AA meter would be more appropriate. In cases of very low flow, other techniques will have to be employed to determine water quantity, such as capturing flow in a receptacle during established time periods.

## Summary

This water quality monitoring plan was developed as part of the Sonoran Desert Network's (SODEN) Vital Signs Inventory and Monitoring Program. It was designed with the assumption that managers need reliable data to maintain resources unimpaired for future generations, especially as conditions outside of parks rapidly change. For the area of water, the goal of the Inventory and Monitoring Program is to identify trends in water quality and quantity, to help guide management actions or trigger new inquiries. The report summarized herein represented the second phase of a study that examined water quality issues. In the course of 2 years of research, the authors evaluated threats to park water quality, data needs, current methodologies, and quality assurance/quality control protocols. Using a mixture of concerns including data usefulness, ease of use, and pricing, the authors identified a series of water quality parameters and protocols to monitor them that the National Park Service may choose to implement as part of a third phase in the Vital Signs Inventory and Monitoring Program.