Summary of Cyanobacteria Monitoring and Assessments in USGS Water Science Centers

USGS scientists, in cooperation with local, State, Tribal, and other Federal partners, are pioneering new monitoring, assessment, and laboratory capabilities needed to address cyanobacteria issues in freshwaters across the Nation.

Why Cyanobacteria? - An evolving issue of concern with both a national (U.S.) and global impact relates to the occurrence of cyanobacteria and associated toxins and taste-and-odor compounds. Cyanobacterial toxins, called cyanotoxins, can be harmful to aquatic and terrestrial organisms, including humans and taste-and-odor compounds, which are not toxic but may impart earthy or musty tastes and odors to drinking water and fish flesh. The World Health Organization has established suggested thresholds for human health exposure to microcystins, one class of cyanotoxins in finished drinking water and recreational contact (http://www.who.int/water_sanitation_health/resourcesquality/toxicyanbact/en/). These guidelines or variations have been adopted by several U.S. states.

Cyanotoxins and taste-and-odor compounds represent economic and public-health concerns and resource managers, drinking water treatment plant operators, lake associations, and local officials are increasingly faced with decisions about cyanobacteria that affect public awareness, exposure, and health. Understanding the environmental factors associated with the occurrence and concentration of cyanobacteria and associated toxins and taste-and-odor compounds is critical to effective lake management strategies and drinking water treatment decisions and minimization of human and ecological health risks. (*See box for more detail.*)

USGS Activities - Activities relating to cyanobacteria have been completed, are ongoing, or in planning stages in at least 20 States across the Nation. Specific outcomes to these activities are improved decisions in water supply management and protection of public health through:

- an enhanced understanding of environmental factors—including biological, physiochemical, hydrological, and meteorological—affecting the occurrence, fate, transport, and temporal variability of cyanobacteria and associated toxins and taste-and-odor compounds;
- real-time monitoring strategies to develop early warning systems; and,
- development of models and other assessment tools to predict occurrence.

What are cyanobacteria? - Cyanobacteria naturally occur in aquatic ecosystems and are true bacteria that function like algae. They commonly are referred to as "blue-green algae" and are photosynthetic organisms like green plants that consume carbon dioxide and produce oxygen. Cyanobacteria become a concern when their population grows so large that they are visible to the eye.

What is a cyanobacteria harmful algal bloom? – A harmful algal bloom can occur anytime water use is impaired due to excessive accumulations of algae. Cyanobacteria are the dominant group of harmful, bloom-forming algae in freshwater. Potential impairments during cyanobacterial blooms include restricted recreational activities because of algal accumulations, potential loss of public water supply because of taste-and-odor compounds, and the production of toxins that can threaten human and ecosystem health. There is a perception that cyanobacteria harmful algal blooms are increasing in frequency.

What are cyanotoxins? - Cyanotoxins are natural toxins produced by cyanobacteria. Information is lacking on when or why these toxins are produced. The cyanobacteria and/or their toxins have been reported to cause allergic and (or) respiratory reactions in some cases. Cyanotoxins can cause issues with the liver, kidneys, and the nervous systems in mammals. Exposure can be through inhalation, skin and eye contact during recreational activities, and (or) consumption of contaminated water.

What are taste-and-odor compounds? – Taste-and-odor compounds are chemicals that also are naturally produced by cyanobacteria and can impart an undesirable taste and (or) odor to water. These compounds are not known to cause any human health effects, but are of particular concern to drinking-water suppliers because of customer dissatisfaction with malodorous drinking water.

Understanding cyanobacteria and environmental factors associated with its occurrence and concentrations of associated taste-and-odor compounds and cyanotoxins is very complicated, but critical to surface-water management and drinking water treatment decisions and minimization of human health risks. While the general factors influencing cyanobacteria blooms are well known, the specific factors driving particular occurrences of taste-and-odor compounds and toxins remain highly variable and therefore relatively unclear.

As demonstrated through selected USGS studies described in this document, the complexities present unique challenges for monitoring and assessment. When, where, and how samples are collected can substantially influence results because of rapidly changing conditions. Wind conditions, for example, can change cyanobacteria locations within a freshwater body over short periods. Teasing out the relative importance of the many physical, chemical, and biological factors affecting cyanobacteria is a continual challenge, as they manifest differently in lake, environmental, and land-use settings and over time. There are several possible potential cyanobacterial producers for most cyanotoxins and some strains may produce multiple toxins simultaneously while others do not produce any toxins. Other challenges relate to the wide variety of cyanotoxins and the fact that new cyanotoxins are continually being discovered. By providing practical applications of cutting edge cyanobacteria harmful algal bloom research, USGS studies have pushed the science forward regarding our understanding of impacts as well as human and ecological health protection.

Background on USGS: Many of the USGS studies highlighted in this document are conducted through the USGS Cooperative Water Program (CWP), which is the Water Mission Area's "bottom-up, on-the-ground" cost-share program working in every State, protectorate, and territory of the U.S in partnership with nearly 1,600 local, State, and Tribal agencies. These CWP studies, as well as studies with other federal agencies, such as the National Park Service and U.S. Bureau of Reclamation, are conducted within 48 USGS Water Science Centers located across the country. Jointly planned monitoring and science efforts bring local, State, Tribal, and federal water needs and decision-making together with USGS capabilities, including nationally consistent methods and quality assurance; innovative monitoring technology, models, and analysis tools; and robust data management and delivery systems. A distributed national workforce located in USGS Centers helps to identify and respond to emerging issues which often surface at local and State levels, but develop into those of regional, national, and even global significance. Because USGS data and analyses adhere to strict national protocols, findings are comparable across local, State, Tribal, and regional boundaries; water issues in a specific watershed, municipality, State, or region can therefore be compared and transferred to those in other geographic regions and through time.

It should be noted that the USGS activities in States described below are supported by other USGS research that focuses on, for example, cyanobacterial culturing and taxonomy; development of robust methods for analysis of cyanotoxins; utility of satellite imaging techniques to track historic trends; effects on estuaries; possible human and ecological risks; and description of cyanotoxins mixtures. A large amount of research is conducted through the USGS Toxic Substances Hydrology Program (http://toxics.usgs.gov/highlights/algal_toxins/index.html). In addition, research is conducted in USGS Ecosystem Centers, such as in the Western Fisheries Research Center, which is assessing threats that algal toxins pose to juvenile Lost River and shortnose suckers in the Upper Klamath River Basin, Oregon (http://pubs.usgs.gov/fs/2009/3111/).

Kansas

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- Cooperative studies at Cheney Reservoir, a drinking water supply for the city of Wichita, Kansas, are focused on linking biological, physicochemical, hydrological, and meteorological processes to refine relations to estimate taste-and-odor occurrences and develop new relations with other variables of concern, such as cyanotoxins. (Learn more - http://ks.water.usgs.gov/studies/qw/cheney/)

- Severe taste-and-odor episodes in Cheney Reservoir, a key drinking water supply for the city of Wichita, Kansas, during the early 1990's prompted the development of real-time estimation of water-quality constituent concentrations and transport from the watershed. Continuously monitored variables, such as light, temperature, conductivity, and turbidity have been used to develop real-time water-quality models to estimate when geosmin, a common taste-and-odor causing compound, concentrations will exceed the human detection threshold of 10 nanograms per liter (view real-time estimates of geosmin concentrations in Cheney Reservoir). The city of Wichita uses these models, along with other variables measured in real

time, to aid the management of Cheney Reservoir and decrease water-treatment costs. (Learn more: http://ks.water.usgs.gov/studies/qw/cyanobacteria/).

- A study released in July 2012, done in cooperation with the City of Lawrence, the City of Topeka, Johnson County WaterOne, Kansas Water Office, and the Kansas Department of Health and Environment, presented findings on the fate and transport of cyanobacteria and associated toxins and taste-and-odor compounds from upstream reservoir releases in the Kansas River. (Learn more: http://pubs.usgs.gov/sir/2012/5129/)

- A follow-up 5-year Kansas River study (through 2017) has been initiated to develop a real-time water-quality notification system for drinking-water suppliers using the Kansas River as a source-water supply. The Kansas River is important because it is a primary source of drinking water for about 800,000 people in northeastern Kansas. Cyanobacterial blooms typically do not develop in the Kansas River; however, reservoirs in the lower Kansas River basin do occasionally develop blooms. The Kansas River experiences periodic taste-and-odor episodes that likely are caused by either cyanobacterial production of taste-and-odor compounds in upstream reservoirs or actinomycetes bacteria production and transport with sediment during runoff events. Downstream transport of cyanobacteria and associated toxins and taste-and-odor compounds from reservoirs in the lower Kansas River basin was documented during releases from Milford, Tuttle Creek, and Perry reservoirs during September and October, 2011 (see previous study). However, the sources, frequency of occurrence, and causes of cyanobacteria, cyanotoxins, and taste-and-odor compounds in the Kansas River have not been fully characterized. The objectives of the Kansas River study are to: 1) provide an advanced real-time notification system with sufficient lead time to alert water suppliers that use the Kansas River as a source-water supply of changing water-quality conditions that may affect treatment processes or cause cyanotoxin and/or taste-and-odor events and 2) characterize the sources, frequency of occurrence, and potential causes, including fate and transport from upstream reservoirs, of cyanobacteria and associated toxins and taste-and-odor compounds in the Kansas River.

- USGS scientists in Kansas worked with the USGS Toxic Substances Hydrology Program (http://toxics.usgs.gov/highlights/algal_toxins/index.html) to assess co-occurrence of cyanotoxins and taste-and-odor causing compounds in 23 Midwestern lakes. The findings are significant because studies assessing toxicity and risk of cyanotoxin exposure have historically focused on only one class of toxins (microcystins). The common presence of several types of cyanotoxins indicates that there is the potential for inaccurately quantifying hazards using current assessment methods. Additionally, these results suggest that odor (e.g. earthy, musty smells) may serve as an additional warning signal of the presence of cyanotoxins in water, albeit cyanotoxins may be present in the absence of taste-and-odor problems. (Learn more: http://pubs.acs.org/doi/abs/10.1021/es1008938)

- USGS scientists in Kansas worked with EPA, States, and Tribes on the 2007 National Lake Assessment, which includes the first-ever national study of algal toxins in lakes. Microcystin—a toxin that can harm humans, pets, and wildlife—was found to present in about one-third of the Nation's lakes and at levels of concern in about 1 percent of lakes (Learn more: http://www.epa.gov/owow/LAKES/lakessurvey/pdf/nla_report_low_res.pdf; http://water.epa.gov/type/lakes/assessmonitor/lakessurvey/upload/NLA-2012-Fact-Sheet-for-Communities.pdf)

Texas

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- Cooperators have developed capabilities to study cyanobacterial blooms and their associated toxins and taste-and-odor compounds through reservoir monitoring, continuous monitoring, and ecological data collection. In cooperation with the Texas Commission on Environmental Quality, for example, USGS sampled 36 sites at 30 reservoirs in 2006 to assess linkages among Cyanobacteria abundance, the toxin microcystin, and the taste-and-odor compounds geosmin and methyl-isoborneol (MIB). A geodatabase was developed that allows managers to query and map detections of individual compounds in source-water reservoirs.

- USGS, in cooperation with the City of Houston, is assessing rapidly changing hydrologic and water-quality conditions influencing taste-and-odor causing organisms and compounds in Lake Houston using discrete and continuous monitoring data. Specifically, relatively sudden changes in hydrology, such as related to inflows and water residence times, turbidity,

and nutrient concentrations continue to cause substantial changes in taste-and-odor causing organisms Cyanobacteria over relatively short periods of time. (Learn more: http://pubs.usgs.gov/sir/2011/5121/)

- In cooperation with the City of Houston, City of Waco, and the U.S. Army Corps of Engineers, USGS has developed real-time, in-lake chlorophyll-fluorescence monitoring strategies using in vivo fluorescence (IVF) chlorophyll sensors to track algal biomass and Cyanobacteria occurrence. The real-time data are used to identify periods when potential algal blooms are developing; peaks in inferred chlorophyll concentrations are used to indicate when to verify Cyanobacteria occurrence through traditional water-quality and Cyanobacteria monitoring. (Learn more: http://pubs.usgs.gov/fs/2008/3009/)

South Carolina

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- USGS scientists, in cooperation with Spartanburg Water, South Carolina, assessed seasonal lake conditions in 2006-2009 to help explain the occurrence of Cyanobacteria and cyanobacterial-derived compounds, geosmin, MIB, and microsystin in two reservoirs in Spartanburg, County. Environmental variables, such as nutrients, water temperature, residence times, and other hydrodynamic and basin water characteristics were included in a regression model to evaluate the likelihood that the taste-and-odor compound geosmin could exceed threshold levels for human detection. Overall, the models indicated increased likelihood that geosmin could exceed the human detection threshold during periods of lower nitrogen concentrations and higher water levels in the reservoirs. Model findings highlighted a possible issue related to links between Cyanobacterial bio-volumes and internal phosphorus cycling. The model serves as a tool in ongoing watershed monitoring and management by Spartanburg Water to reduce the occurrence of Cyanobacteria and associated nuisance compounds. (Learn more: http://pubs.usgs.gov/sir/2011/5060/)

South Dakota

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- USGS, in cooperation with the City of Rapid City, released algal and water-quality data for Rapid Creek and Canyon Lake near Rapid City, South Dakota. The study found no taste-and-odor problems with the drinking water; however, the presence of Cyanobacteria known to contain taste-and-odor producing strains indicates the potential for taste-and-odor problems under certain physical and chemical conditions. (Learn more: http://pubs.usgs.gov/ds/354/)

Minnesota

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- Relations among nutrient enrichment, sediment, algal growth and potentially toxic cyanobacteria were assessed by USGS in partnership with the National Park Service in Kabetogama Lake, Voyageurs National Park in northern Minnesota. The data were evaluated in relation to changes in water levels in the lake following changes to dam operations starting in 2000. Kabetogama Lake often was mixed vertically, except for a few stratified areas including Lost Bay in the northeastern part of the lake. The internal loading from Lost Bay and several other areas with relatively large sediment phosphorus concentrations may be associated with the cyanobacterial hepatotoxin, microcystin, which was detected in 7 of 14 cyanobacterial bloom samples, with total concentrations exceeding the 1.0 microgram per liter World Health Organization guideline for finished drinking water. Comparisons of the results to previous studies indicate improved chlorophyll-a concentrations and trophic state indices since 2000 when dam operations changed. However, concentrations of total phosphorous have not changed since that time. (Learn more: http://pubs.usgs.gov/sir/2011/5096/)

Oregon

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- The USGS and U.S. Bureau of Reclamation assessed water quality conditions in Agency and Upper Klamath Lakes in south-central Oregon, gathering information from multi-parameter continuous water-quality monitors, physical water samples, and meteorological stations. The 2006 study showed close relations between water-quality seasonal patterns and bloom dynamics of the cyanobacterium *Aphanizomenon flos-aquae.* High dissolved oxygen and pH conditions in both lakes

before the bloom declined in July, which coincided with seasonal high temperatures and resulted in seasonal lows in dissolved oxygen and decreased pH. Dissolved oxygen and pH in Upper Klamath and Agency Lakes increased again after the bloom recovered. Seasonal low dissolved oxygen and decreased pH coincided with seasonal highs in ammonia and orthophosphate concentrations. The study also found that conditions potentially harmful to fish were influenced by seasonal patterns in bloom dynamics and bathymetry. Potentially harmful low dissolved oxygen and high un-ionized ammonia concentrations occurred mostly at the deepest sites in the Upper Klamath Lake during late July, coincident with a bloom decline. Potentially harmful pH conditions occurred mostly at sites outside the deepest parts of the lake in July and September, coincident with a heavy bloom. Instances of possible gas bubble formation, inferred from dissolved oxygen data, were estimated to occur frequently in shallow areas of Upper Klamath and Agency Lakes simultaneously with potentially harmful pH conditions. (Learn more: http://pubs.usgs.gov/sir/2008/5201/)

- USGS and the U.S. Fish and Wildlife Service have tested the applicability of acoustic Doppler current profilers in Upper Klamath Lake in south-central Oregon in determining temporal (seasonal, weekly, and daily) variation in suspended solids where massive cyanobacterial blooms occur annually. Measured variables were water velocity, wind speed, air and water temperatures, and relative backscatter. Findings showed that water column stability and turbulence in the lake were more important factors in controlling seasonal vertical distribution of cyanobacteria colonies than light. Weak currents and elevated air temperatures at the water surface correlated with increased cyanobacteria colonies at more frequent time scales (weekly, daily). Results suggest that the use of acoustic Doppler profilers for measured vertical velocity and backscatter as a surrogate for suspended material have the potential to contribute significant additional insight into the occurrence and dynamics of selected cyanobacteria colonies in Upper Klamath Lake. (Learn more: http://pubs.usgs.gov/sir/2010/5203/)

Arkansas
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- USGS, in cooperation with the Beaver Water District, has been monitoring and assessing phytoplankton biomass in Beaver Lake, a large flood-control, hydroelectric, and water-supply reservoir in northwest Arkansas. Phytoplankton samples were collected from 2002-2010 at 7 sites, aggregated into four categories (greens, cyanobacteria, diatoms, and flagellates), with a focus on the cyanotoxin producer, *Cylindrospermopsis*. The study showed that *Cylindrospermopsis* occurred at all sites and has increased about three times in the densest of samples. Relations showed that *Cylindrospermopsis* was greatest when water temperatures were between 25 and 32 degrees Celsius; when concentrations of total phosphorus were around 0.02 milligrams per liter; and when concentrations of total nitrogen were around 0.3 milligrams per liter. Preliminary results suggest that a dominant contributor of *Cylindrospermopsis* to Beaver Lake may be War Eagle Creek.

Florida
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- USGS worked in collaboration with the University of Central Florida, Florida Department of Environmental Protection, and Florida Department of Transportation to assess the transport of two cyanotoxins, microcystin and *Cylindrospermopsin* in groundwater in sandy aquifer sediments beneath stormwater ponds and implications for harvesting of infiltrating stormwater, such as for irrigation. Findings showed that sandy soil provided little sorption-based removal of either cyanotoxins, but suggested biodegradation-based removal of microcystin. Thus, the potential exists for harvested water to be impacted in sandy aquifer systems by both microcystin and *Cylindrospermopsin* present in stormwater. (Presented at the International Groundwater Quality Conference held in Zurich, Switzerland, June 2010; Learn more: http: www.iahs.info/redbooks/a342/abs_342_0107.pdf)

Louisiana
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- In January 2013, the USGS, in cooperation with the Louisiana Department of Transportation and Development (LaDOTD), will begin an assessment of the quality of water and bottom material in four oxbow lakes in northern and central Louisiana.

Surface water samples will be collected three times per year at two sites in each lake: once in late spring, once in late summer-early fall, and once in winter, and analyzed for physicochemical properties, a comprehensive list of chemicals constituents, and biological indicators of water quality, including chlorophylls and phytoplankton/algal toxins. Bottom material will be collected once per year at one site per lake, and analyzed for pesticides. Analyses will focus on (1) relations of sampling to eutrophication; (2) urbanization issues and the degree to which land use affects water quality; (3) changes in water quality over the last several decades (through comparisons with water-quality data collected in the late 1970s-mid 1980s); and, (4) relations to selected USEPA drinking-water standards. Findings from this study will provide water managers and planners with information to help assess the use of these lakes as multiple-use resources. The results of the 3-year study will be published in a LaDOTD Water Resources Technical Report.

Michigan
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- A two-year algal toxin study is being conducted by the USGS Michigan Water Science Center and USGS Kansas Organic Geochemistry Research Laboratory, in cooperation with the National Park Service (NPS). Sampling began in the summer of 2012 and will continue through the fall of 2013 at three National Parks, including Isle Royale National Park, Sleeping Bear Dunes National Lakeshore and Pictured Rocks National Lakeshore. Routine surface water samples will be taken at 3 times throughout the recreation season each year and analyzed for the presence of microcystin, saxitoxin and cylindrospermopsin toxins. Samples are also being collected when evidence of an algal bloom is observed and analyzed for the same series of toxins. Currently, no data exists on the concentrations of algal toxins in the surface waters used for drinking and recreation at these three parks and results from this study will inform managers and scientists about the occurrence and type of algal toxins as well as provide a baseline for algal toxins in these parks when no algal blooms are present.

Nebraska
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- USGS, in cooperation with the Lower Elkhorn Natural Resources District, the Nebraska Department of Environmental Quality, the Nebraska Game and Parks Commission, the Nebraska Department of Natural Resources, the University of Nebraska, and the Nebraska Environmental Trust began a study in 2012 to characterize cyanobacteria levels in the Willow Creek Reservoir in Pierce, Nebraska, located in the northeastern part of the State. The study will help to assess possible causes for elevated cyanobacteria levels and harmful algal blooms within the reservoir and Willow Creek basin, which can lead to improved strategies for managing cyanobacteria in Willow Creek Reservoir.

New Jersey
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- The USGS operates two real-time continuous water column chlorophyll-sensors in cooperation with the New Jersey Department of Environmental Protection and the Passaic Valley Water Commission. The New Jersey Department of Environmental Protection will use the continuous chlorophyll-a data to calibrate a water-quality model of the Barnegat Bay estuary as part of a nutrient Total Maximum Daily Load project. Water-column continuous chlorophyll-a concentrations and algal community information (4 groupings based on cellular pigment fluorescence) is used by the Passaic Valley Water Commission to minimize potential unpleasant taste and odors and to reduce the need for additional treatments during the production of potable water.

North Carolina
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- In Summer 2012, USGS began a partnership with the NC Division of Water Quality, NC Division of Marine Fisheries, U.S. Fish and Wildlife Service and East Carolina University to monitor water and sediment at sites distributed throughout Albemarle Sound and its tributaries. Water samples will be analyzed for phytoplankton community composition, nutrients, cyanotoxins, the pesticides atrazine and glyphosate, metals, total suspended solids, chlorophyll-a, and other ancillary data.

This project fills a monitoring gap for the Albemarle Sound because a sound-wide synoptic of phytoplankton has not been conducted since the late 1980's and a sound-wide synoptic of cyanotoxins has never been conducted. This project serves as a pilot study of the National Monitoring Network for U.S. Coastal Waters and their Tributaries (aka referred to as the "Network"). Goals of the Network are to provide information about the health of our oceans and coastal ecosystems and inland influences on coastal waters for improved resource management. The Network is an integrated, multi-disciplinary, and multi-organizational program using multiple sources of data to augment current monitoring programs (http://acwi.gov/monitoring/network/).

- USGS, in partnership with the NC Division of Water Quality and U.S. Fish and Wildlife Service, is monitoring water quality at Lake Mattamuskeet in Hyde County in eastern North Carolina. Preliminary data, collected through continuous water monitors and individual samples, suggest that elevated levels of cyanobacteria occur on the west side of the lake, while the east side continues to host a healthy community of submerged aquatic vegetation and critical foraging ground for migratory waterfowl.

- USGS, in cooperation with the Town of Cary, is assessing water quality and lake stratification in the New Hope Arm of Jordan Lake in Chatham County. Jordan Lake is a eutrophic, multi-purpose reservoir in central North Carolina. The Town of Cary, who uses the reservoir as a drinking-water supply, plans to install an innovative, high-capacity, mixing system in early 2014 to enhance the quality of raw water. The multi-year project (through October 2015) will evaluate water-column stratification, chemical quality (nutrients, iron and manganese), and phytoplankton characteristics (chlorophyll *a*, taste-and-odor compounds, and community composition) before and after installation of the mixing system.
- USGS, in cooperation with the Triangle Area Water Supply Monitoring Steering Committee, has planned a reconnaissance of cyanotoxins, taste and odor compounds, and phytoplankton communities in water-supply reservoirs in the Triangle Area of North Carolina. Water-supply reservoirs in the Triangle Area of North Carolina range from mesotrophic to highly eutrophic. Algae in the reservoirs vary seasonally and among locations, and algal blooms occasionally are observed. To assess whether cyanotoxins and taste and odor compounds occur at levels of concern, samples will be collected at six reservoirs during April-October 2014. Samples will be analyzed for four classes of cyanotoxins (microcystins, cylindrospermopsin, anatoxin-a, and saxitoxins), and two taste and odor compounds (geosmin and MIB). Phytoplankton samples will be analyzed for taxonomic identification, enumeration, and bio-volume estimates.

  The reconnaissance is part of a larger water-quality Triangle Area Water Supply Monitoring program supported by the Steering Committee, which began in 1988, and provides long-term data for field parameters, chlorophyll *a*, nutrients, major ions, metals, and other constituents. The Steering Committee is comprised on the Towns of Apex, Cary, Hillsborough, and Morrisville; City of Durham; Orange Water and Sewer Authority; Chatham and Orange Counties; Triangle J Council of Governments, North Carolina. (Learn more: http://nc.water.usgs.gov/projects/triangle/index.html).

Ohio

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- USGS, in collaboration with the Ohio Water Development Authority, Ohio Department of Natural Resources, Grand Lake St. Mary State Park, and the City of Celina, is monitoring and assessing cyanobacteria populations in the reservoir, Grand Lake St. Marys, in northwest Ohio. Grand Lake St. Marys is a State Park for recreation and wildlife, and also serves as a water-supply reservoir for the City of Celina. Planktothrix is the main cyanobacteria in the lake. Incidences with aphanizomenon blooms also have spurred on multiple remediation projects and assorted data collection efforts on the lake.

- *Proposed* – USGS is proposing a study to conduct extensive testing at recreational beaches, utilizing both optical sensors and qPCR methods (both DNA and RNA) to better understand linkages between cyanobacteria community structure, environmental and water-quality factors, and bloom toxicity. USGS scientists are hopeful that the study will contribute to an improved early-warning system to better inform beach managers and the public. Seven recreational beaches (four on Lake Erie and two on inland lakes in central Ohio) are proposed in partnership with the Ohio Department of Natural Resources, Division of Parks and Recreation (ODNR), Ohio Environmental Protection Agency, University of Toledo, Erie County

General Health District, and Lake County General Health District. Key parameters included in the study are water temperature, turbidity, pH, dissolved oxygen, conductivity, dissolved and total nutrients, cyanotoxins (microcystin, saxitoxin, and cylindrospermopsins), phytoplankton abundance and community structure by microscopy, chlorophyll, phycocyanin and qPCR genetic analysis on 4 levels (total cyanobacteria, total *Microcystis*, genus-specific DNA *mcyE* assays, and genus-specific RNA *mcyE* assays). Environmental data such as solar radiation, currents, and wind direction/speed will be compiled from NOAA and other sources.

Oklahoma

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- *Proposed* – USGS is proposing an investigation of the occurrence, distribution, and causes of cyanobacteria (blue-green algae) and related cyanotoxins in Grand Lake o'The Cherokees in Oklahoma. The proposed study would be of relevance to federal and State stakeholders, including, for example, the Grand River Dam Authority, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and the Oklahoma Department of Environmental Quality, who are responsible for drinking-water and recreational management and protection. Localized intermittent sampling of lakes in Oklahoma in the summer of 2011 indicated that cyanobacteria may be present in large numbers in Grand Lake o' The Cherokees and other lakes in northeast Oklahoma. The USGS, therefore, proposes a more comprehensive study with periodic sampling for cyanobacteria, algae, and related chemical compounds and physical properties at 10 sites on Grand Lake o' The Cherokees. Data collected would be used to determine the spatial and temporal variability of cyanobacteria and cyanotoxins and to evaluate environmental factors associated with these microorganisms. This information could also be used to develop an analytical tool for low-cost prediction of the occurrence of these microorganisms and associated toxins.

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