The US Geological Survey–National Park Service Water Quality Partnership

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The National Park Service (NPS) and the US Geological Survey (USGS) work together to administer and operate a water quality-focused partnership program. This program was started as part of the Clean Water Action Plan, a 1998 presidential initiative to commemorate the 25th anniversary of the Clean Water Act through plans and actions to further restore and protect America's waters. Under the partnership, water quality projects are developed jointly by USGS and NPS personnel to support a broad range of policy and management needs related to high-priority issues in national parks.

The National Park Service manages highly valued aquatic systems across the country, including portions of the Great Lakes, ocean and coastal zones, historic canals, reservoirs, large rivers, high-elevation lakes and streams, geysers, springs, and wetlands. The water quality partnership program has proven tremendously successful in supporting USGS-led studies, resulting in nearly 160 completed projects that support efforts to conserve and improve the nation's water resources. Some of the ongoing projects are highlighted in the NPS Call to Action item "Crystal Clear," which celebrates national park water resource initiatives to provide clean water into the next century of park management (www.nature.nps.gov/water/crystalclear/).

Partnership projects range from one-year technical assistance activities that provide consultation with USGS scientists to three-year intensive projects involving hypothesis-driven data collection, assessment, and publication in peer-reviewed reports. These partnership projects are developed in response to an annual request for proposals that is released to national parks through their regional offices and USGS science centers. To date, 197 partnership projects have been undertaken in over 120 national park units. The current program bibliography (http://water.usgs.gov/nps_partnership/pubs.php) includes over 135 publications.

Project selection is highly competitive, funding only 8 new projects each year out of the approximately 75 short pre-proposals that are initially submitted for the annual call. At each

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stage in the evaluation and selection process, proposals are reviewed by teams composed of experienced professionals in equal numbers from USGS and NPS to ensure that the process reflects a true and equal partnership. Recent projects have addressed issues such as identifying and quantifying impacts of historical mining operations to help prioritize cleanup efforts, evaluating nutrient inputs related to reservoir level management, identifying recreational use effects, and providing state-of-the-art research on the presence of endocrine-disrupting compounds and their impacts on fish and other organisms within park units. In the following four common project themes for partnership work, a completed project is highlighted along with the key information gained by these collaborative studies between USGS and NPS.

Historic land use and reclamation

Many NPS-managed lands have experienced impacts from land use activities including mining, logging, road construction, and water diversion projects. Evaluating current water quality conditions related to past development and gauging the effectiveness of environmental remediation projects has been an important component of the partnership program. A recently completed assessment of mining reclamation at Kantishna Hills in Denali National Park and Preserve in Alaska provides an example of treatment efficacy research (Brabets and Ourso 2013).

The Kantishna Hills is an area of low-elevation mountains in the northwestern part of Denali National Park and Preserve. The Kantishna Hills are drained by clearwater streams derived from rain, snowmelt, and subsurface aquifers that support several species of fish. Past mining practices that began in 1903 and continued until 1985 generated acid mine drainage and excessive sediment loads that negatively affected water quality and aquatic habitat. Currently the effects of mining are visible on more than 1,500 acres of land covering 12 watersheds in the Kantishna Hills area. Due in part to a short growing season, recovery through natural processes is limited and several reclamation projects have been implemented on multiple streams in the Kantishna Hills region in an effort to improve degraded water quality. Projects consisted of (1) removing hazardous materials, contaminated soils, and abandoned equipment, and (2) reconstructing floodplain and stream channel structures to stabilize stream banks from erosion and revegetating sites. A cooperative study between USGS and NPS was undertaken during the years 2008–2011 in order to assess the water quality of the Kantishna Hills' streams and determine whether reclamation efforts have proven effective.

In 2008 and 2009, 104 macroinvertebrate taxa and 164 algae taxa were identified from samples collected at seven different locations encompassing six different streams. Eighty-six percent of the macroinvertebrates were insects and most of the algae consisted of diatoms. An assessment of stream quality using biological indices (National Community Index) indicates Rock Creek (a reference site) and Caribou Creek (a reclaimed mining stream) exhibited the best overall stream conditions. Slate Creek and Friday Creek, two small streams that were abandoned after extensive mining without reclamation efforts, exhibited the worst stream conditions. This study establishes improvements to water quality and the necessity of site reclamation following intensive mining within this sensitive environment.

Figure 1. Tim Brabets, USGS Alaska Water Science Center, and Larissa Yocum, Denali National Park and Preserve, processing a water sample. Photo by Dan Long, USGS.

Nutrient loading impacts

Nutrient loading of aquatic systems in parks from land use development outside the park's boundaries can be a major resource management challenge. Excessive nutrient enrichment can lead to eutrophication and losses of biological diversity and habitat value. Streams and lakes located within national parks can be affected by increased nutrient inputs from sources that include septic systems, agricultural production, atmospheric deposition, and municipal wastewater.

An NPS–USGS partnership study was initiated to examine nutrient loading to Kabetogama Lake in Voyageurs National Park, Minnesota. The southwest shore of Kabetogama Lake

Figure 2. Most of the sampling sites in the Denali National Park study were very remote and required helicopter service to access. Photo by Tim Brabets, USGS.

is not part of the park and therefore is open for development. The numerous homes, cabins, and resorts along the roughly 19 kilometers of shoreline are a potential source of nutrients. Residential and commercial areas on Ash River, which flows into Kabetogama Lake, also are a source of nutrients. As a result, additional development on Kabetogama Lake may cause additional eutrophication, thereby threatening the lake's water quality, ecology, and recreational value. Dam operations at Kabetogama Lake were modified in 2000 to restore more natural water dynamics and improve water quality. In particular, new rule curves were expected to lower phosphorus loading by lessening the effects of drying and rewetting of sediments from fluctuating water levels, reducing nutrient inputs resulting from littoral vegetation, and reducing nutrient concentrations because of increased volume. Nutrient enrichment has led to excessive algal growth in the lake. Microcystin-LR, a cyanotoxin, was detected with concentrations as high as 3.94 micrograms per liter (µg/L) in 2006.

The USGS and NPS partnership project evaluated nutrient, algae, and nuisance bloom data in relation to changes in water level management of Kabetogama Lake through extensive water quality sampling in 2008 and 2009 (Christensen, et al. 2011). The project found that chlorophyll *a* concentrations have decreased, whereas total phosphorus (TP) concentrations have not changed substantially since the beginning of water level manipulations. The study found that the Lost Bay area of the lake is one of several that may be contributing to internal loading of TP from lake sediments. Internal loading of TP is a concern because increased TP may cause excessive algal growth, including that of potentially toxic cyanobacteria. Using these analyses, park managers are able to show the benefits of lake level manipulation as well as better understand the source of total phosphorous inputs.

Visitor use impacts

Wilderness areas in the US receive substantial use by day hikers, backpackers, and pack animals (stock), with recreational visitor-use days having increased sixfold from 1965 to 1994, when the number of visitors approached 17 million/year. NPS and others are concerned that visitor activities in high-use areas of wilderness may be affecting natural resources, including

Figure 3. Kabetogama Lake, Voyageurs National Park, under typical conditions. Photo by Victoria Christensen, USGS.

Figure 4. A wilderness lake sampled in the Sequoia and Kings Canyon National Park investigation on visitor use and water quality. Photo By David Clow, USGS.

water quality. The influence of pack animals and backpackers on water quality in wilderness lakes and streams was evaluated in Sequoia and Kings Canyon National Parks (Clow et al. 2013) and a similar study was begun in Yosemite National Park in 2013. The studies included a synoptic survey of water quality in park wilderness areas, paired water quality sampling in areas with differing types of visitor use, and intensive monitoring using in-stream sensors to examine temporal variations in water quality. Sites are characterized based on minimal use, use by backpackers only, and mixed backpacker and stock use.

Results indicate that water downstream of mixed-use areas had higher concentrations of some constituents examined (including particulate phosphorus and *E. coli*), while backpacker only locations were minimally influenced by use when compared to upstream values. Overall, results from this study indicated water quality in the backcountry streams examined was generally good, except during rain events when pollutants are washed into adjacent waterways. Visitor use appears to have a small, but statistically significant influence on streamwater quality. Additional USGS–NPS partnership studies in other parks are currently underway to better understand the relationships between specific visitor use activities and water quality impacts.

Contaminants of emerging concern

Pharmaceutical compounds and personal care product residuals have been identified as contaminants of emerging concern that can bioaccumulate and adversely affect physiological processes in fish and other sensitive aquatic biota. USGS and NPS conducted a reconnais-

sance study at Lake Mead National Recreation Area, Nevada, to investigate the occurrence of pharmaceutical compounds in water samples collected from the lake and from Las Vegas Wash, which receives treated wastewater from the Las Vegas metropolitan area and flows into the lake (Boyd and Furlong 2002). The most frequently detected compounds in water samples from Las Vegas Wash included caffeine, carbamazepine (used to treat epilepsy), cotinine (a metabolite of nicotine), and a metabolite of the antianginal drug nifedipine. Less frequently detected compounds included several antibiotics, acetaminophen, and codeine, among others.

Fewer compounds were detected in samples collected from Lake Mead than from Las Vegas Wash. Caffeine was detected in all samples collected from Lake Mead. Other compounds detected in samples collected from Lake Mead were acetaminophen, carbamazepine, cotinine, 1,7-dimethylxanthine (a caffeine metabolite), and sulfamethoxazole (an antibiotic). Additional research related to this effort has been synthesized in a report on science and management of Lakes Mead and Mohave (Rosen et al. 2012). Documentation of emerging contaminants has helped NPS develop a productive partnership with the city of Las Vegas and the Southern Nevada Water Authority, which are working to reduce the occurrence of these compounds.

Conclusion

The water quality partnership program funds USGS-led scientific studies that would be otherwise limited or unavailable at the park level. Identification of research and investigation needs by NPS resource managers and a rigorous proposal and study plan review process ensures that priority NPS water quality issues are addressed by USGS scientists. The water quality partnership program exemplifies the ability of federal agencies to work together in order to efficiently and effectively manage the nation's valuable resources.

Since 1998, the water quality partnership program has enabled the NPS to make informed management decisions based on USGS-supported data analyses and interpretations. The partnership promotes the interaction of park staff with USGS scientists and creates long-standing relationships for continued science-based resource management. This program continues to produce high-quality, cost-effective products that are used to make defensible decisions regarding water resource protection so that this critical resource can be enjoyed by current and future generations.

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