

Measuring Colorado Water Quality in the Grand Canyon NP

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The Glen Canyon Environmental Studies (GCES), a program under the Bureau of Reclamation, was created in 1983. Agencies and organizations participating in the GCES program include the USFWS, the Arizona Game and Fish Department, Arizona State University and environmental consultants to these participants. More recently, the USGS has played an important role in this effort.

These studies, under the auspices of GCES are designed to provide information on the effects of the Glen Canyon Dam and its operations on the downstream resources of the remaining Glen Canyon and Grand Canyon of the Colorado River. The information gained from such studies will be used in the environmental impact statement (EIS) analysis currently underway

and in other management decisions regarding future development of water quality monitoring programs. Decisions will be made on which flows are necessary to maintain the natural processes of this riverine system. These studies have been done by the GCES with the cooperation of the Bureau of Reclamation and the NPS.

Because the interactions of sediment, river flow, water chemistry and biology, are four of the most important factors influencing the health and recreational value of the ecosystem of the Colorado River, the USGS has and continues to contribute a great deal of hydrologic research effort to GCES.

The first synoptic study under GCES focused on water chemistry and biology on different reaches and tributaries of the Colorado River

and under different flow regimes downstream from Glen Canyon dam. These studies provide detailed information on water quality spatially and by flow level. Such information should assist the National Park Service not only in determining locations for long-term monitoring throughout the river corridor but also in refining management objectives that may drive decisions regarding the release of water from Glen Canyon Dam.

Synoptic sampling is used to assess, in a comprehensive manner, the characteristics or conditions of a system, such as the Colorado River, at a fixed point in time. Sampling is coordinated and carried out simultaneously at several carefully predetermined locations. These sites are selected to provide the maximum amount of information regarding important inputs or disturbances to the system.

The purpose of this type of experiment is to permit the development of a general understanding of the system and to provide a large data base of information for use in defining the spatial characteristics in as much detail as possible. In addition, the data base is useful for establishing protocols and direction for much more detailed and specific future investigations and research studies.

In the case of large river systems, repetitious sampling, closely spaced in time, can provide additional information regarding short-term variations in chemical and biological water quality in relation to a variety of physical variations including hydrologic, meteorologic, and diel conditions. Executing water-quality synoptic experiments during different seasons of the year can also provide information concerning long-term temporal variations. Collectively, this information can provide a rapid and compre-

Table 1. Chemical determinations made on synoptic samples

Nutrients	Trace Elements Cont'd
Nitrate	Boron
Phosphate	Cadmium
Ammonium ion	Chromium
Dissolved nitrogen	Cobalt
Dissolved phosphorus	Copper
Dissolved organic carbon	Iron
Major ions	Lithium
Calcium	Lead
Magnesium	Manganese
Sodium	Mercury
Potassium	Molybdenum
Silica	Nickel
Chloride	Selenium
Sulfate	Strontium
Trace Elements	Thallium
Aluminum	Uranium
Arsenic	Vanadium
Barium	Zinc
Beryllium	

Measuring Colorado Water Quality, Cont'd from P. 12

hensive analysis of the status and variability of the water quality in a large and complex river system. Differentiation of unstable properties, the significance of the magnitude and diversity of important components, and the sensitivity of their response to physical variables provide a

systematic way to evaluate present and future water-quality conditions.

Such a water-quality synoptic experiment was conducted on the Colorado River, Nov. 5 and 6, 1990. Ten mainstream river stations and 6 tributary stations (at confluence) were se-

lected for water-quality measurements and sample collection for chemical and biological analysis. A total of 470 river kilometers (the tailwater of Glen Canyon Dam to Columbine Falls) was included in the synoptic experiment. Included also was the forebay of Lake Powell formed by Glen Canyon Dam where the water that would ultimately be released into the river was sampled.

Sixty-eight people (all but four from the USGS) participated in the synoptic experiment. At each mainstream sampling station, or combination mainstream-tributary station, a team leader was designated. The team leader was assigned the responsibility for directing the sampling, processing samples, and recording field data. Training of team leaders and team members on field measurements and sample collection was performed on Oct. 29, 1990, at Lees Ferry, AZ. Three training sessions, including 3 to 4 hours of classroom instruction and riverside equipment demonstration and use, were presented by scientists from the USGS National Research Program.

After training and equipment testing, personnel were transported to their assigned sampling locations. Personnel were at their stations by late Saturday, Nov. 3, 1990. Sunday, Nov. 4, 1990, was used to establish local sampling schemes, and field-measurement sites, and to practice measurements and sample collection.

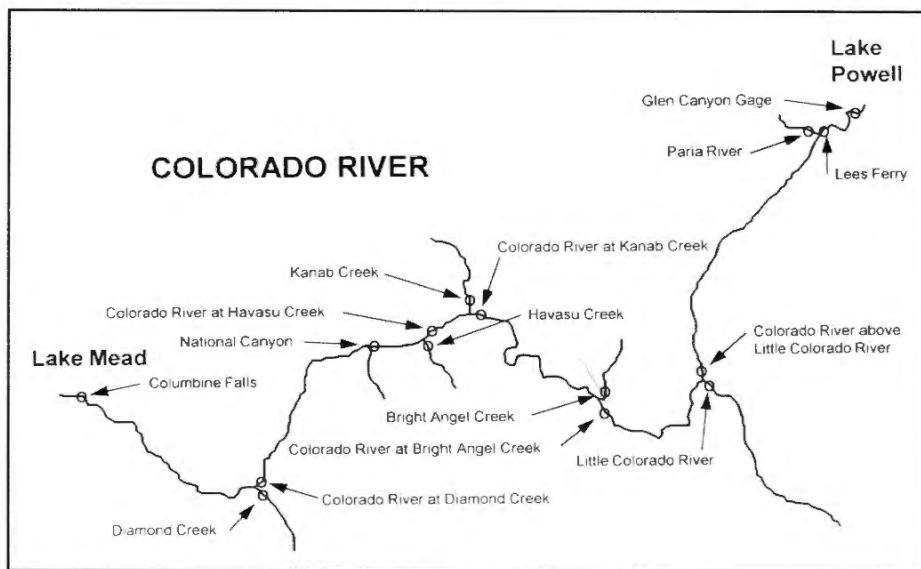
Of the 10 mainstream Colorado River sampling stations, 6 have cableways that cross the river for discharge measurement and sample collection. The cableways were used in the synoptic experiments for water-sample collection. At stations where a cableway was not available, sampling and measurements were performed using a winch and boom mounted on a boat. In small tributaries, samples were collected by depth-integrated discharge-weighted procedures. The samples from the cableways and by boat were collected by the D-77 sampler, modified to permit use of the collapsible-bag technique as described by Meade and Stevens (1990). Samples collected by wading used the DH-81 sampler. In both cases, sampling equipment was designed and configured to maintain the integrity of samples for low-level trace-element analysis.

Field measurements and sample collection began at 6:00 am on Monday, Nov. 5, 1990, and continued every 6 hours thereafter, until and including midnight, Nov. 6, 1990. This scheme provided 8 measuring and sampling times over a 48-hour period, accommodating diel variations and fluctuating river stage caused by variable water release from Glen Canyon Dam. All subsequent water samples for chemical and biological analysis were field-filtered and preserved, if necessary, at the time of collection. The samples were shipped chilled to the USGS National Research Program laboratory at Arvada, CO, for laboratory analysis (Taylor and others, 1990).

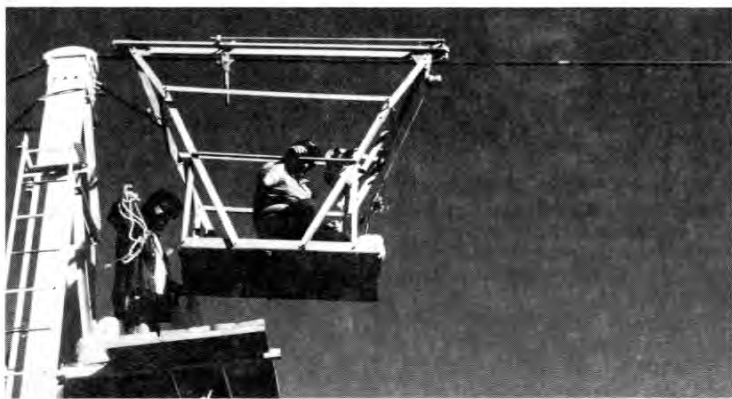
Field measurements at each station included river and tributary discharge, temperature, alkalinity, specific conductance, pH, dissolved oxygen concentration, and Secchi-disk depth. About



Samples collected by wading used the DH-81 Sampler



Colorado River showing sampling station localities and river miles from Lees Ferry for the 11/5/90 USGS water-quality synoptic studies. o-indicates sampling localities



Cableway, used in synoptic experiments for water sample collections on the Colorado mainstream.

780 field measurements were made during the synoptic experiment. Water samples were collected for analysis of chemical and biological characteristics and suspended-sediment concentration. Chemical determinations are listed in Table 1. Biological determinations included drift biomass collected with 100 mm orifice-diameter nets at all sites and 0.5 M orifice-diameter nets at selected sites; benthic invertebrates at the lowest flow in the main stem Colorado River and at sampling-time flow in the tributaries; phytoplankton and zooplankton abundance; and, at several stations, chlorophyll a concentration (Averett and Iwatsubo, in press). About 2,300 water samples were collected for chemical and biological measurements. In addition to the specific determinations, team leaders and team members were careful to make detailed notes on river conditions, including floating material in the river, and to take pictures of the river and sampling sites at the time of the synoptic experiment.

Summary

Synoptic sampling provides a way of rapidly evaluating water quality in large river systems. These data are especially useful in guiding fu-

ture research directions. By designing time variation in the synoptic sampling, additional information can be obtained regarding temporal changes in chemical and biological properties.

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