Louisville District Water Quality Program
CY2016 Annual Report

Please address questions to:

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Louisville District Water Quality

11 SEPT 2017

US Army Corps of Engineers
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Executive Summary

The **authority** of the Louisville District Water Quality Program is founded on the **Federal Water Pollution Control Act** of 1948 and its amendments including the **Clean Water Act** of 1977 and the **Water Quality Act** of 1987. Collectively, these Acts strongly affirm the Federal interest in environmental management, ecosystem restoration, and water quality related activities. *Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

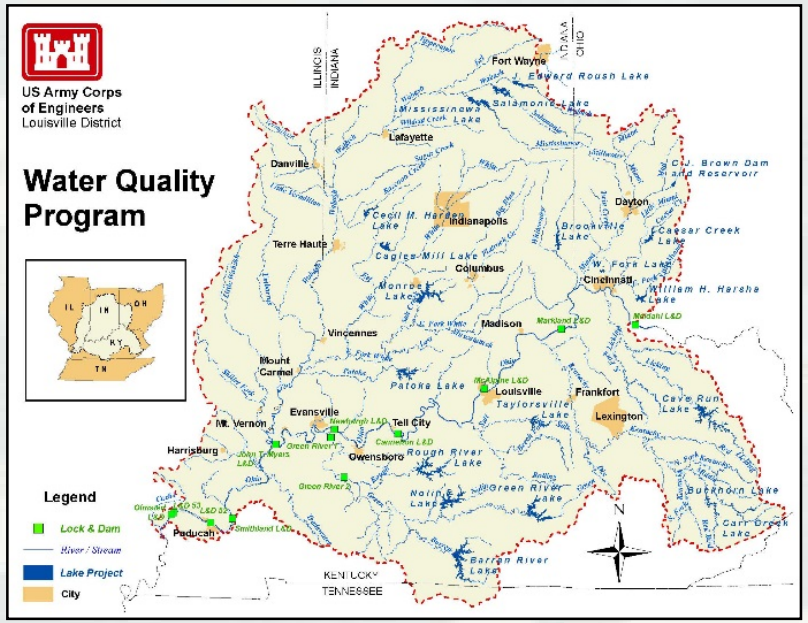

Figure 1. Louisville District Water Quality Program boundaries

Major Findings of 2016 Sampling

- Water Quality data collected in 2016 revealed **five** exceedances of state water quality criteria in lake tailwaters.
  - West Fork Lake (WFR)
    - In the case of the WFR exceedances, limited infrastructure (bypass gates) is the cause of the four DO exceedances.
  - Caesar Creek Lake (CCK)
    - In the case of the CCK temperature exceedance, it would appear that the tailwater temperature was higher than any temperature located in the lake. This would indicate that the exceedance was due to the data collection location or instrument misoperation instead of lake operation.
- At 17/20 lakes, exceedances of USEPA's recommended nutrient criteria were documented.
- All 2016 exceedances of state water quality criteria and USEPA recommended criteria have been reported to the appropriate state regulatory agencies.
- Phytoplankton results revealed that all 20 Louisville District (LRL) lakes were dominated by cyanobacteria genera during the 2016 sampling season.
- Phytoplankton taxa richness ranged from 66 taxa collected at Carr Creek Lake to 129 taxa collected at Monroe Lake.
- No changes in operation are recommended.

2016 Macroinvertebrate Study

- The tailwaters and inflows of Barren River Lake, Green River Lake, Nolin River Lake, and Rough River Lake were assessed using the Macroinvertebrate Bioassessment Index (MBI).
- MBI ratings ranged from "Very Poor" to "Excellent" with 62% of sites as "Fair".
- The high proportion of "Fair", "Poor", and "Very Poor" MBI ratings (90%) indicate moderate levels of human disturbance and impacts to water quality within the assessed watersheds.

2016 HAB Results

Harmful Algal Blooms (HABs) were confirmed at the following lakes:

- Nolin
- Brookville
- Harden
- Roush
- Monroe
- Salamonie
- Harsha
- CJ Brown

Figure 2. Water Quality contractors sample Green River Lake macroinvertebrate sample site, station 2GRRCASEY.

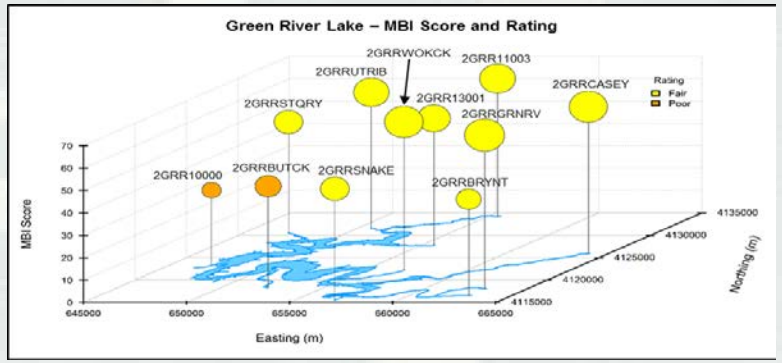

Figure 3. Lollipop chart of MBI scores and ratings. Lollipop height and circle size corresponds to MBI score. Circle color corresponds to MBI rating.

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LRL Water Quality Program Description

Figure 1. Water quality biologists respond to a winter zooplankton bloom at Nolin River Lake.

Water Quality Program Authority

- Federal Water Pollution Control Act of 1948 and its amendments including the Clean Water Act of 1977 and the Water Quality Act of 1987.
- Executive Order 12088 "Federal Compliance with Pollution Control Standards" (13 OCT 1978)
- Collectively, these Acts strongly affirm the Federal interest in environmental management, ecosystem restoration, and water quality related activities.

Water Quality Program Objectives

- Ensure compliance with applicable state and federal water quality regulations as mandated by federal law and EO 12088
- Provide support internally to the Corps
- Monitor water quality conditions, establish baseline conditions, assess current water quality status and identify any significant water quality trends
- Evaluate the effectiveness of the Water Control Plan

Figure 2. Water Quality limnologist holds a live Bluegill (*Lepomis macrochirus*) found in a Brookville Lake inflow site.

Table 1. Water Quality Program survey and study type descriptions.

Survey or Study Type	Description	Frequency
Project profiles	Temperature and dissolved oxygen data collected from the damsite and tailwater that aid in project operation.	Every 2 weeks during thermal stratification
Ambient surveys	Surveys conducted at a lake, inflows, and tailwater once per year during the summer.	Once per year
Intensive surveys	Surveys conducted during the spring, summer, and fall at two lakes per year. Additional biological data will also be collected.	Three times per year at two lakes
Special studies	Studies conducted to answer unique questions as they arrive (e.g. Greenhouse gas, incident response, or HABs)	As needed

Nolin River Lake (2016)

Nolin River Lake (NRR) is located in Edmonson, Grayson, and Hart counties in Kentucky (KY). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) and began operation in March 1963. The primary purpose of the lake is flood control. The dam site is located at river mile 8 of the Nolin River and, at summer pool, the surface area of NRR is 5,795 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

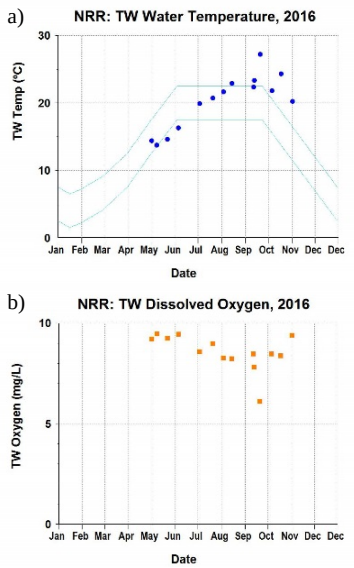

Figure 1. NRR time series data collected from the tailwater (2NRR10000; Figure 3): a) water temperature; and b) dissolved oxygen.

Figure 2. Photograph of NRR inflow stream detail.

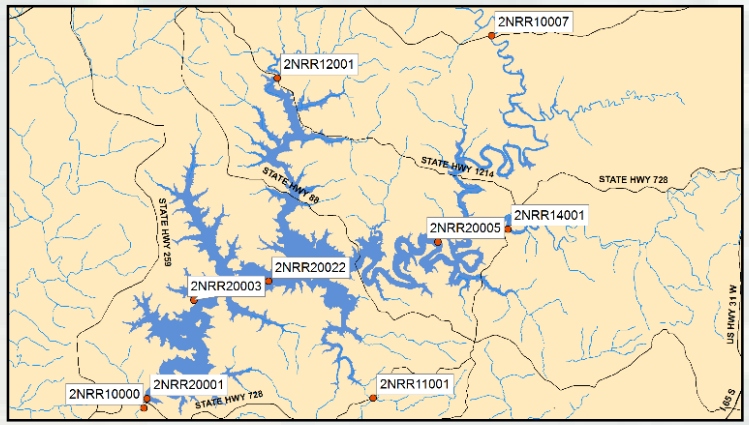

Figure 3. NRR sample sites in 2016 for field and chemical data.

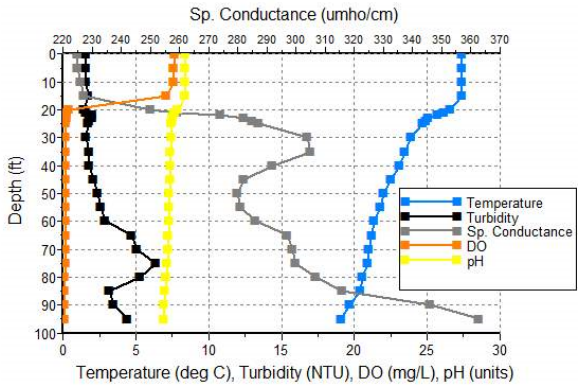

Figure 4. Field data taken at the dam site (2NRR20001; Figure 3) on 9/21/2016 at 07:00.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2NRR10000; Figure 3). However, NRR exceeded the USEPA's recommended criteria for total nitrogen (Criteria: 0.69 mg/L; Measurements: 1.23 and 1.0 mg/L) and turbidity (Criteria: 5.7 FTU; Measurements: 7.7 NTU). All exceedances have been reported to KDOW.**

Figure 5. Photograph of NRR tailwater (NRR10000; Figure 3).

Harmful Algal Blooms (HABs) in KY are addressed by the KDOW as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at NRR in September. The distribution and identification of phytoplankton was measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 6 illustrate the relative abundance for the entire phytoplankton community at NRR during each sampling event. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the dominant genera during the September sampling event.**

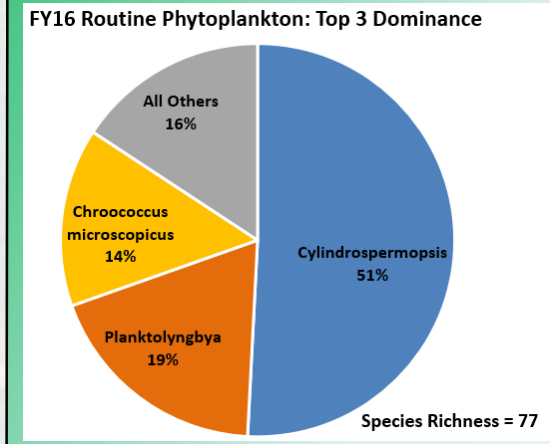

Figure 6. 2016 relative abundance of the entire phytoplankton community at NRR.

Barren River Lake (2016)

Barren River Lake (BRR) is located in Allen, Barren, and Monroe counties in Kentucky (KY). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) and became operational in October 1964. The primary purpose of the lake is flood control. The drainage area above the dam is 940 sq. miles and, at summer pool, the surface area of BRR is 10,000 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

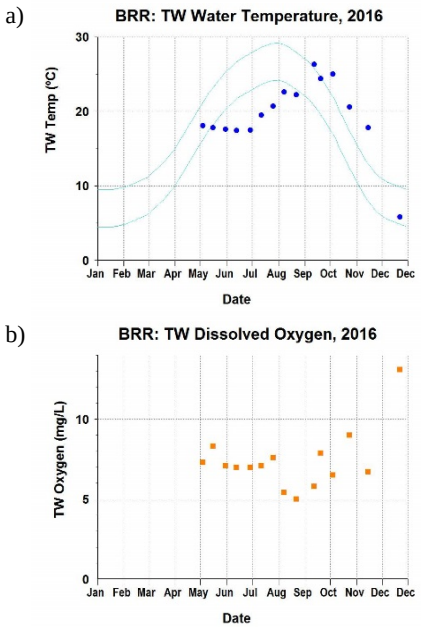

Figure 1. BRR time series data collected from the tailwater (2BRR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

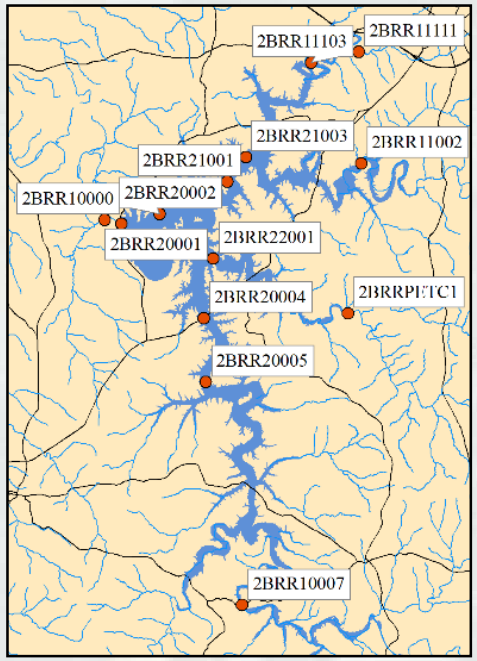

Figure 2. BRR sample sites in 2016 for field and chemical data.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at BRR in September. The distribution and identification of phytoplankton was measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 3 illustrates the relative abundance for the entire phytoplankton community at BRR during each sampling event. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the dominant genera during the September sampling event.**

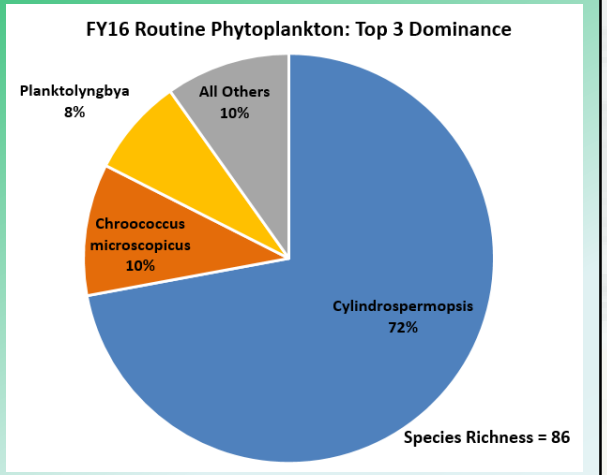

Figure 3. 2016 relative abundance of the entire phytoplankton community at BRR.

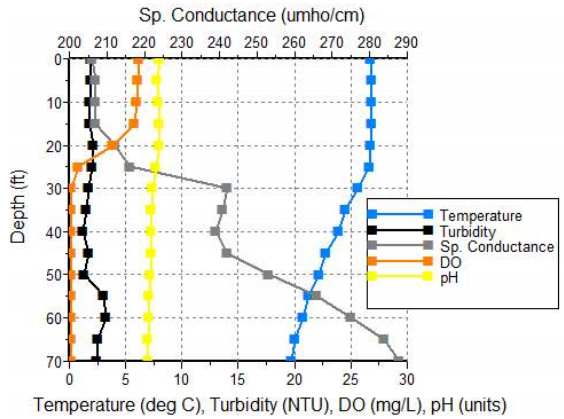

Figure 4. Field data taken at the dam site (2BRR20001; Figure 2) on 9/20/2016 at 08:00.

Figure 5. WQ biologists collecting water samples at BRR.

Harmful Algal Blooms (HABs) in KY are addressed by the KDOW as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2BRR10000; Figure 2). However, BRR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurement: 96.0 ug/L) and total nitrogen (Criteria: 0.69 mg/L; Measurement: 1.17 mg/L). All exceedances have been reported to KDOW.**

Green River Lake (2016)

Green River Lake (GRR) is located in Adair and Taylor counties in Kentucky (KY). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) and began operation in June 1969. The primary purpose of the lake is flood control. The dam site is located at river mile 305.7 of the Green River and, at summer pool, the surface area of GRR is 8,210 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

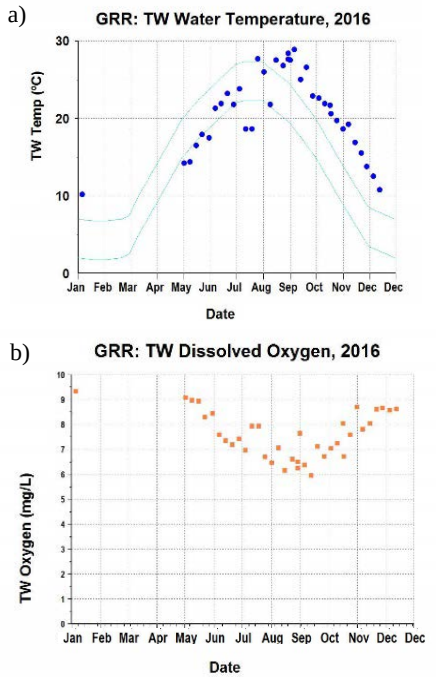

Figure 1. GRR time series data collected from the tailwater (2GRR10000; Figure 5): a) water temperature; and b) dissolved oxygen.

Figure 2. Green River upstream of GRR.

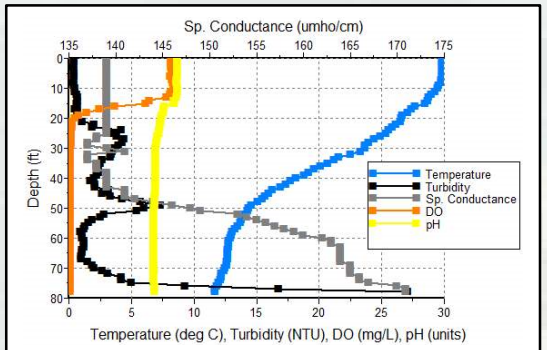

Figure 3. Field data taken at the dam site (2GRR20001; Figure 5) on 8/30/2016 at 07:00.

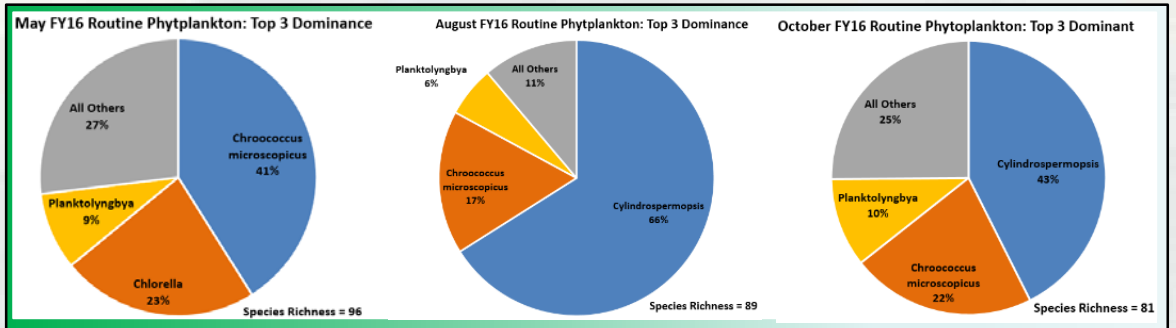

Figure 4. 2016 relative abundance of the entire phytoplankton community at GRR in May, August, and October.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at GRR in May, August, and October. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at GRR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths for each sampling event. **Chroococcus microscopicus was the dominant species in May, while Cylindrospermopsis was the dominant genera in August and October. Both dominant taxa are genera of cyanobacteria.**

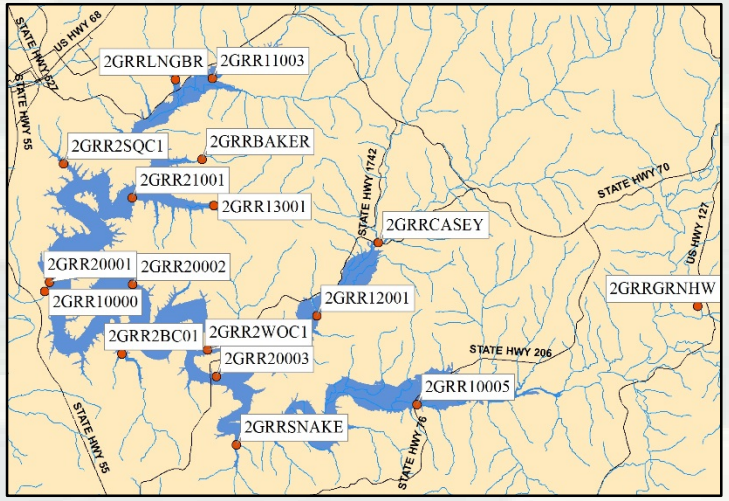

Figure 5. GRR sample sites in 2016 for field and chemical data.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2GRR10000; Figure 5). However, GRR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurements: 56 and 44.0 ug/L) and total nitrogen (Criteria: 0.69 mg/L; Measurements: 0.82 and 0.96 mg/L). All exceedances have been reported to KDOW.**

Harmful Algal Blooms (HABs) in KY are addressed by the KY Division of Water (KDOW) as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

Rough River Lake (2016)

Rough River Lake (RRR) is located in Breckinridge, Hardin, and Grayson counties in Kentucky (KY). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control. The drainage area above the dam is 454 square miles and, at summer pool, the surface area of RRR is 5,100 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

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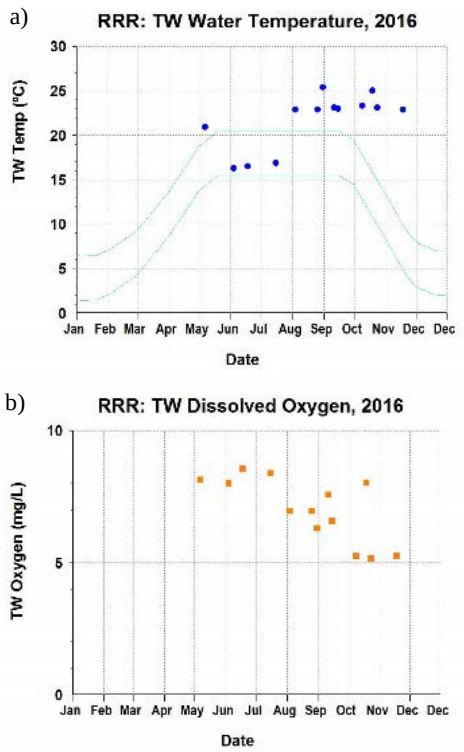

Figure 1. RRR time series data collected from the tailwater (2RRR10000; Figure 3): a) water temperature; and b) dissolved oxygen.

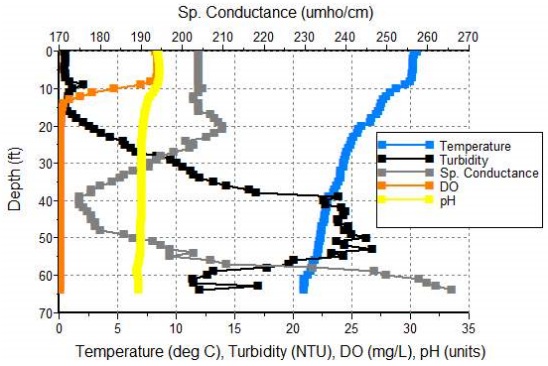

Figure 2. Field data taken at the dam site (2RRR20001; Figure 3) on 8/31/2016 at 09:00.

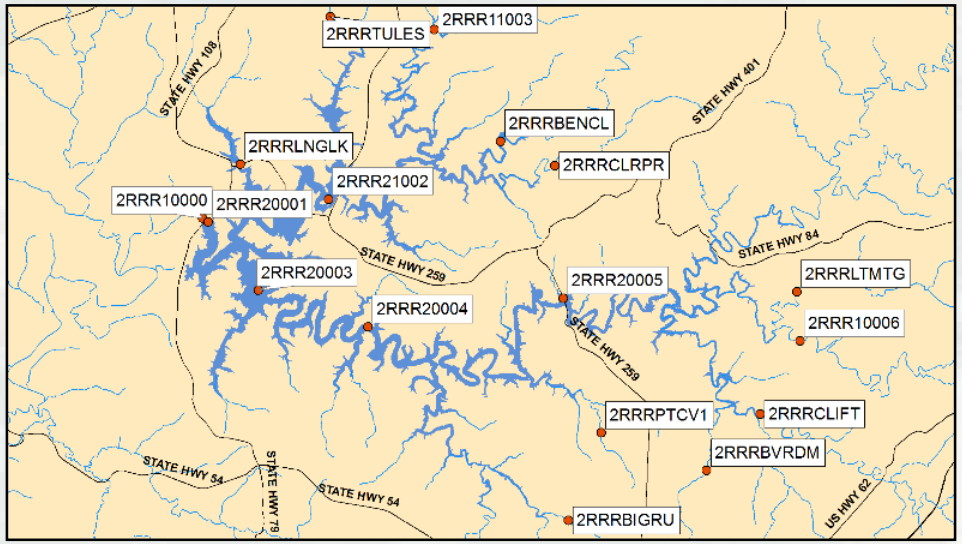

Figure 3. RRR sample sites in 2016 for field and chemical data.

Harmful Algal Blooms (HABs) in KY are addressed by the KDOW as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2RRR10000; Figure 3). However, RRR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurements: 110.0 and 134.0 ug/L), total nitrogen (Criteria: 0.69 mg/L; Measurements: 1.25, 1.45, and 0.99 mg/L), and turbidity (Criteria: 5.7 FTU; Measurements: 22.9, 32.5, 14.2 NTU). All exceedances have been reported to KDOW.**

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at RRR in August and October of 2016. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at RRR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Planktolyngbya* was the most dominant genera in August and *Chroococcus microscopicus* was the dominant species in October found at RRR. Both dominant taxa are genera of cyanobacteria.**

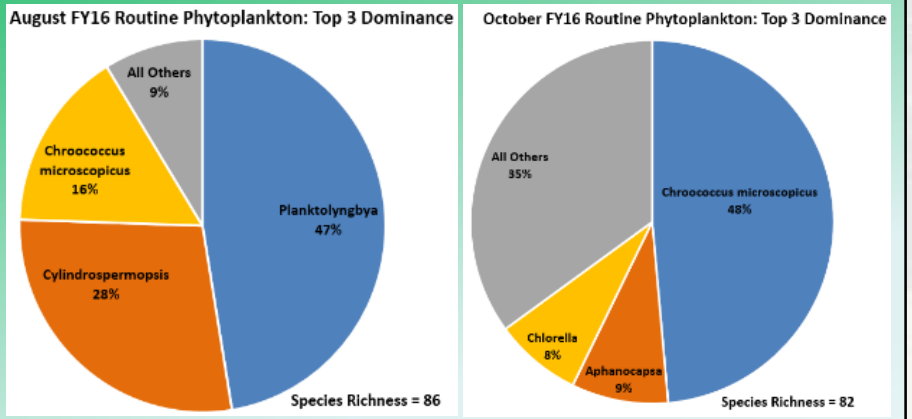

Figure 4. 2016 relative abundance of the entire phytoplankton community at RRR in August (left) and October (right).

Salamonie Lake (2016)

Salamonie Lake (SRR) is located in Wabash and Huntington counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in September 1966. The dam site is located at river mile 3.1 of the Salamonie River. The drainage area above the dam is 553 square miles and, at summer pool, the surface area of SRR is 2,665 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

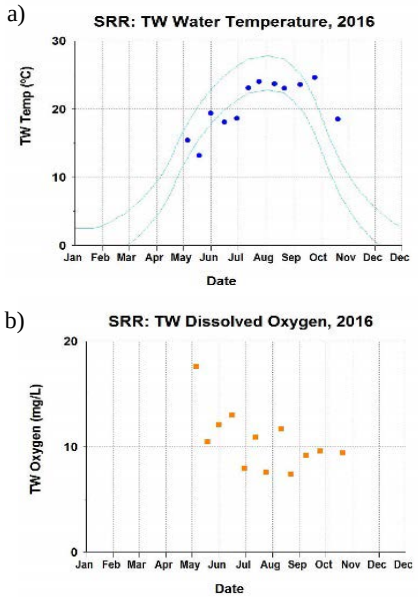

Figure 1. SRR time series data collected from the tailwater (2SRR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

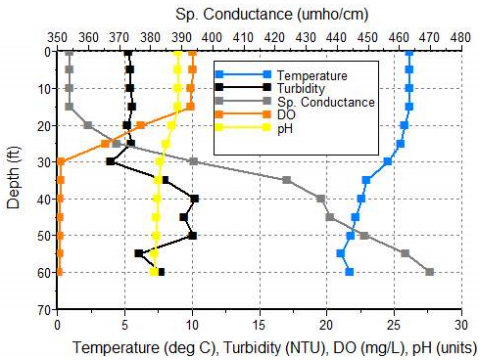

Figure 3. Field data taken at the dam site (2SRR20001; Figure 2) on 8/24/2016 at 08:00.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IN Department of Environmental Management (IDEM). **No criteria were exceeded in the tailwater (2SRR10000; Figure 2). However, SRR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 76.25 ug/L; Measurement: 186.0 ug/L), total nitrogen (Criteria: 2.18 mg/L; Measurement: 3.11 ug/L), and turbidity (Criteria: 6.36 FTU; Measurement: 19.4 NTU). All exceedances have been reported to IDEM.**

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. The IN Department of Environmental Management (IDEM) samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

SRR has 12 sample sites, and was sampled June-August of 2016. *Dolichospermum* was the dominant taxa in the first two samples and was replaced by *Chroococcus microscopicus* in August. The highest cell counts were measured in June with site HAB02 at the top with 1.8 million cells/mL.

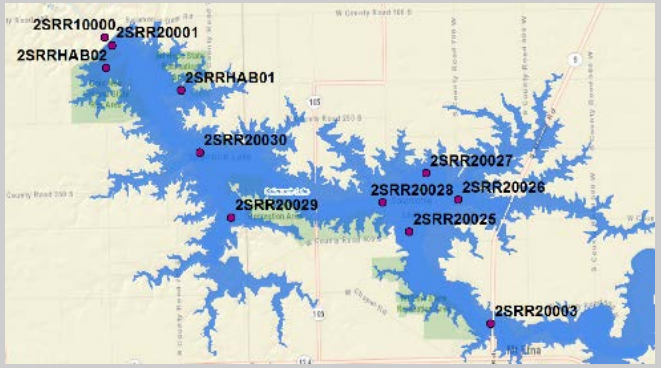

Figure 5. 2016 HAB sampling sites at SRR.

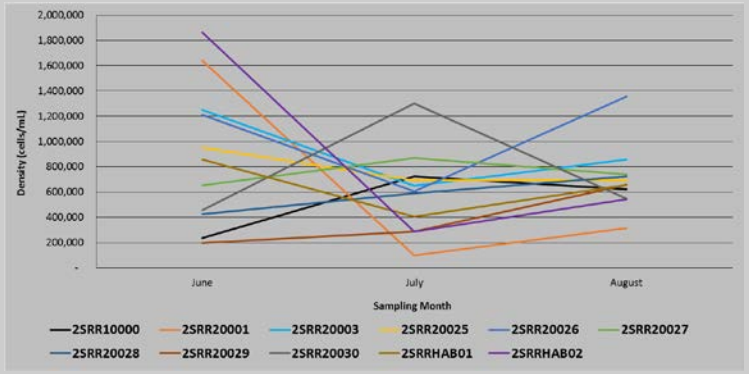

Figure 6. Monthly cyanobacteria cell count data summary from SRR.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at SRR in August. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at SRR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Aphanizomenon*, a genera of cyanobacteria, was the most dominant genera found at SRR.**

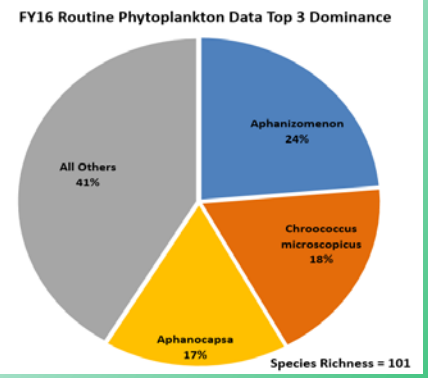

Figure 4. 2016 relative abundance of the entire phytoplankton community at SRR.

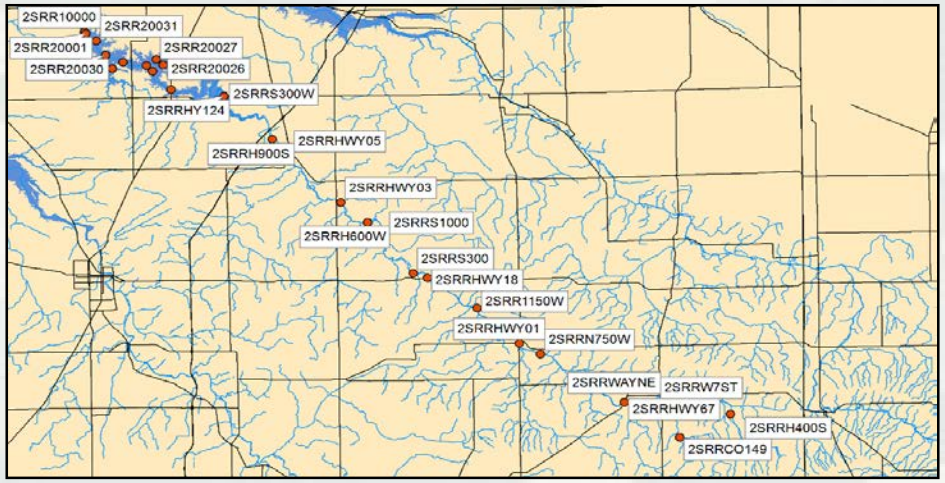

Figure 2. SRR sample sites in 2016 for field and chemical data.

J. Edward Roush Lake (2016)

J. Edward Roush Lake (HTR) is located in Huntington and Wells counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control. The drainage area above the dam is 707 square miles and, at summer pool, the surface area of HTR is 900 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

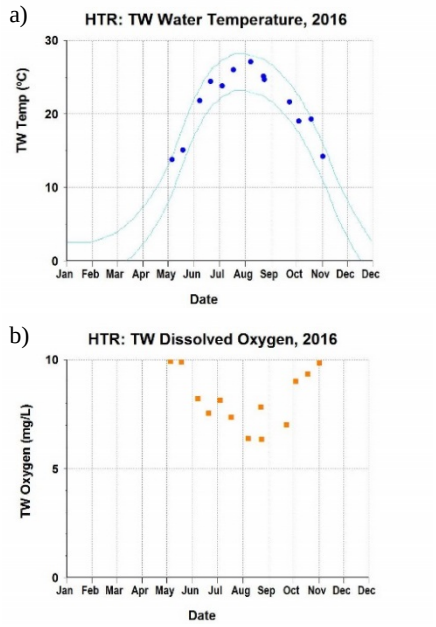

Figure 1. HTR time series data collected from the tailwater (2HTR10000; Figure 3): a) water temperature; and b) dissolved oxygen.

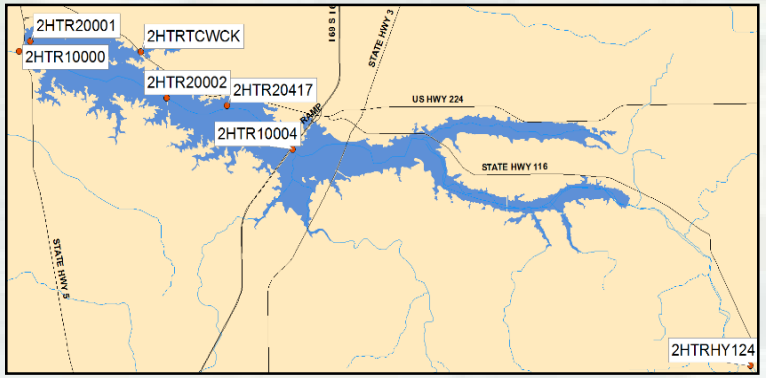

Figure 3. HTR sample sites in 2016 for field and chemical data.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IN Department of Environmental Management (IDEM). **No criteria were exceeded in the tailwater (2HTR10000; Figure 3). However, HTR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 76.25 ug/L; Measurement: 207.0 ug/L) and turbidity (Criteria: 6.36 FTU; Measurement: 28.6 NTU). All exceedances have been reported to IDEM.**

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. IDEM samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

HTR has 7 sampling sites (Figure 5) and sampled June-August of 2016. The general trend for HABs in 2016 was a dip in the cell counts in July, except at site HAB02, which experienced a consistent increasing trend during the sampling months. Peak cell counts were measured in June with the highest being just under 2.1 million cells/mL at Site 20001. Site 10004 was consistently measured the lowest cell counts (minimum 372K, max 547K) during the sampling events.

Figure 5. 2016 HAB sampling sites at HTR.

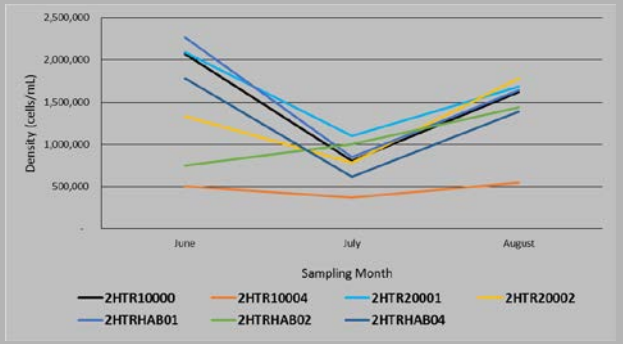

Figure 6. Monthly cyanobacteria cell count data summary from HTR.

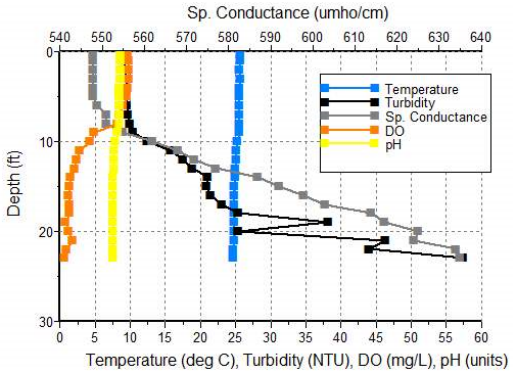

Figure 2. Field data taken at the dam site (2HTR20001; Figure 3) on 8/24/2016 at 10:00.

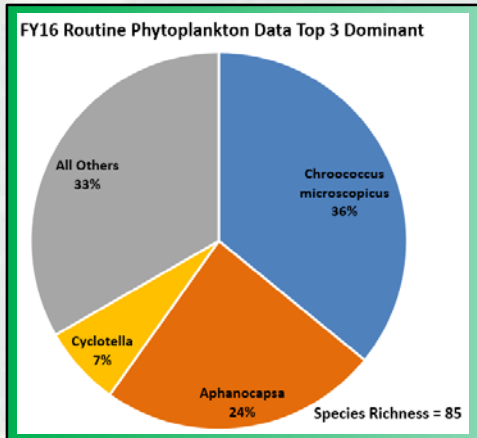

Figure 4. 2016 relative abundance of the entire phytoplankton community at HTR.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at HTR in August. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at HTR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths**. *Chroococcus microscopicus*, a species of cyanobacteria, was the dominant species found at HTR.**

Mississinewa Lake (2016)

Mississinewa Lake (MSR) is located in Wabash, Miami, and Grant counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in October 1967. The drainage area above the dam is 809 square miles and, at summer pool, the surface area of MSR is 3,180 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

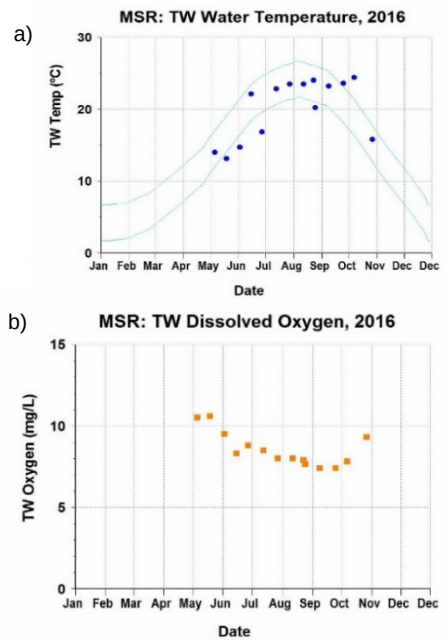

Figure 1. MSR time series data collected from the tailwater (2MSR10000; Figure 3): a) water temperature; and b) dissolved oxygen.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IN Department of Environmental Management (IDEM). **No criteria were exceeded in the tailwater (2MSR10000; Figure 3). However, MSR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 76.25 ug/L; Measurement: 174.0 ug/L) and turbidity (Criteria: 6.36 FTU; Measurement: 22.2 NTU). All exceedances have been reported to IDEM.**

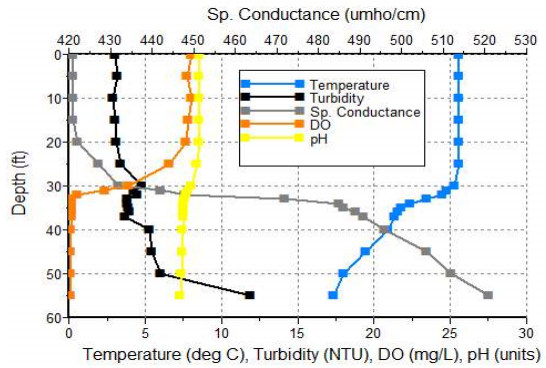

Figure 2. Field data taken at the dam site (2MSR20001; Figure 3) on 8/25/2016 at 08:00.

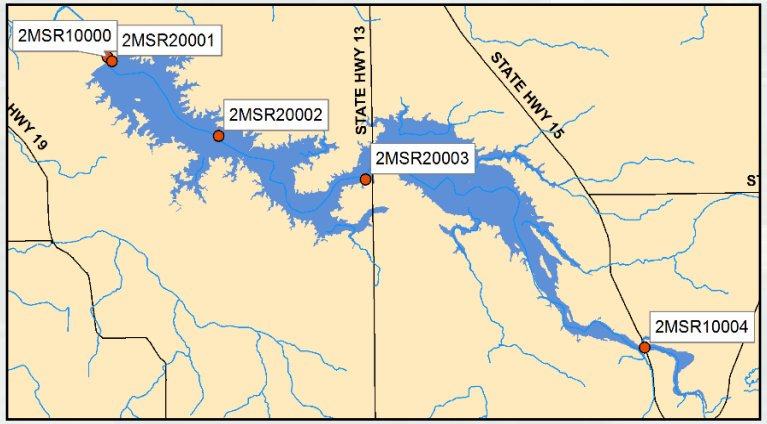

Figure 3. MSR sample sites in 2016 for field and chemical data.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at MSR in August. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at MSR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the dominant genera found at MSR.**

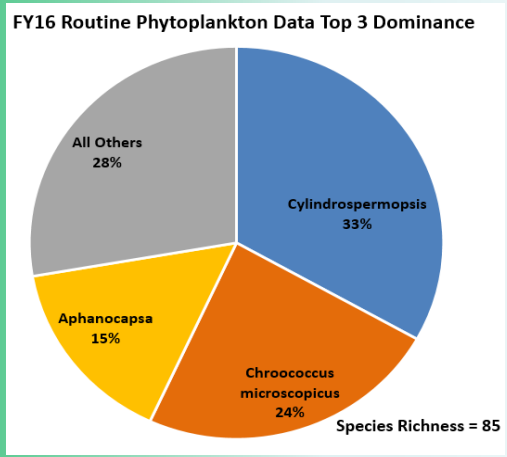

Figure 4. 2016 relative abundance of the entire phytoplankton community at MSR.

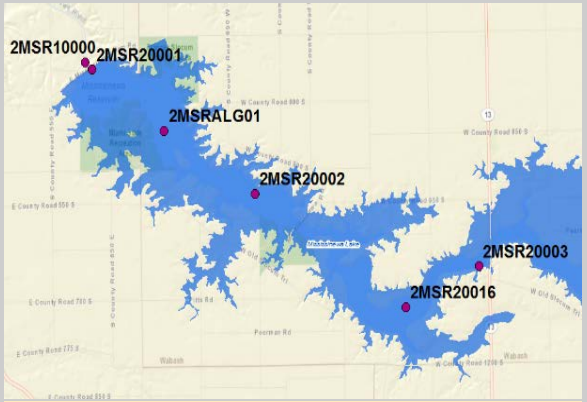

Figure 5. 2016 HAB sampling sites at MSR.

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. The IN Department of Environmental Management (IDEM) samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

MSR has 6 sampling sites and wasn't triggered for HAB response until August of 2016, resulting in only one sample being collected. *Chroococcus microscopicus* was the dominant taxa for the sampling event.

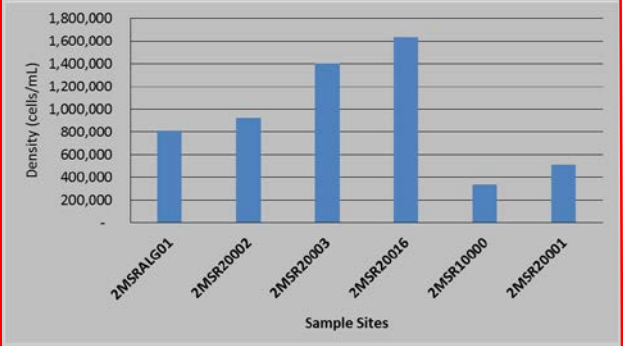

Figure 6. Monthly cyanobacteria cell count data summary from MSR.

Monroe Lake (2016)

Monroe Lake (MNR) is located in Monroe, Brown, Jackson, and Lawrence counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control. The dam site is located at river mile 25.9 of Salt Creek. At summer pool, the surface area of MNR is 10,750 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

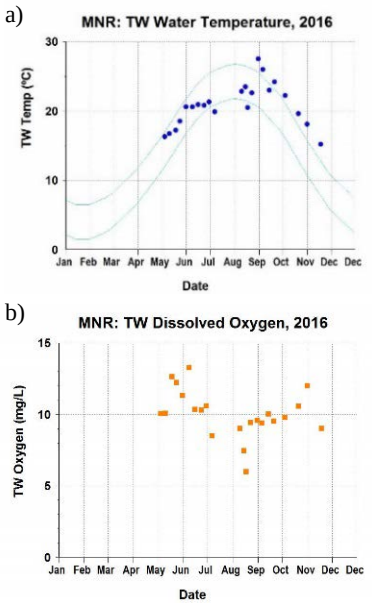

Figure 1. MNR time series data collected from the tailwater (2MNR10000; Figure 3): a) water temperature; and b) dissolved oxygen.

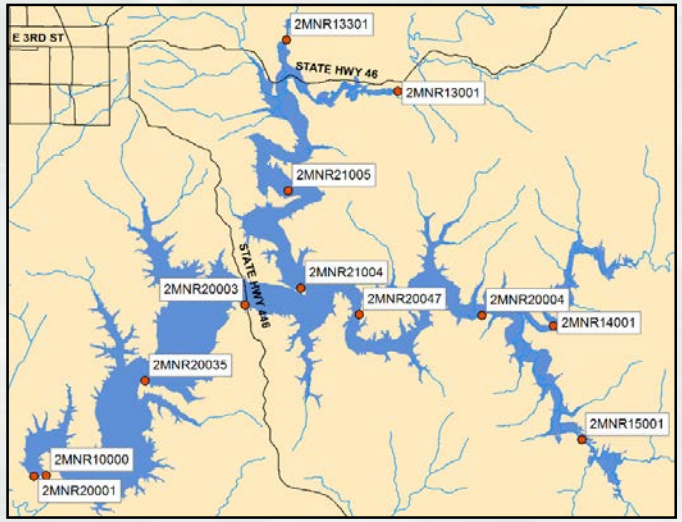

Figure 3. MNR sample sites in 2016 for field and chemical data.

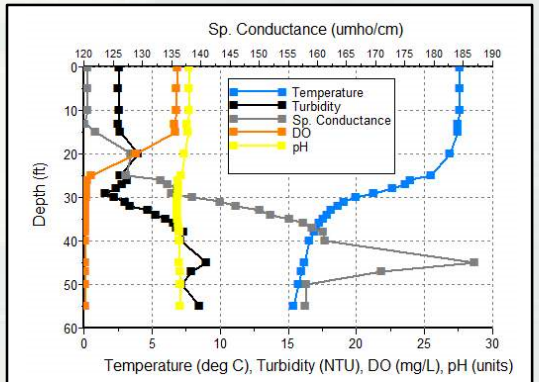

Figure 2. Field data taken at the dam site (2MNR20001; Figure 3) on 8/17/2016 at 07:00.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at MNR in August. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

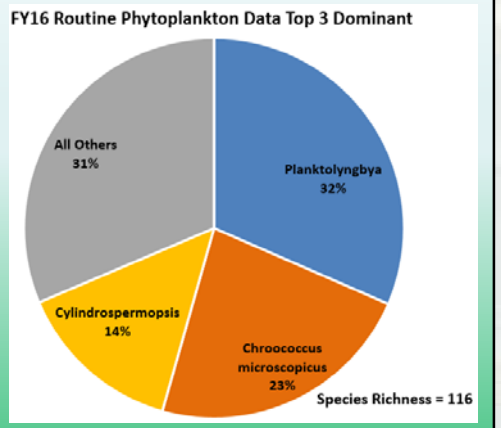

Figure 4. 2016 relative abundance of the entire phytoplankton community at MNR.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at MNR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Planktolyngbya*, a species of cyanobacteria, was the dominant genera found at MNR.**

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. The IN Department of Environmental Management (IDEM) samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

MNR was sampled twice in August 2016, once at the beginning of the month and once at the end. There was an unfortunate mix up in the sampling plans which resulted in the 8/29/2016 samples being collected from some sites on an old sampling plan rather than the current.

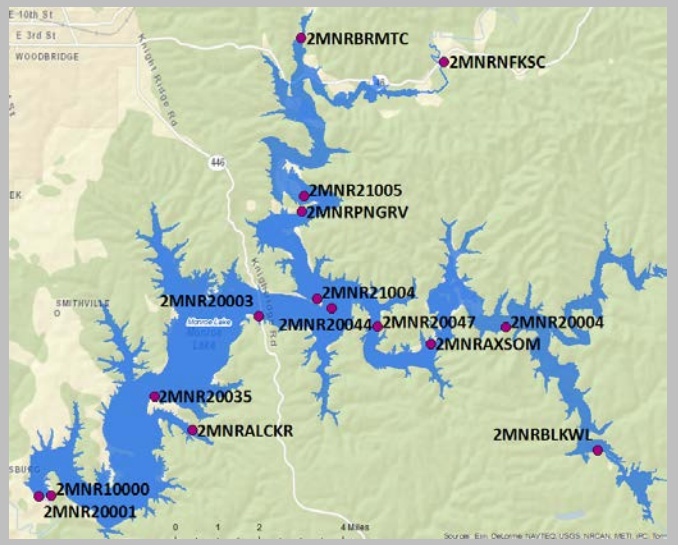

Figure 5. 2016 HAB sampling sites at MNR.

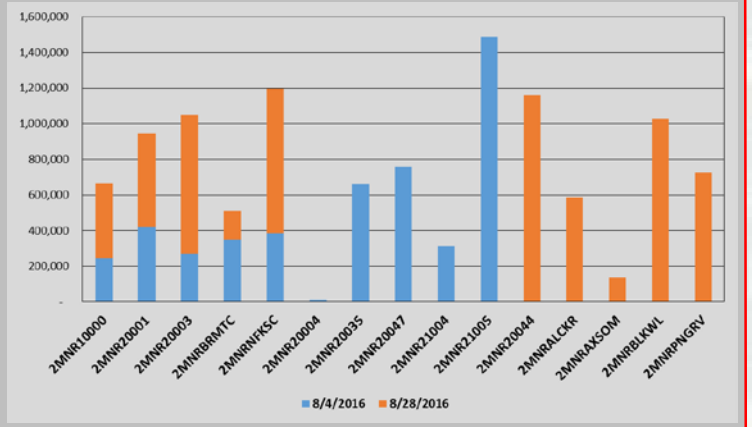

Figure 6. Cyanobacteria cell count data summary from MNR.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IN Department of Environmental Management (IDEM). **No criteria were exceeded in the tailwater (2MNR10000; Figure 3). However, MNR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurement: 131.0 ug/L), total nitrogen (Criteria: 0.69 mg/L; Measurement: 0.79 mg/L), and turbidity (Criteria: 5.7 FTU; Measurement: 6.1 NTU). All exceedances have been reported to IDEM.**

Cecil M. Harden Lake (2016)

Cecil M. Harden Lake (CHL) is located in Parke and Putnam counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in July 1960. The dam site is located at river mile 33 of Big Raccoon Creek. The drainage area above the dam is 216 square miles and, at summer pool, the surface area of CHL is 2,110 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

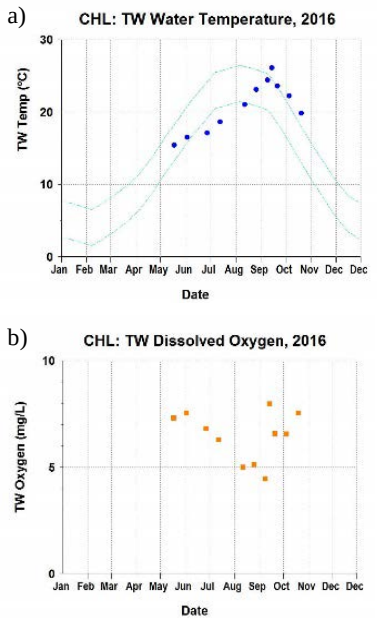

Figure 1. CHL time series data collected from the tailwater (2CHL10000; Figure 2): a) water temperature; and b) dissolved oxygen .

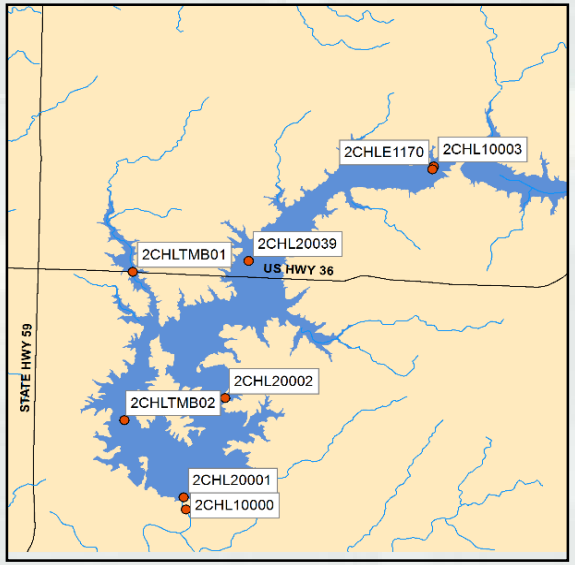

Figure 2. CHL sample sites in 2016 for field and chemical data.

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. IDEM samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

CHL has 9 sampling sites (Figure 5) and sampled June-August of the 2016 recreational season. 2016 sampling events were dominated by different cyanobacteria taxa in each sampling month. Site E1170, in the upper end of the lake, had the peak cell counts in August when cell counts exceeded 2.5 million cells/mL, this same site had the highest cell counts in 2015. Cell counts at sites TMB02 and 20035 peaked in July whereas counts at 20037 and 20002 dipped during this time. Counts at 20039 remained relatively constant throughout the sampling months.

Figure 4. Monthly cyanobacteria cell count data summary from CHL.

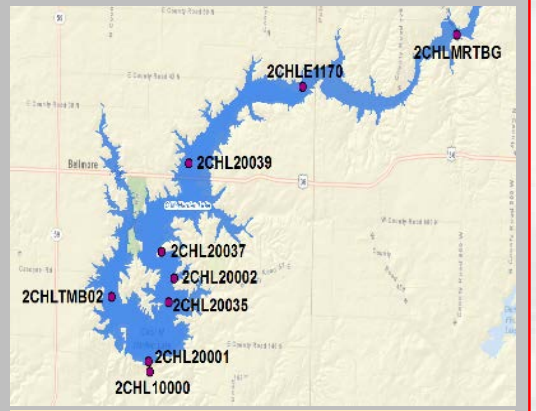

Figure 5. 2016 HAB sampling sites at CHL.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IN Department of Environmental Management (IDEM). **No criteria were exceeded in the tailwater (2CHL10000; Figure 2). However, acute dissolved oxygen was measured as 4.44 mg/L on 9/9/2016 (Acute criteria: 4.0 mg/L; Daily minimum average: 5.0 mg/L). Also, CHL exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurement: 99.0 ug/L) and total nitrogen (Criteria: 0.69 mg/L; Measurement: 1.50 mg/L). All exceedances have been reported to IDEM.**

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at CHL in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 3 illustrates the relative abundance for the entire phytoplankton community at CHL. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the dominant genera found at CHL.**

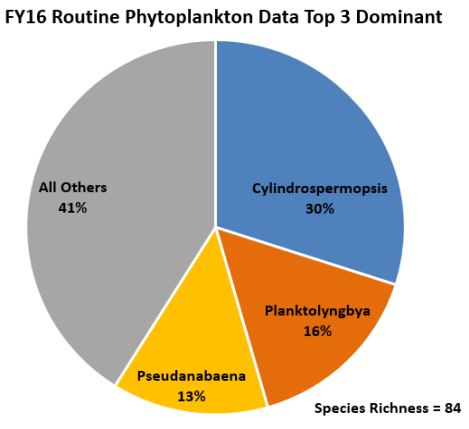

Figure 3. 2016 relative abundance of the entire phytoplankton community at CHL.

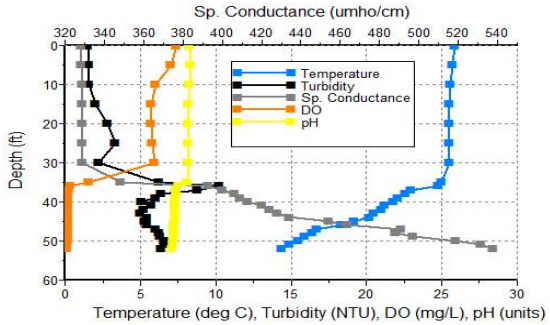

Figure 6. Field data taken at the dam site (2CHL20001; Figure 2) on 9/14/2016 at 12:00.

Cagles Mill Lake (2016)

Cagles Mill Lake (CMR) is located in Putnam and Owen counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in June 1953. The dam site is located at river mile 2.8 of Mill Creek. The drainage area above the dam is 295 square miles and the minimum surface area of CMR is 1,400 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

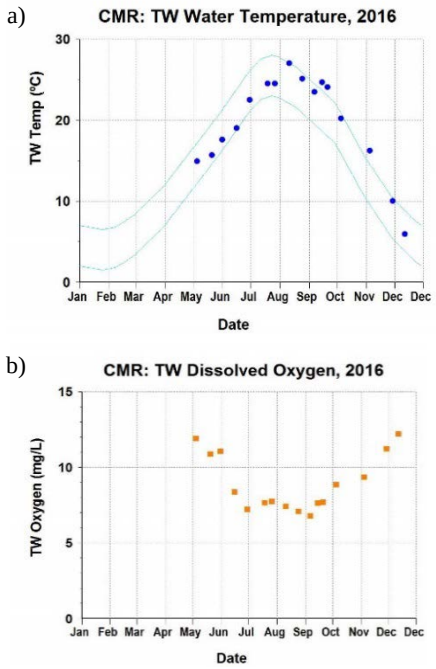

Figure 1. CMR time series data collected from the tailwater (2CMR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

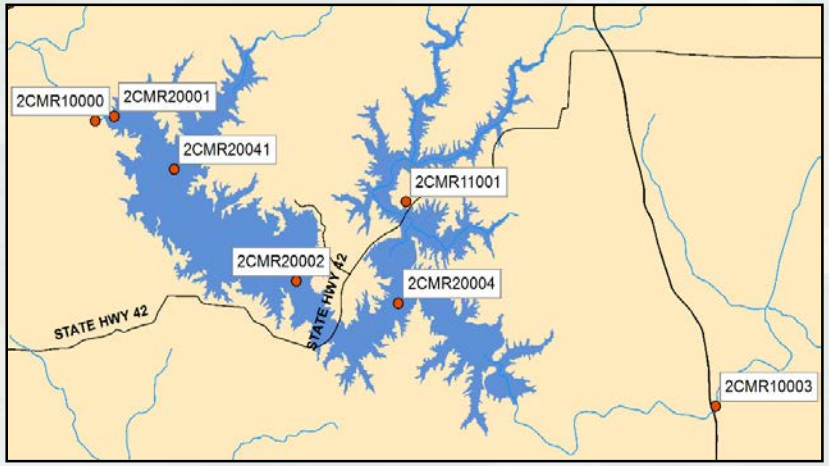

Figure 2. CMR sample sites in 2015 for field and chemical. data

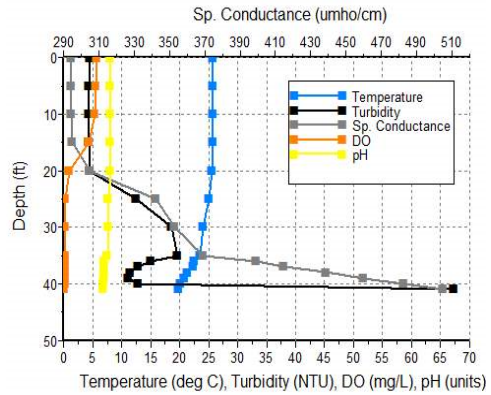

Figure 3. Field data taken at the dam site (2CMR20001; Figure 2) on 9/15/2016 at 10:00.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IDEM. **No criteria were exceeded in the tailwater (2CMR10000; Figure 2). However, CMR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurement: 103.0 ug/L), total nitrogen (Criteria: 0.69 mg/L; Measurement: 4.39 mg/L), and turbidity (Criteria: 5.7 FTU; Measurement: 13.8 NTU). All exceedances have been reported to IDEM.**

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at CMR in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at CMR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the dominant genera found at CMR.** While HABs have not previously been a reported WQ issue at CMR, the results from the phytoplankton sampling indicate that HABs have the potential to become problematic at CMR.

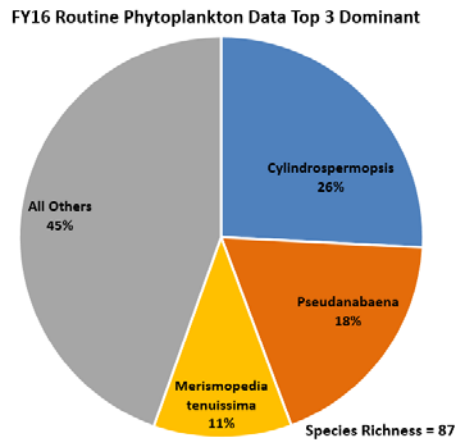

Figure 4. 2016 relative abundance of the entire phytoplankton community at CMR

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. The IN Department of Environmental Management (IDEM) samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

Patoka Lake (2016)

Patoka Lake (PRR) is located in Dubois, Crawford, and Orange counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in February 1978. The dam site is located at river mile 118.3 of the Patoka River. At summer pool, the surface area of PRR is 8,880 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

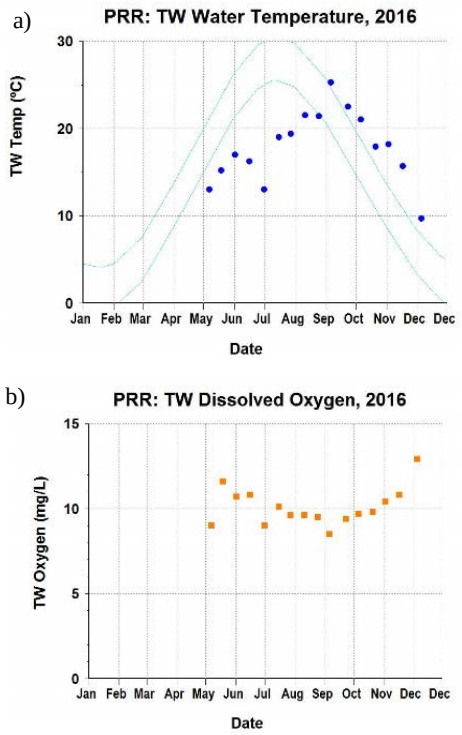

Figure 1. PRR time series data collected from the tailwater (2PRR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

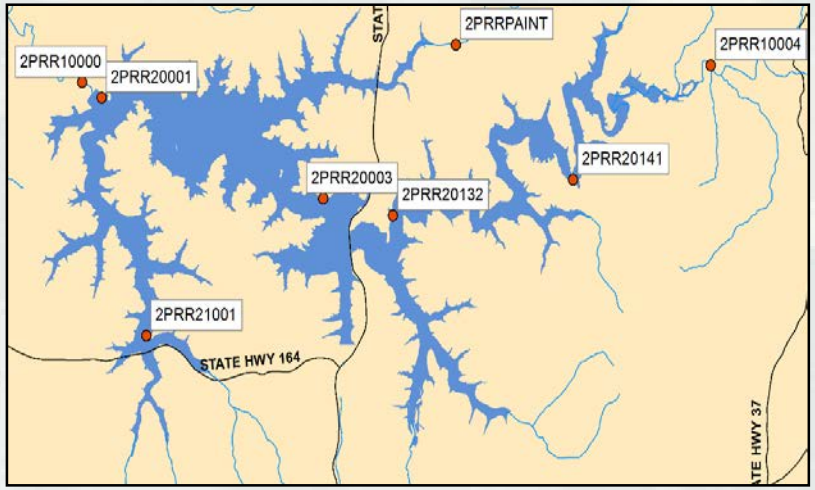

Figure 2. PRR sample sites in 2016 for field and chemical data.

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. The IN Department of Environmental Management (IDEM) samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

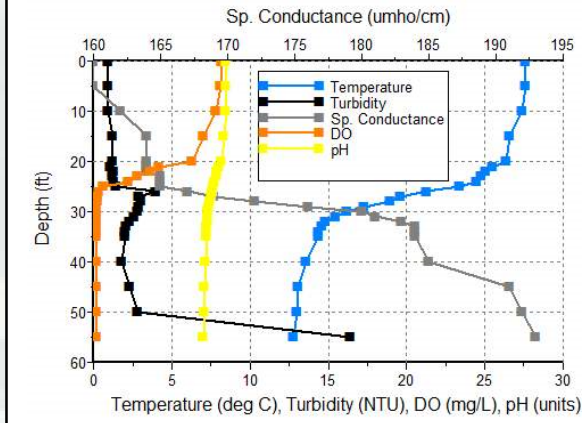

Figure 4. Field data taken at the dam site (2PRR20001; Figure 2) on 9/7/2016 at 08:00.

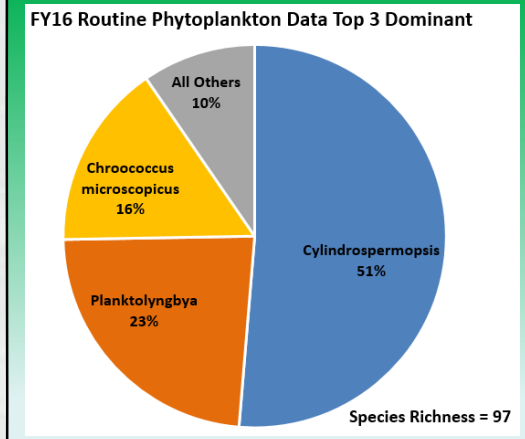

Figure 3. 2016 relative abundance of the entire phytoplankton community at PRR.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at PRR in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 3 illustrates the relative abundance for the entire phytoplankton community at PRR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a species of cyanobacteria, was the dominant species found at PRR.** HABs were not a reported WQ issue at PRR in 2016, however results from the phytoplankton sampling indicate that HABs have the potential to become problematic at PRR.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IN Department of Environmental Management (IDEM). **No criteria were exceeded in the tailwater (2PRR10000; Figure 2). However, PRR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurement: 37.0 ug/L), total nitrogen (Criteria: 0.69 mg/L; Measurement: 0.802 mg/L), and turbidity (Criteria: 5.7 FTU; Measurement: 29.5 NTU). All exceedances have been reported to IDEM.**

Caesar Creek Lake (2016)

Caesar Creek Lake (CCK) is located in Warren, Clinton, and Greene counties in Ohio (OH). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control. The dam site is located at river mile 3 of Caesar Creek. At summer pool, the surface area of CCK is 2,830 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

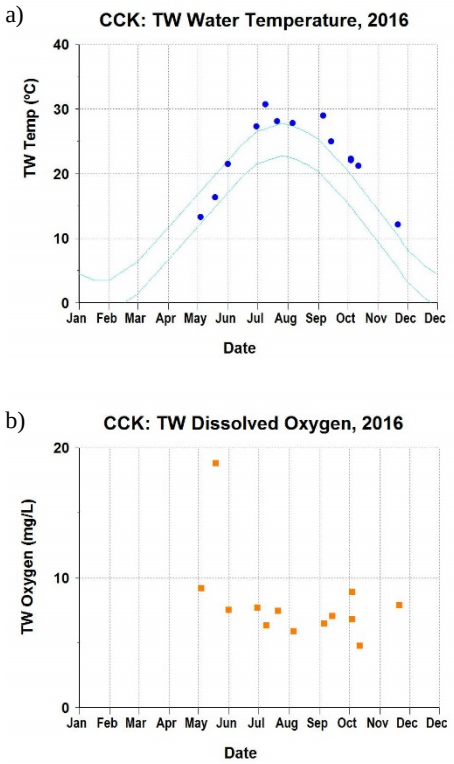

Figure 1. CCK time series data collected from the tailwater (2CCK10000; Figure 2): a) water temperature; and b) dissolved oxygen.

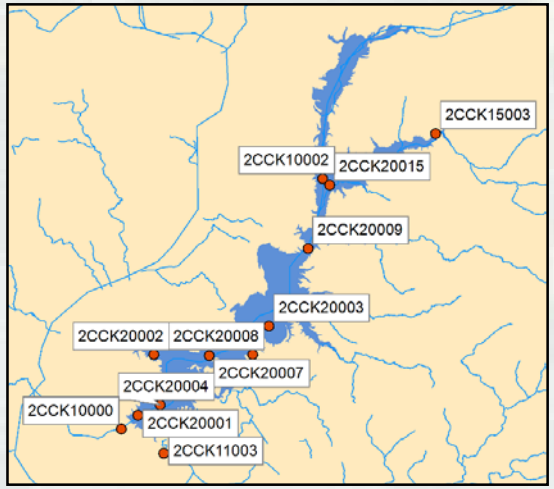

Figure 2. CCK sample sites in 2016 for field and chemical data.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at CCK in October. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at CCK. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the dominant genera found at CCK.**

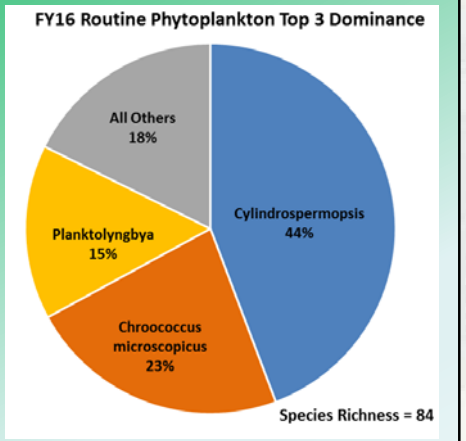

Figure 4. 2016 relative abundance of the entire phytoplankton community at CCK.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the OH Environmental Protection Agency (OHEPA). **The tailwater (2CCK10000; Figure 2) exceeded criteria for temperature (Criteria: 29.4°C for July 1-31; Measurement: 30.7°C on 7/9/2016). All exceedances have been reported to OHEPA.**

Harmful Algal Blooms (HABs) in OH are addressed by the OH Department of Natural Resources (ODNR) as they are the lead agency for HAB response in the state. The ODNR works with the OHEPA and OH Department of Health to sample for cyanobacteria and cyanotoxins at designated swimming beaches and to post any required recreational advisories. LRL supports the state agencies by reporting any visual HAB indicators and by participating in a Sign Posting & Communication Plan to communicate HAB potential to the visiting public.

Figure 3. Caesar Creek Lake (photo by J. Pisarowicz).

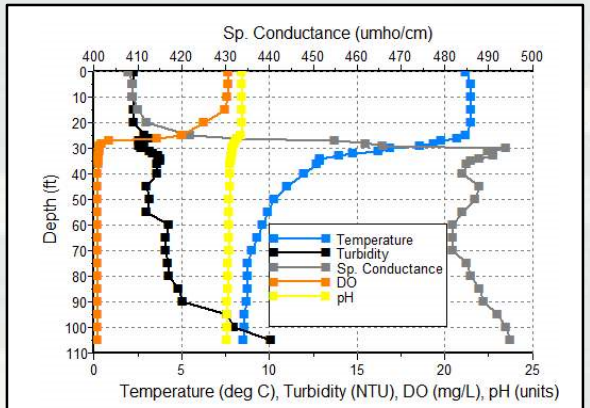

Figure 5. Field data taken at the dam site (2CCK20001; Figure 2) on 10/4/2016 at 08:00.

William H. Harsha Lake (2016)

William H. Harsha Lake (EFR) is located in Clermont County, Ohio (OH). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in May 1978. The drainage area above the dam is 342 square miles and, at summer pool, the surface area of EFR is 2,160 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

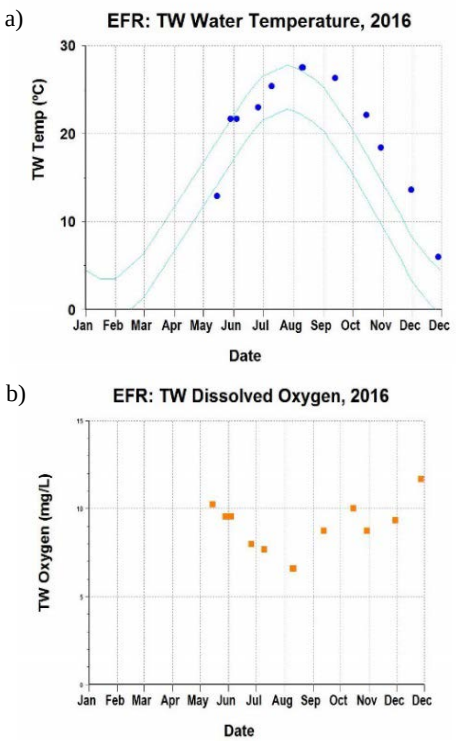

Figure 1. EFR time series data collected from the tailwater (2EFR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the OH Environmental Protection Agency (OHEPA). **No criteria were exceeded in the tailwater (2EFR10000; Figure 2). However, EFR exceeded the USEPA's recommended criteria for turbidity (Criteria: 6.36 FTU; Measurements: 8.06 and 7.5 NTU). All exceedances have been reported to OHEPA.**

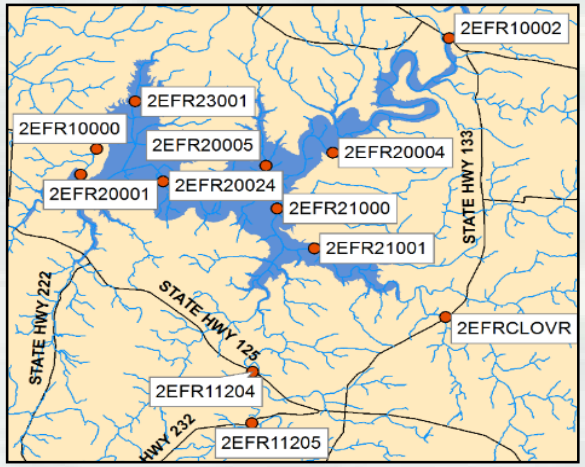

Figure 2. EFR sample sites in 2016 for field and chemical data.

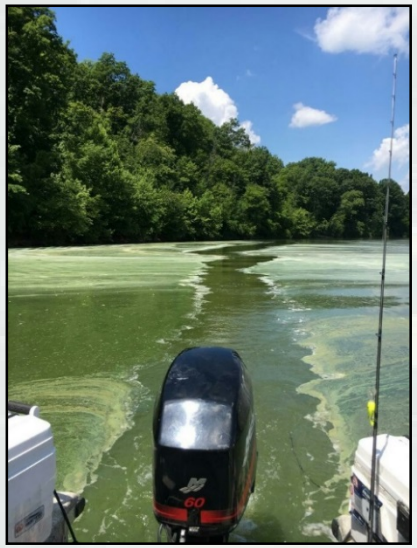

Figure 3. Field sampling at EFR illustrating algal scum on surface.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at EFR in August and September. The distribution and identification of phytoplankton was measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body on each date.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at EFR during each sampling event. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis* was the dominant genera in August and *Chroococcus microscopicus* was the dominant species in September. Both dominant taxa are genera of cyanobacteria.**

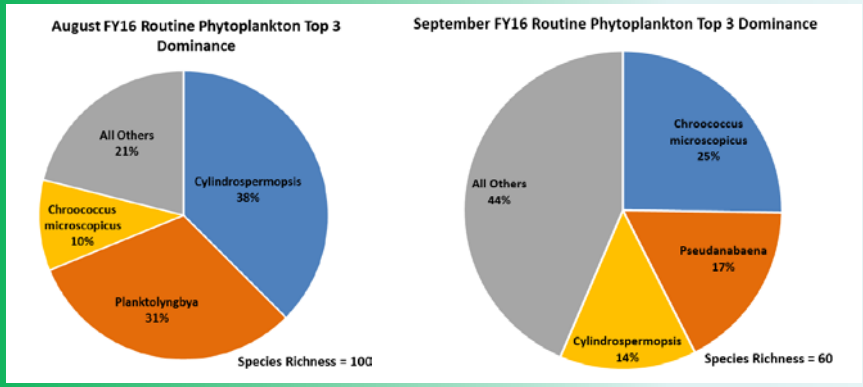

Figure 4. 2016 relative abundance of the entire phytoplankton community at EFR for collections made in August and September.

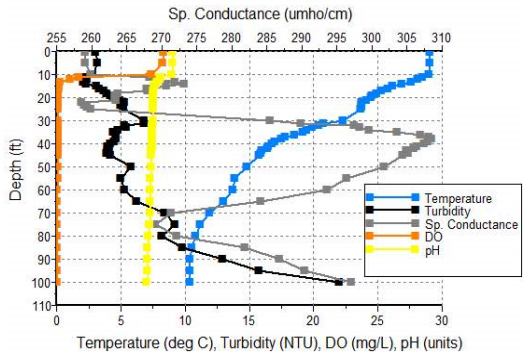

Figure 5. Field data taken at the dam site (2EFR20001; Figure 2) on 8/11/2016 at 09:00.

Harmful Algal Blooms (HABs) in OH are addressed by the OH Department of Natural Resources (ODNR) as they are the lead agency for HAB response in the state. The ODNR works with the OHEPA and OH Department of Health to sample for cyanobacteria and cyanotoxins at designated swimming beaches and to post any required recreational advisories. LRL supports the state agencies by reporting any visual HAB indicators and by participating in a Sign Posting & Communication Plan to communicate HAB potential to the visiting public.

West Fork Lake (2016)

West Fork Lake (WFR) is located in the metropolitan Cincinnati area in Hamilton County, Ohio (OH). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in December 1952. The dam site is located at river mile 6.5 of the west fork of Mill Creek. The drainage area above the dam is 29.5 square miles and, at summer pool, the surface area of WFR is 183 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

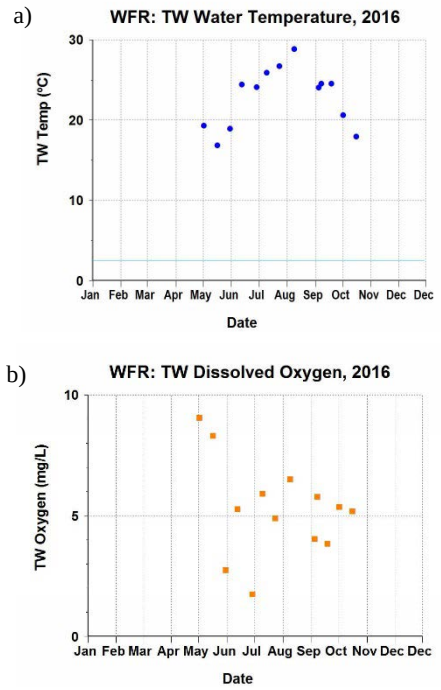

Figure 1. WFR time series data collected from the tailwater (2WFR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

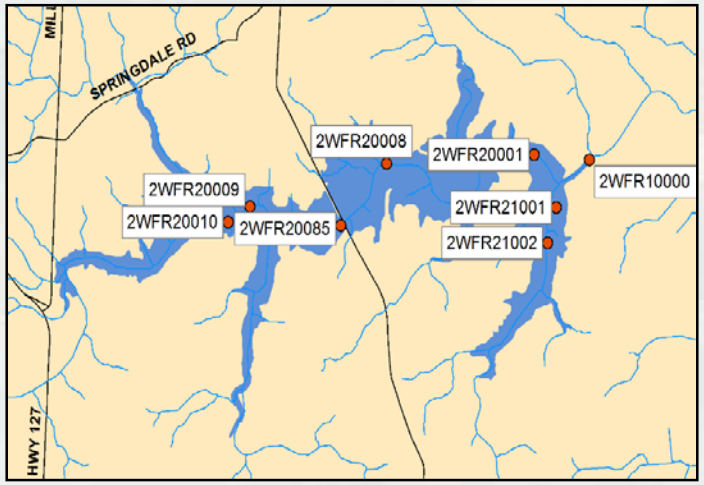

Figure 2. WFR sample sites in 2016 for field and chemical data.

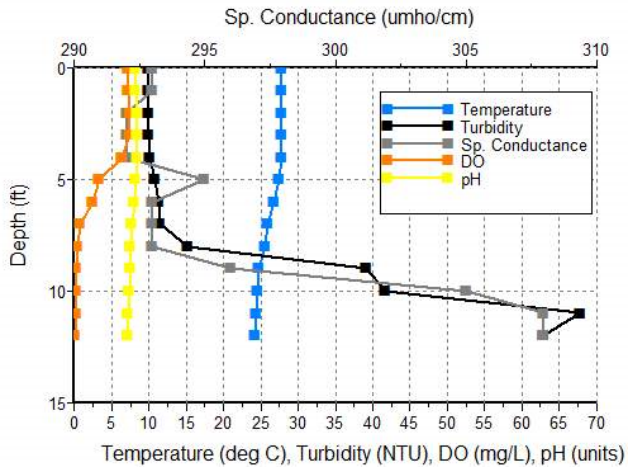

Figure 4. Field data taken at 2WFR20001 (Figure 2) on 9/8/2016 at 10:00.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the OH Environmental Protection Agency (OHEPA). **The tailwater (2WFR10000; Figure 2) exceeded criteria for dissolved oxygen (Acute criteria: 4.0 mg/L; Acute measurements: 2.73, 1.73, and 3.83 mg/L). Also, WFR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 76.25 ug/L; Measurement: 156.0 ug/L) and turbidity (Criteria: 6.36 FTU; Measurement: 13.8 NTU). All exceedances have been reported to OHEPA.**

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at WFR in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 3 illustrates the relative abundance for the entire phytoplankton community at WFR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Chroococcus microscopicus*, a species of cyanobacteria, was the most dominant species found at WFR**.

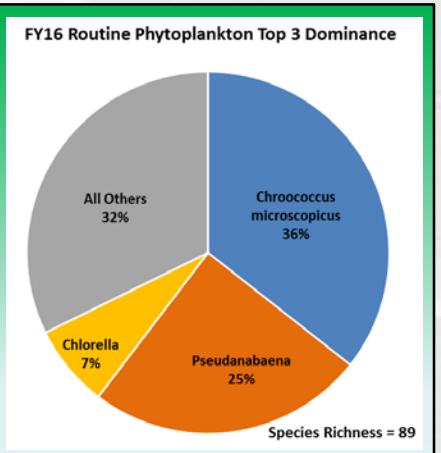

Figure 3. 2016 relative abundance of the entire phytoplankton community at WFR.

Harmful Algal Blooms (HABs) in OH are addressed by the OH Department of Natural Resources (ODNR) as they are the lead agency for HAB response in the state. The ODNR works with the OHEPA and OH Department of Health to sample for cyanobacteria and cyanotoxins at designated swimming beaches and to post any required recreational advisories. LRL supports the state agencies by reporting any visual HAB indicators and by participating in a Sign Posting & Communication Plan to communicate HAB potential to the visiting public.

C.J. Brown Dam & Reservoir (2016)

C.J. Brown Dam & Reservoir (CBR) is located in Clark County, Ohio (OH). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in September 1974. The dam site is located at river mile 7 of Buck Creek. The drainage area above the dam is 83 square miles and, at summer pool, the surface area of CBR is 2,120 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

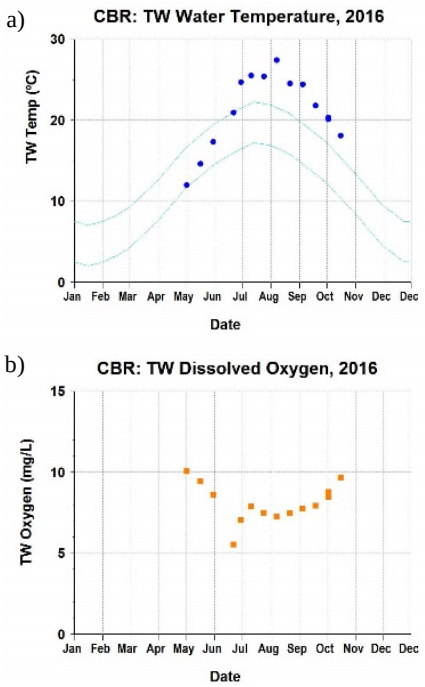

Figure 1. CBR time series data collected from the tailwater (2CBR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the OH Environmental Protection Agency (OHEPA). **No criteria were exceeded in the tailwater (2CBR10000; Figure 2).**

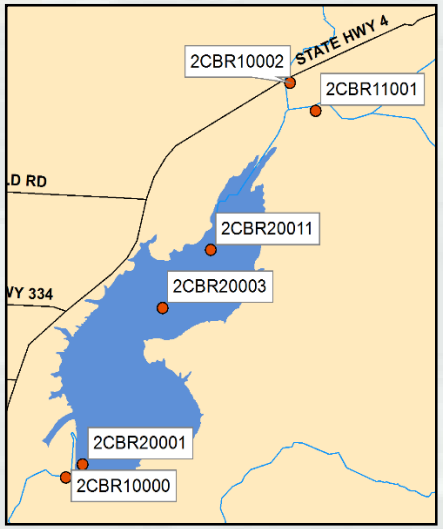

Figure 2. CBR sample sites in 2016 for field and chemical data.

Harmful Algal Blooms (HABs) in OH are addressed by the OH Department of Natural Resources (ODNR) as they are the lead agency for HAB response in the state. The ODNR works with the OHEPA and OH Department of Health to sample for cyanobacteria and cyanotoxins at designated swimming beaches and to post any required recreational advisories. LRL supports the state agencies by reporting any visual HAB indicators and by participating in a Sign Posting & Communication Plan to communicate HAB potential to the visiting public.

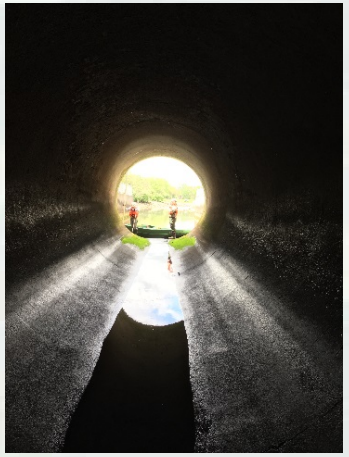

Figure 3. Conduit of the dam at CBR.

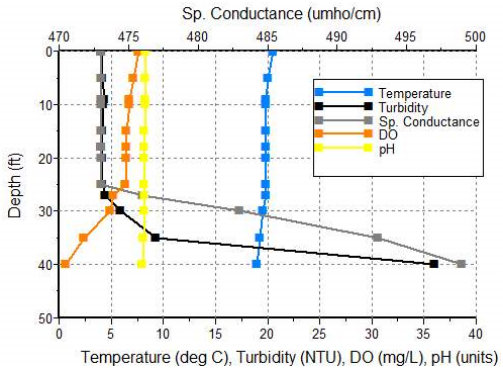

Figure 4. Field data taken at the dam site (2CBR20001; Figure 2) on 10/3/2016 at 11:00.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at CBR in October. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 5 illustrates the relative abundance for the entire phytoplankton community at CBR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Planktolyngbya limnetica*, a species of cyanobacteria, was the dominant species found at CBR**.

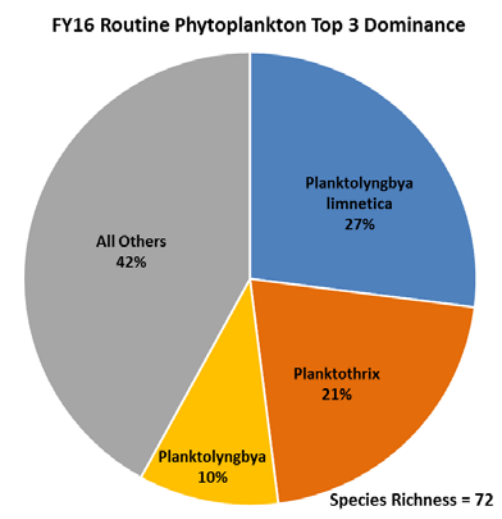

Figure 5. 2016 relative abundance of the entire phytoplankton community at CBR.

Brookville Lake (2016)

Brookville Lake (BVR) is located in Franklin and Union counties in Indiana (IN). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) for the primary purpose of flood control and became operational in 1974. The drainage area above the dam is 379 square miles and, at summer pool, the surface area of BVR is 5,260 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

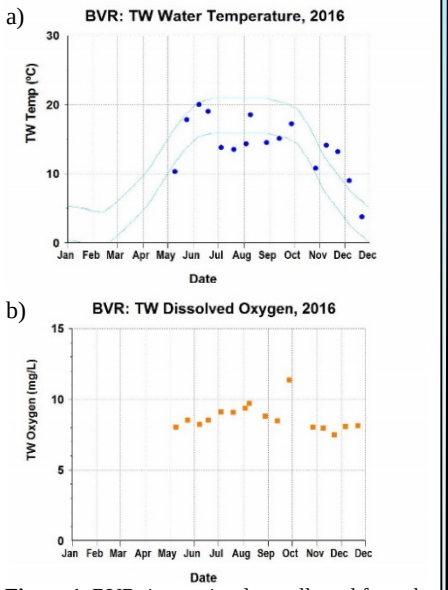

Figure 1. BVR time series data collected from the tailwater (2BVR10000; Figure 4) a) water temperature; and b) dissolved oxygen.

Figure 3. Banded Darter (*Etheostoma zonale*, above) and Rainbow Darter (*Etheostoma caeruleum*, below) captured at inflow tributaries to BVR.

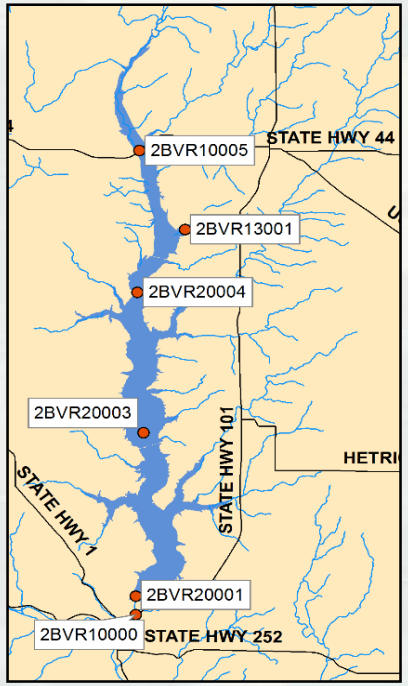

Figure 4. BVR sample sites in 2016 for field and chemical data.

Harmful Algal Blooms (HABs) in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. IDEM samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.

BVR has 6 sample sites (Figure 7) and collected samples every month of the 2016 recreational season. In 2016 the dominant cyanobacteria species across all sampling events was *Chroococcus microscopicus*. The highest cell count measured in 2016 was over 1.9 million cells/mL at site 2BVR20016. In the last samples collected in 2016 three sites had cell counts exceeding 1.5 million cells/mL.

Figure 6. Monthly cyanobacteria cell count data summary from BVR.

Figure 7. 2016 HAB sampling sites at BVR

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the IN Department of Environmental Management (IDEM). **No criteria were exceeded in the tailwater (2BVR10000; Figure 4).**

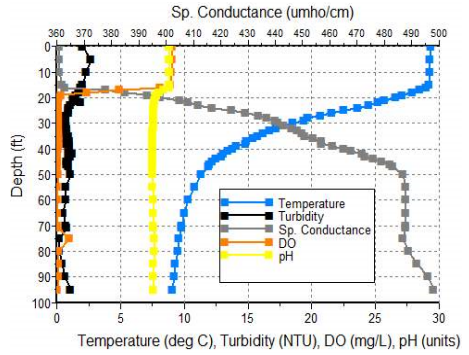

Figure 2. Field data taken at the dam site (2BVR20001; Figure 4) on 8/9/2016 at 10:00.

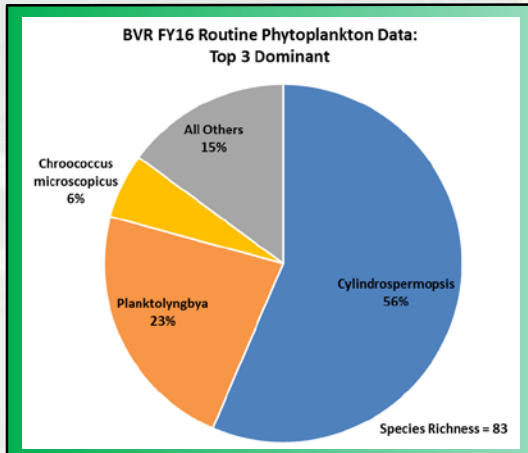

Figure 5. 2016 relative abundance of the entire phytoplankton community at BVR.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at BVR in August. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 5 illustrates the relative abundance for the entire phytoplankton community at BVR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the most dominant genera found at BVR.**

Buckhorn Lake (2016)

Buckhorn Lake (BHR) is located in Leslie and Perry counties in Kentucky (KY). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) at river mile 43 of the Middle Fork of the Kentucky River. The primary purpose of the lake is flood control and secondarily provides water supply. At summer pool, the surface area of BHR is 1,230 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

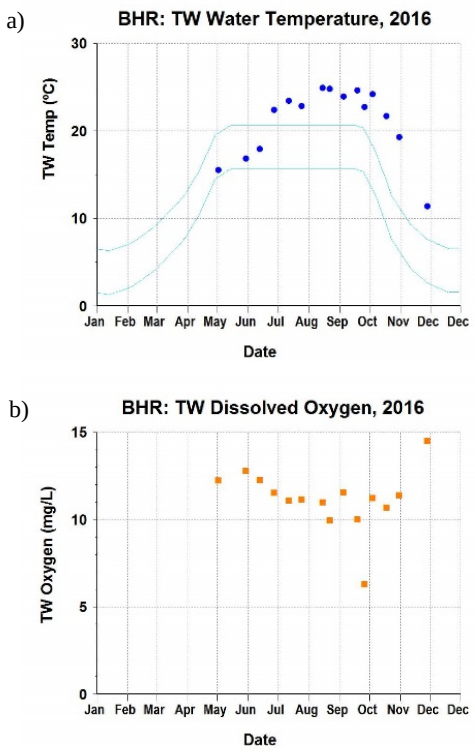

Figure 1. BHR time series data collected from the tailwater (2BHR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

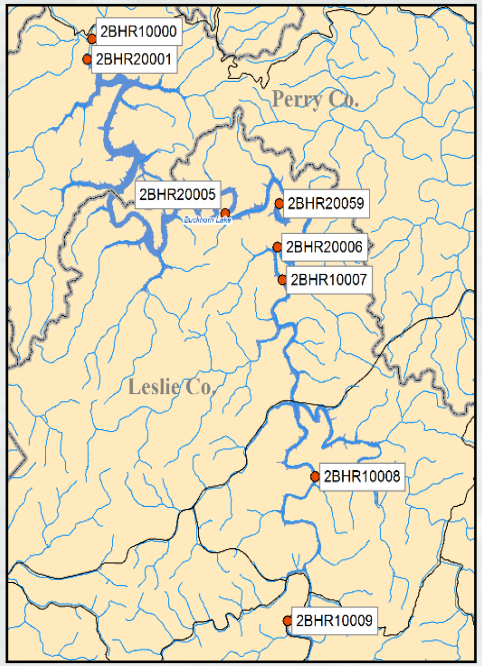

Figure 2. BHR sample sites in 2016 for field and chemical data.

Figure 3. Buckhorn Lake dam.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2BHR10000; Figure 2). However, BHR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 10.0 ug/L; Measurement: 17.0 ug/L), total nitrogen (Criteria: 0.31 mg/L; Measurement: 0.36 mg/L), and turbidity (Criteria: 2.3 NTU; Measurement: 2.3 NTU). All exceedances have been reported to KDOW.**

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at BHR in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at BHR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Chroococcus microscopicus*, a species of cyanobacteria was the most dominant species found at BHR.** While HABs have not previously been a reported WQ issue at BHR, the results from the phytoplankton sampling indicate that HABs have the potential to become problematic at BHR.

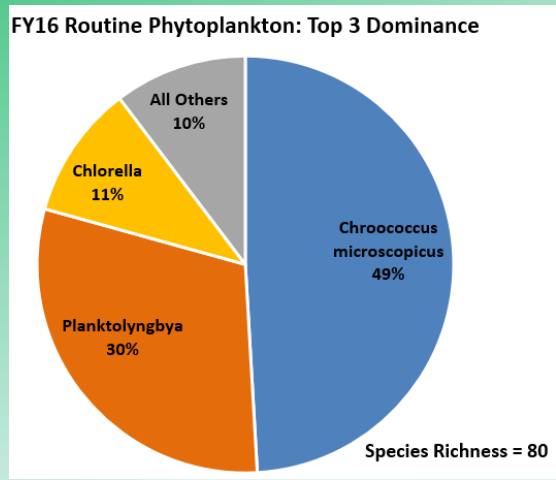

Figure 4. 2016 relative abundance of the entire phytoplankton community at BHR.

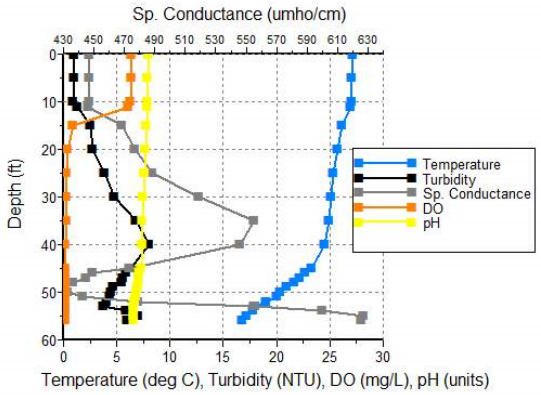

Figure 5. Field data taken at the dam site (2BHR20001; Figure 2) on 9/26/2016 at 13:00.

Harmful Algal Blooms (HABs) in KY are addressed by the KDOW as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

Carr Creek Lake (2016)

Carr Creek Lake (CFK) is located in Knott County, Kentucky (KY). The dam was built and is operated by the Louisville District of the US Army Corps of Engineers (LRL). The primary purpose of the lake is flood control and secondarily water supply. The dam site is located at river mile 8.8 of Carr Fork and the surface area of CFK is 710 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

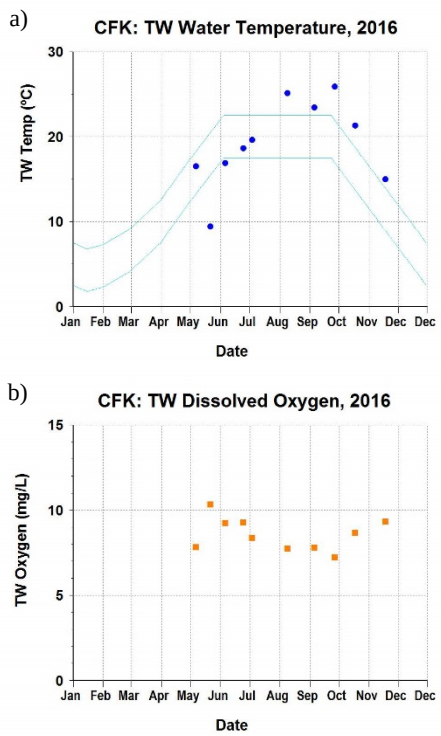

Figure 1. CFK time series data collected from the tailwater (2CFK10000; Figure 2) a) water temperature; and b) dissolved oxygen.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2CFK10000; Figure 2). However, CFK exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 10.0 ug/L; Measurement: 28.0 ug/L), total nitrogen (Criteria: 0.31 mg/L; Measurement: 2.81 mg/L), and turbidity (Criteria: 2.3 NTU; Measurement: 7.86 NTU). All exceedances have been reported to KDOW.**

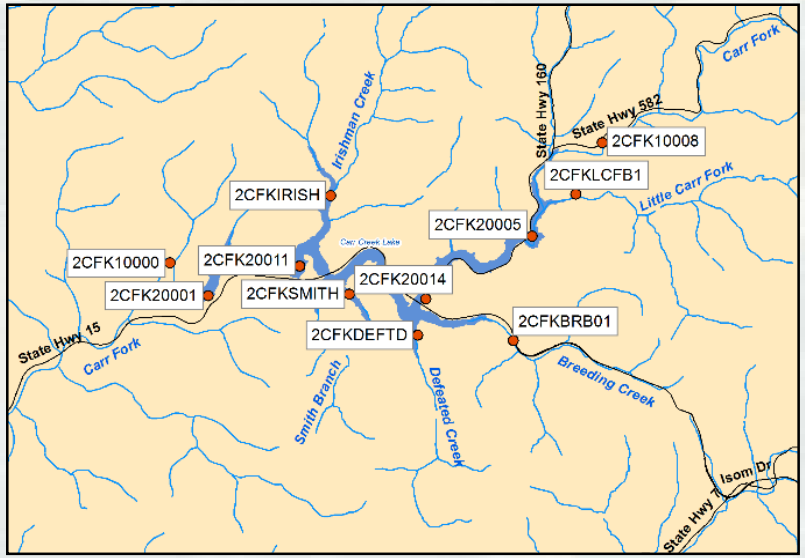

Figure 2. CFK sample sites in 2016 for field and chemical data.

Harmful Algal Blooms (HABs) in KY are addressed by the KDOW as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

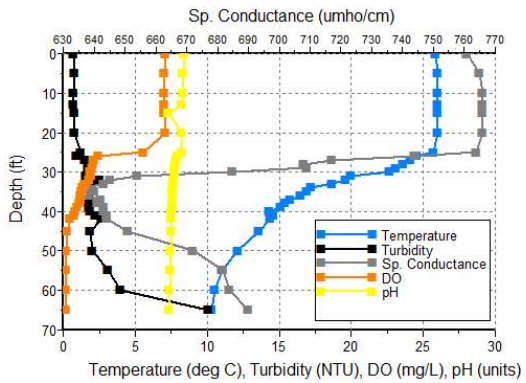

Figure 3. Field data taken at the dam site (2CFK20001; Figure 2) on 9/27/2016 at 10:00.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at CFK in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at CFK. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Chroococcus microscopicus*, a species of cyanobacteria, was the dominant species found at CFK**. While HABs have not previously been a reported WQ issue at CFK, the results from the phytoplankton sampling indicate that HABs have the potential to become problematic at CFK.

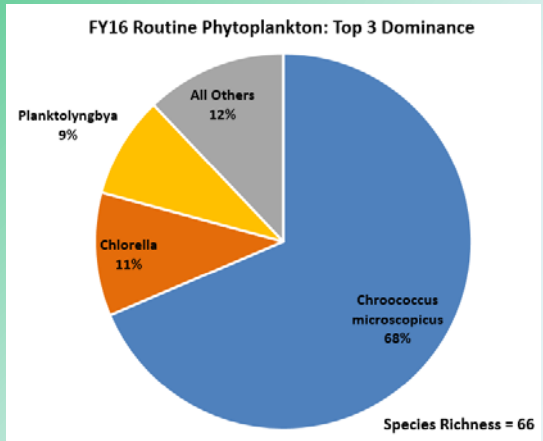

Figure 4. 2016 relative abundance of the entire phytoplankton community at CFK.

Figure 5. Carr Creek Lake dam.

Cave Run Lake (2016)

Cave Run Lake (CRR) is located in Bath, Rowan, Morgan, and Menifee counties, Kentucky (KY). The dam was built by the Louisville District of the US Army Corps of Engineers (LRL) and began operation in February 1974. The primary purpose of the lake is flood control and secondarily water supply. The dam site is located at river mile 173.6 of the Licking River and, at summer pool, the surface area of CRR is 8,270 acres. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

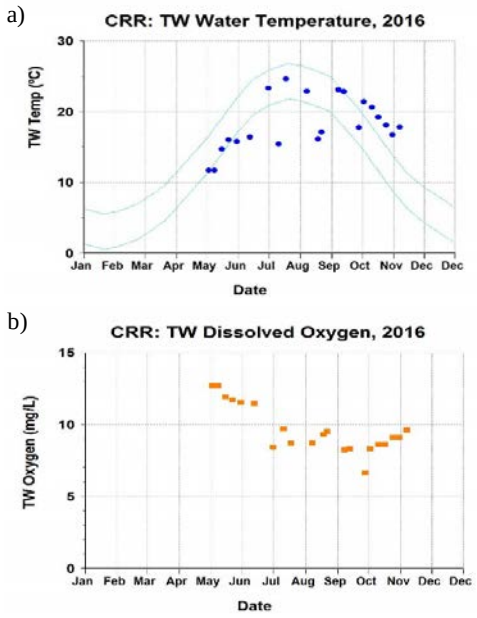

Figure 1. CRR time series data collected from the tailwater (2CRR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

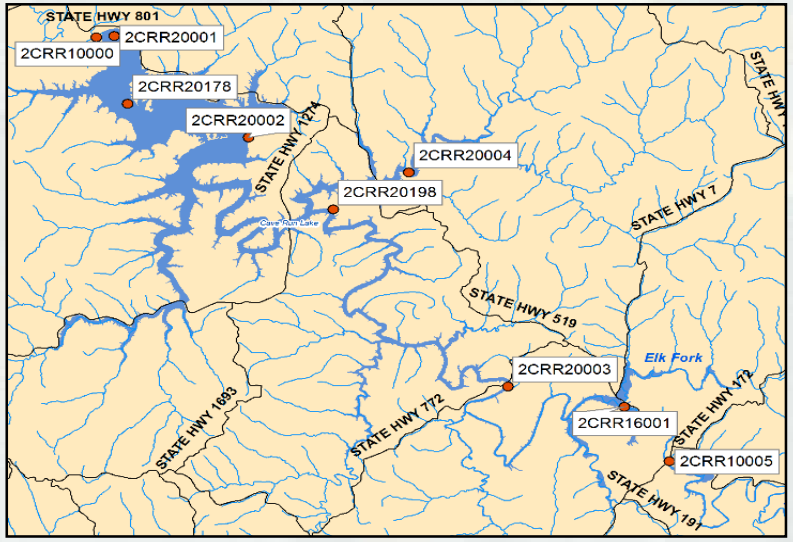

Figure 2. CRR sample sites in 2016 for field and chemical data.

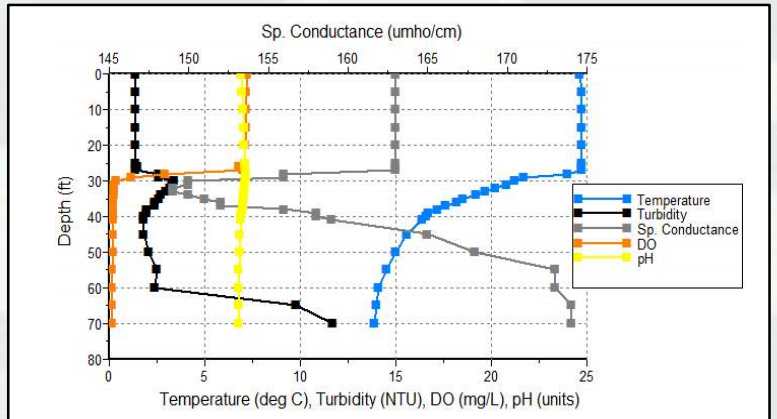

Figure 3. Field data taken at the dam site (2CRR20001; Figure 2) on 9/29/2016 at 09:00.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at CRR in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 4 illustrates the relative abundance for the entire phytoplankton community at CRR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Planktolyngbya*, a genera of cyanobacteria, was the dominant genera found at CRR.** While HABs have not previously been a reported WQ issue at CRR, the results from the phytoplankton sampling indicate that HABs have the potential to become problematic at CRR.

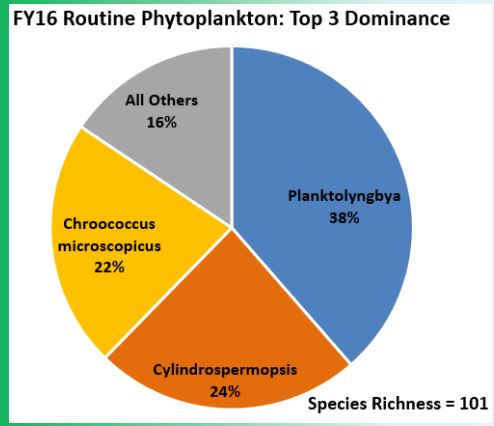

Figure 4. 2016 relative abundance of the entire phytoplankton community at CRR.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2CRR10000; Figure 2). However, CRR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 10.0 ug/L; Measurement: 26.0 ug/L), total nitrogen (Criteria: 0.31 mg/L; Measurement: 0.78 mg/L), and turbidity (Criteria: 2.3 NTU; Measurement: 40.9 NTU). All exceedances have been reported to KDOW.**

Harmful Algal Blooms (HABs) in KY are addressed by the KY Division of Water (KDOW) as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

Taylorsville Lake (2016)

Taylorsville Lake (TAR) is located in Spencer, Nelson, and Anderson counties in Kentucky (KY). The dam is located at river mile 60 of the Salt River and was placed in operation in January 1983 by the Louisville District of the US Army Corps of Engineers (LRL). The primary purpose of the lake is flood control. The drainage area above the dam is 352 square miles. At summer pool, surface area is 3,050 acres and the length of the lake is 18 miles. Note: The term "lake" is substituted for the technically correct "reservoir" throughout this document for consistency.

Temperature and dissolved oxygen (DO) profile data are regularly collected from LRL lakes. This data informs water control engineers on how to best use existing selective withdrawal capabilities to meet downstream water quality (WQ) targets established by each lake's Water Control Plan (WCP). Additionally, temperature and DO data collected from the tailwaters of LRL lakes are used to assess the success of the WCP and to satisfy LRL's requirement to comply with WQ standards as required by the Federal Water Pollution Control Act and Executive Order 12088. Figure 1a shows a time series graph of the 2016 tailwater water temperature compared with the guide curve from the lake's WCP. Figure 1b shows a 2016 time series graph of the lake's tailwater dissolved oxygen data.

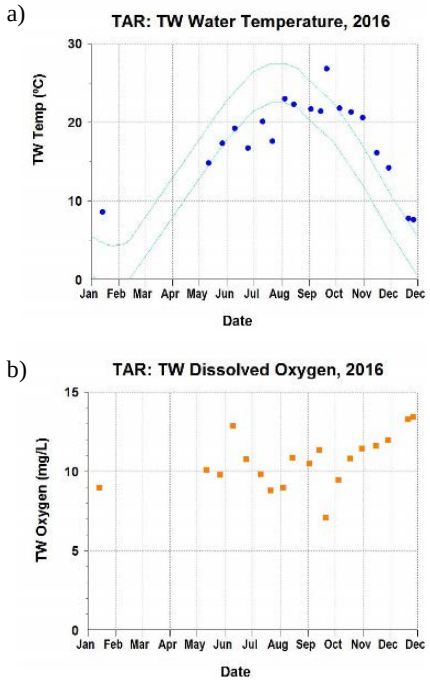

Figure 1. TAR time series data collected from the tailwater (2TAR10000; Figure 2): a) water temperature; and b) dissolved oxygen.

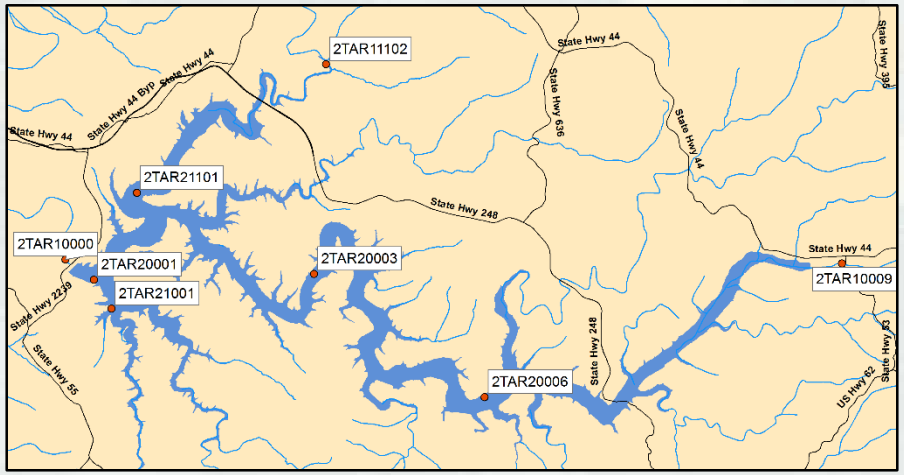

Figure 2. TAR sample sites in 2016 for field and chemical data.

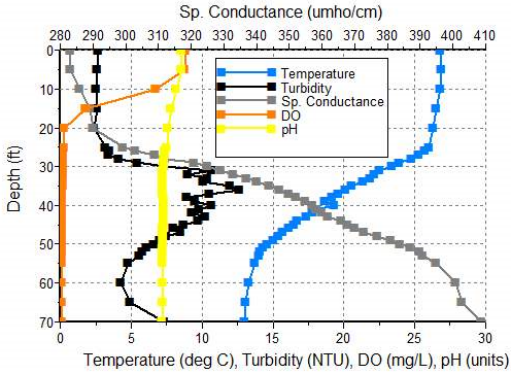

Figure 4. Field data taken at the dam site (2TAR20001; Figure 2) on 9/22/2016 at 09:00.

Phytoplankton (Algae) and green plants are the base of the food chain in aquatic food webs and convert nutrients and CO2 through photosynthesis into biomass for all aquatic life. The LRL WQ Program sampled the phytoplankton community at TAR in September. The distribution and identification of phytoplankton is measured throughout the water column at depths of 0,5,10, and 20 feet at multiple locations across the lake body.

Figure 3 illustrates the relative abundance for the entire phytoplankton community at TAR. The relative abundance percentage was calculated using the density of phytoplankton species from all sample sites, at all depths. ***Cylindrospermopsis*, a genera of cyanobacteria, was the most dominant genera found at TAR.**

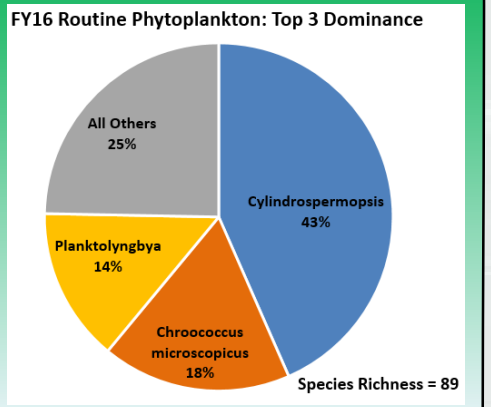

Figure 3. 2016 relative abundance of the entire phytoplankton community at TAR.

Figure 5. The Water Quality Team samples a TAR inflow for macroinvertebrates.

WQ in the Tailwater is assessed by analyzing exceedances of WQ criteria established by the KY Division of Water (KDOW). **No criteria were exceeded in the tailwater (2TAR10000; Figure 2). However, TAR exceeded the USEPA's recommended criteria for total phosphorus (Criteria: 36.56 ug/L; Measurement: 301.0 ug/L), total nitrogen (Criteria: 0.69 mg/L; Measurement: 2.53 mg/L), and turbidity (Criteria: 5.7 FTU; Measurement: 11.0 NTU). All exceedances have been reported to KDOW.**

Harmful Algal Blooms (HABs) in KY are addressed by the KDOW as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.

Barren River Lake
2016 Macroinvertebrate Study

Figure 1. Caney Fork (2BRRCANCK).

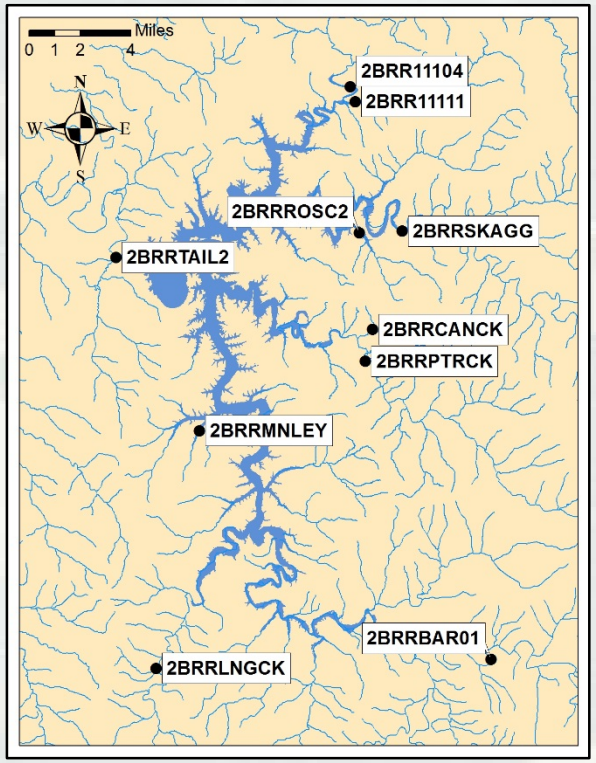

Figure 2. Map of site locations at Barren River Lake.

Background

One of the most comprehensive methods for assessing water quality conditions is evaluating the benthic macroinvertebrate community (i.e., bottom-dwelling animals that lack a backbone). The KY Division of Water (KDOW) evaluates streams by using the Macroinvertebrate Bioassessment Index (MBI) developed specifically for KY streams. The MBI calculates a score (0-100) that is used to assign a rating based on the size and location of the stream. MBI ratings, in order of decreasing stream health, are: Excellent, Good, Fair, Poor, and Very Poor.

Methods

Nine of the primary inflows and the tailwater of Barren River Lake were sampled in the spring and summer of 2016 following KDOW methods (Figure 2). This included the collection of benthic macroinvertebrates using a semi-quantitative riffle kick sample and a qualitative multi-habitat sample. Habitat was assessed and assigned ratings (Good, Fair, and Poor) using KDOW methods. Some of the metrics used in calculating MBI include: taxa richness – the number of taxa (i.e., types of organism); and EPT richness – the number of taxa from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which are sensitive to poor water quality. In general, low values of taxa richness and EPT richness are associated with poor stream health.

Results

Table 1 and Figure 3 show that all of the MBI ratings were either Fair (60%) or Poor (40%), with the tailwater being Poor. The majority of the habitat ratings were Poor (50%) with the remaining split between Fair (30%) and Good (20%). Taxa richness ranged from 21 to 35 taxa and EPT richness ranged from 2 to 15 taxa.

Conclusions

Although no sites had a MBI rating of Very Poor, the high proportion of Poor sites indicate several streams (including the tailwater) suffer impacts from human disturbance. The high proportion of Poor habitat ratings supports this, although other water quality issues could impact sites with Poor MBI ratings and Good-to-Fair habitat ratings. The moderate-to-low values taxa richness and EPT richness also suggest a lack of good stream health. Fair MBI ratings do not indicate severe impacts, however the lack of Good and Excellent MBI ratings can be concerning for the water quality of the watershed as a whole. The Poor MBI rating of the tailwater may indicate the need to review dam operational strategies that best mitigate impacts to the river.

It is important to note that the MBI is not calibrated to assess streams with a drainage area greater than 200 mi^2; therefore, the results of the tailwater (962 mi^2) should be interpreted with caution. However, KDOW advised the Water Quality Team to utilize the MBI due to the absence of a large river calibration.

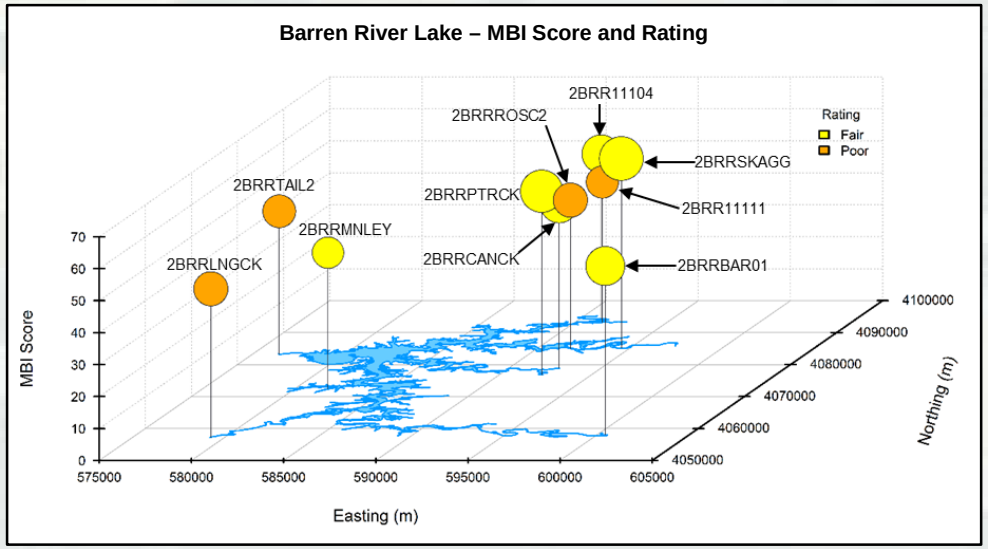

Figure 3. Lollipop chart of MBI scores and ratings. Lollipop height and circle size corresponds to MBI score. Circle color corresponds to MBI rating.

Location	Stream	MBI Score	MBI Rating	Habitat Rating	Taxa Richness	EPT Richness
2BRR11104	Beaver Creek	51.65	Fair	Fair	24	5
2BRR11111	South Fork Beaver Creek	43.77	Poor	Poor	24	5
2BRRBAR01	Barren River	52.82	Fair	Fair	27	6
2BRRCANCK	Caney Fork	51.37	Fair	Poor	28	7
2BRRLNGCK	Long Creek	46.42	Poor	Poor	35	11
2BRRMNLEY	Manley Branch	42.68	Fair	Good	33	15
2BRRPTRCK	Peter Creek	57.40	Fair	Poor	35	9
2BRRROSC2	Rose Creek	46.44	Poor	Good	32	6
2BRRSKAGG	Skaggs Creek	59.31	Fair	Fair	33	10
2BRRTAIL2	Barren River (tailwater)	44.70	Poor	Poor	21	2

Table 1. Results of MBI scores, ratings, metrics, and habitat ratings.

Green River Lake
2016 Macroinvertebrate Study

Figure 1. Butler Creek (2GRRBUTCK).

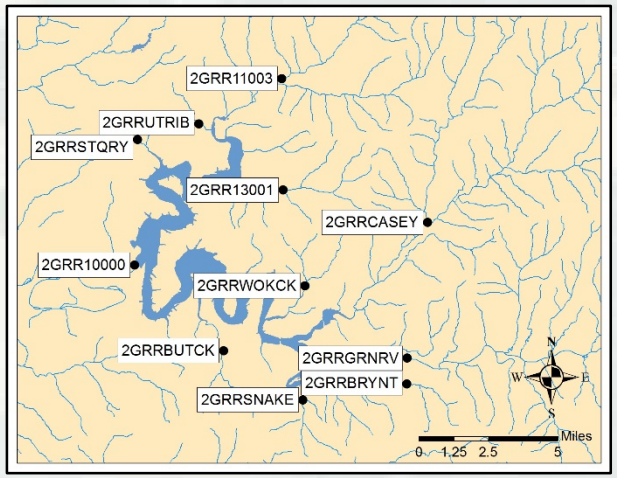

Figure 2. Map of site locations at Green River Lake.

Background

One of the most comprehensive methods for assessing water quality conditions is evaluating the benthic macroinvertebrate community (i.e., bottom-dwelling animals that lack a backbone). The KY Division of Water (KDOW) evaluates streams by using the Macroinvertebrate Bioassessment Index (MBI) developed specifically for KY streams. The MBI calculates a score (0-100) that is used to assign a rating based on the size and location of the stream. MBI ratings, in order of decreasing stream health, are: Excellent, Good, Fair, Poor, and Very Poor.

Methods

Ten of the primary inflows and the tailwater of Green River Lake were sampled in the spring and summer of 2016 following KDOW methods (Figure 2). This included the collection of benthic macroinvertebrates using a semi-quantitative riffle kick sample and a qualitative multi-habitat sample. Habitat was assessed and assigned ratings (Good, Fair, and Poor) using KDOW methods. Some of the metrics used in calculating MBI include: taxa richness – the number of taxa (i.e., types of organism); and EPT richness – the number of taxa from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which are sensitive to poor water quality. In general, low values of taxa richness and EPT richness are associated with poor stream health.

Results

Table 1 and Figure 3 show that all of the MBI ratings were Fair, with the exception of Butler Creek and the tailwater (both Poor). The majority of habitat ratings were Poor (55%) with the remaining split between Fair (27%) and Good (18%). Taxa richness ranged from 18 to 41 taxa and EPT richness ranged from 2 to 18 taxa.

Conclusions

The high proportion of Fair MBI ratings suggest the watershed has some level of impact but still has fair stream health, with the exception of Butler Creek and the tailwater. These two sites likely suffer more severe impacts from physical human disturbance, as they also had Poor habitat ratings. The moderate-to-low values taxa richness and EPT richness also suggest a lack of good stream health. Fair MBI ratings do not indicate severe impacts, however the lack of Good and Excellent MBI ratings can be concerning for the water quality of the watershed as a whole. The Poor MBI rating of the tailwater may indicate the need to review dam operational strategies that best mitigate impacts to the river.

It is important to note that the MBI is not calibrated to assess streams with a drainage area greater than 200 mi^2; therefore, the results of the tailwater (682 mi^2) and 2GRRGRNRV (404 mi^2) should be interpreted with caution. However, KDOW advised the Water Quality Team to utilize the MBI due to the absence of a large river calibration.

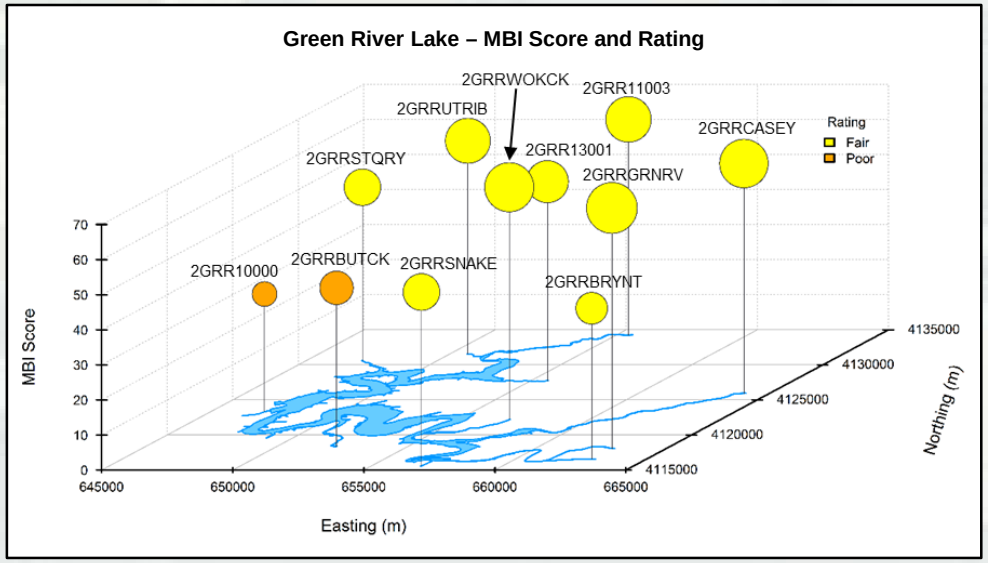

Figure 3. Lollipop chart of MBI scores and ratings. Lollipop height and circle size corresponds to MBI score. Circle color corresponds to MBI rating.

Location	Stream	MBI Score	MBI Rating	Habitat Rating	Taxa Richness	EPT Richness
2GRR10000	Green River (tailwater)	33.59	Poor	Poor	18	2
2GRR11003	Robinson Creek	61.55	Fair	Poor	33	11
2GRR13001	Wilson Creek	56.70	Fair	Poor	29	10
2GRRBRYNT	Bryant Creek	42.98	Fair	Fair	38	15
2GRRBUTCK	Butler Creek	45.17	Poor	Poor	37	9
2GRRCASEY	Casey Creek	65.45	Fair	Fair	27	9
2GRRGRNRV	Green River	68.58	Fair	Poor	35	16
2GRRSNAKE	Snake Creek	49.58	Fair	Fair	41	18
2GRRSTQRY	Stone Quarry Creek	49.43	Fair	Good	32	12
2GRRUTRIB	Unknown tributary to Robinson Creek	60.81	Fair	Good	36	15
2GRRWOKCK	White Oak Creek	66.21	Fair	Poor	39	14

Table 1. Results of MBI scores, ratings, metrics, and habitat ratings.

Nolin River Lake
2016 Macroinvertebrate Study

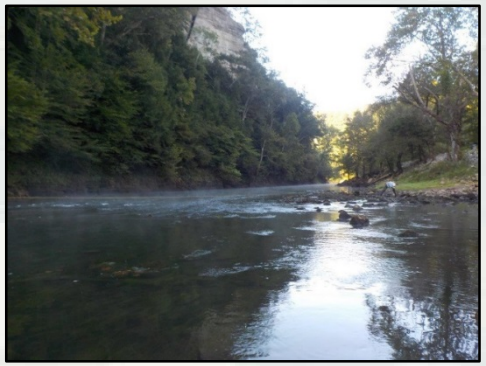

Figure 1. Tailwater of Nolin River Lake facing downstream away from the dam.

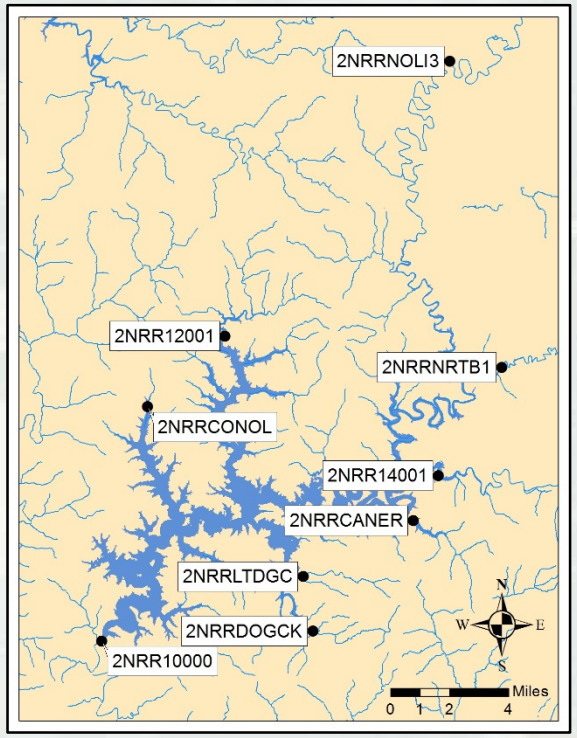

Figure 2. Map of site locations at Nolin River Lake.

Background

One of the most comprehensive methods for assessing water quality conditions is evaluating the benthic macroinvertebrate community (i.e., bottom-dwelling animals that lack a backbone). The KY Division of Water (KDOW) evaluates streams by using the Macroinvertebrate Bioassessment Index (MBI) developed specifically for KY streams. The MBI calculates a score (0-100) that is used to assign a rating based on the size and location of the stream. MBI ratings, in order of decreasing stream health, are: Excellent, Good, Fair, Poor, and Very Poor.

Methods

Eight of the primary inflows and the tailwater of Nolin River Lake were sampled in the spring and summer of 2016 following KDOW methods (Figure 2). This included the collection of benthic macroinvertebrates using a semi-quantitative riffle kick sample and a qualitative multi-habitat sample. Habitat was assessed and assigned ratings (Good, Fair, and Poor) using KDOW methods. Some of the metrics used in calculating MBI include: taxa richness – the number of taxa (i.e., types of organism); and EPT richness – the number of taxa from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which are sensitive to poor water quality. In general, low values of taxa richness and EPT richness are associated with poor stream health.

Results

Table 1 and Figure 3 show that, with the exception of Round Stone Creek, all of the MBI ratings were Fair or higher, including the tailwater with a rating of Fair. Note that 2NRRNOLI3 did not have a riffle sample collected due to the lack of riffles available (therefore, MBI could not be calculated). Habitat ratings were generally Fair or Good with the exception of Dog Creek and 2NRRNOLI3 which were Poor. Taxa richness ranged from 12 to 45 taxa and EPT richness ranged from 4 to 22 taxa.

Conclusions

These results indicate that the tailwater and the majority of the tributaries sampled have some level of impact from human disturbance, but still have fair-to-excellent stream health, with the exception of Round Stone Creek which likely suffers from higher levels of impact due to its poor stream health. Results of taxa richness and EPT richness generally agree, with higher values associated with the highest rated streams. Habitat ratings agree as well, with the exception of Dog Creek.

It is important to note that the MBI is not calibrated to assess streams with a drainage area greater than 200 mi^2; therefore, the results of the tailwater (703 mi^2) should be interpreted with caution. However, KDOW advised the Water Quality Team to utilize the MBI due to the absence of a large river calibration.

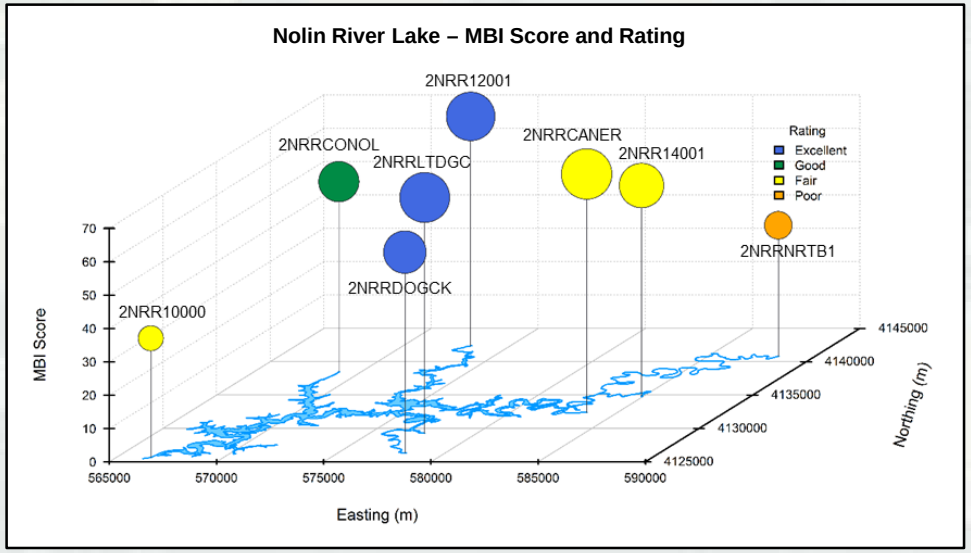

Figure 3. Lollipop chart of MBI scores and ratings. Lollipop height and circle size corresponds to MBI score. Circle color corresponds to MBI rating.

Location	Stream	MBI Score	MBI Rating	Habitat Rating	Taxa Richness	EPT Richness
2NRR10000	Nolin River (tailwater)	35.75	Fair	Fair	12	4
2NRR12001	Rock Creek	68.80	Excellent	Good	37	10
2NRR14001	Bacon Creek	63.11	Fair	Fair	40	8
2NRRCANER	Cane Run	71.48	Fair	Good	45	12
2NRRCONOL	Conoloway Creek	57.00	Good	Good	33	12
2NRRDOGCK	Dog Creek	60.23	Excellent	Poor	36	12
2NRRLTDGC	Little Dog Creek	70.69	Excellent	Good	39	22
2NRRNOLI3	Nolin River	--	--	Poor	32	9
2NRRNRTB1	Round Stone Creek	39.26	Poor	Fair	22	4

Table 1. Results of MBI scores, ratings, metrics, and habitat ratings.

Rough River Lake
2016 Macroinvertebrate Study

Figure 1. Fiddlers Creek (2RRRFIDCK).

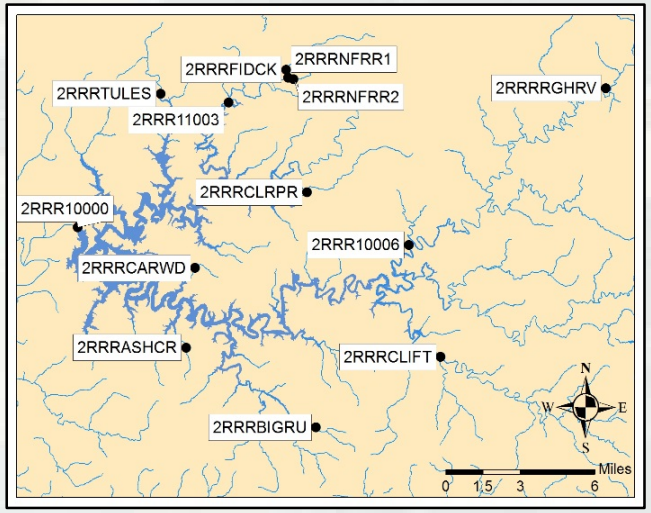

Figure 2. Map of site locations at Rough River Lake.

Background

One of the most comprehensive methods for assessing water quality conditions is evaluating the benthic macroinvertebrate community (i.e., bottom-dwelling animals that lack a backbone). The KY Division of Water (KDOW) evaluates streams by using the Macroinvertebrate Bioassessment Index (MBI) developed specifically for KY streams. The MBI calculates a score (0-100) that is used to assign a rating based on the size and location of the stream. MBI ratings, in order of decreasing stream health, are: Excellent, Good, Fair, Poor, and Very Poor.

Methods

Twelve of the primary inflows and the tailwater of Rough River Lake were sampled in the spring and summer of 2016 following KDOW methods (Figure 2). This included the collection of benthic macroinvertebrates using a semi-quantitative riffle kick sample and a qualitative multi-habitat sample. Habitat was assessed and assigned ratings (Good, Fair, and Poor) using KDOW methods. Some of the metrics used in calculating MBI include: taxa richness – the number of taxa (i.e., types of organism); and EPT richness – the number of taxa from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which are sensitive to poor water quality. In general, low values of taxa richness and EPT richness are associated with poor stream health.

Results

The majority of MBI ratings were Fair (62%) with some Poor (31%) and one Very Poor, which was the tailwater. Habitat ratings were mostly Poor (54%) followed by Fair (31%) and Good (15%). Taxa richness ranged from 14 to 38 taxa and EPT richness ranged from 2 to 13 taxa.

Conclusions

The high proportion of Poor sites indicate several streams suffer impacts from human disturbance, especially the Very Poor rating at the tailwater. The high proportion of Poor habitat ratings supports this, although other water quality issues could impact sites with Poor MBI ratings and Good-to-Fair habitat ratings. The moderate-to-low values taxa richness and EPT richness also suggest a lack of good stream health. Fair MBI ratings do not indicate severe impacts, however the lack of Good and Excellent MBI ratings can be concerning for the water quality of the watershed as a whole. Although the Very Poor MBI rating of the tailwater indicates the need to review dam operational strategies that best mitigate impacts to the river, the presence of the old mill dam 6 river-miles downstream from the lake dam creates a pool throughout this reach of the river and limits the ability to make operational changes that improve tailwater habitat.

It is important to note that the MBI is not calibrated to assess streams with a drainage area greater than 200 mi^2; therefore, the results of the tailwater (455 mi^2) should be interpreted with caution. Additionally, the MBI methods rely on the presence of riffle habitat, in which case was limited to only the concrete tailwater conduit due to the effects of the old mill dam downstream. However, KDOW advised the Water Quality Team to utilize the MBI due to the absence of a large river calibration.

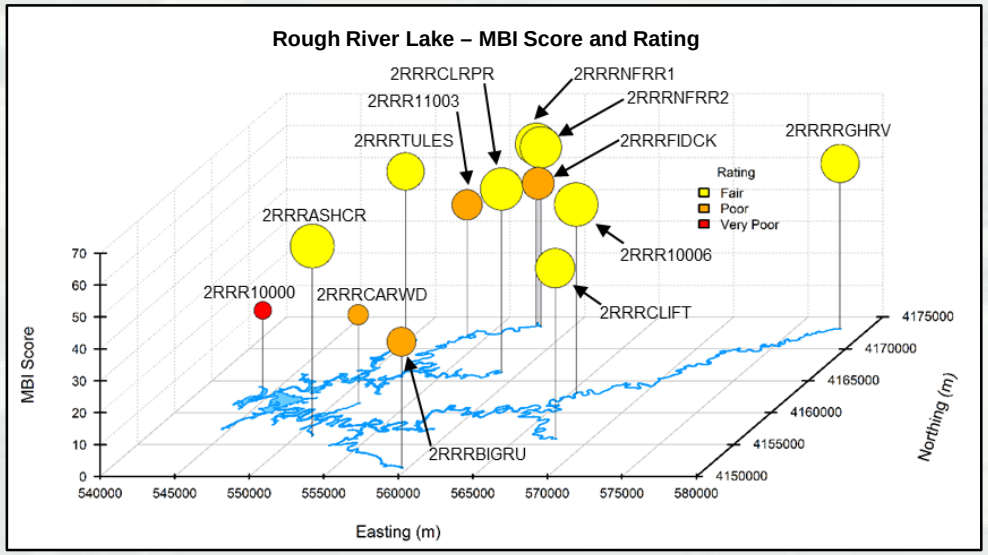

Figure 3. Lollipop chart of MBI scores and ratings. Lollipop height and circle size corresponds to MBI score. Circle color corresponds to MBI rating.

Location	Stream	MBI Score	MBI Rating	Habitat Rating	Taxa Richness	EPT Richness
2RRR10000	Rough River (tailwater)	24.19	Very Poor	Poor	14	2
2RRR10006	Rough River	59.17	Fair	Fair	33	8
2RRR11003	North Fork Rough River	41.26	Poor	Poor	23	6
2RRRASHCR	Ashcraft Branch	59.50	Fair	Fair	38	13
2RRRBIGRU	Big Run Branch	39.47	Poor	Fair	26	9
2RRRCARWD	Pleasant Hill Branch	27.84	Poor	Poor	21	6
2RRRCLIFT	Clifty Creek	53.42	Fair	Poor	29	5
2RRRCLRPR	Clear Prong	57.46	Fair	Poor	34	8
2RRRFIDCK	Fiddlers Creek	43.69	Poor	Good	29	6
2RRRNFRR1	North Fork Rough River	57.00	Fair	Poor	32	5
2RRRNFRR2	North Fork Rough River	56.22	Fair	Good	35	12
2RRRRGHRV	Rough River	51.83	Fair	Poor	31	8
2RRRTULES	Tules Creek	50.71	Fair	Fair	32	8

Table 1. Results of MBI scores, ratings, metrics, and habitat ratings.

Harmful Algal Blooms in Louisville District

Harmful algal blooms (HABs) are defined as an over abundance of cyanobacteria (aka blue-green algae). HABs may not always be visible and some species may produce toxins that can be harmful to human health. HABs are most prevalent during warm-weather months during periods of low precipitation. Nutrient overloading is considered to be one of the primary factors contributing to HAB development. The states located in the Louisville District (LRL) area of responsibility are the water quality authorities that are responsible for developing HAB response plans and determining public advisories for contact and drinking water. The LRL Water Quality Team supports the states in the development and response, upon request of the lead state agencies.

Figure 1. HAB at Roush Lake in June 2016.

Figure 2. HAB at Monroe Lake in October 2016.

Figure 3. HAB at Barren River Lake in March 2017.

HABs in IN are addressed by the IN Department of Natural Resources (IDNR) as they are the lead agency for HAB response in the state. The IN Department of Environmental Management (IDEM) samples the swimming beaches at select lakes across the state for cyanobacteria cell count and cyanotoxins once per month May through September, unless the results exceed established state adopted thresholds, in which case samples are collected every two weeks. To support this effort, when IDEM samples have results that exceed the established thresholds, LRL samples once per month for cyanobacteria cell count at multiple sample sites across the affected lake body. The IDNR uses the results from IDEM and LRL sampling to issue recreational advisories to the visiting public. LRL also supports the state agencies in HAB response by communicating HAB-related recreational advisories to the public.
2016 IN HABs: Brookville, Cecil M. Harden, Monroe Lake, Mississinewa, Roush, and Salamonie-HAB data specific to each of these lakes, is included on each lake report.

HABs in OH are addressed by the OH Department of Natural Resources (ODNR) as they are the lead agency for HAB response in the state. The ODNR works with the OH Environmental Protection Agency (OEPA) and Ohio Department of Health to sample for cyanobacteria and cyanotoxins at designated swimming beaches and drinking water intakes and, to post any required recreational advisories. LRL supports the state agencies by reporting any visual HAB indicators and by participating in a Sign Posting & Communication Plan to communicate HAB potential to the visiting public.
2016 OH HAB Reports: Harsha Lake Early season HAB that resulted in toxin testing which determined that toxin levels were unsafe for contact. **C.J. Brown Lake** After Labor Day, state determined they would not sample for toxins, but would instead monitor the bloom as appropriate.

HABs in KY are addressed by the Kentucky Division of Water (KDOW) as they are the lead agency for HAB response in the state. The KDOW has adopted HAB toxin sampling, in-lieu of HAB cell count, for posting public recreational advisories/cautions. The LRL WQ Program coordinates with, complies with, and supports the state agency's efforts to implement a statewide HAB response plan. LRL assists the KDOW with implementation by reporting visual HAB indicators and collecting HAB toxin samples at locations as specified by the KDOW.
2016 KY HAB Reports: Nolin Lake had three separate reports, two in response to illness reports and one in response to results from an independent study.

Figure 4. Field sampling at Harsha Lake illustrating algal scum on surface.

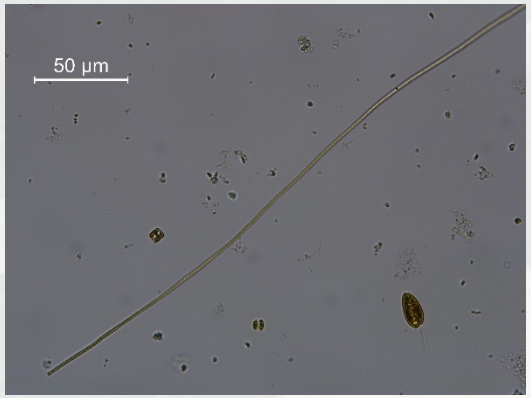

Figure 5. *Pseudanabaena* sp., a common genera of cyanobacteria found in LRL lakes.

LRL Water Quality Program Partnerships

Figure 1. USEPA contractor retrieves a greenhouse gas sampler from Harsha Lake.

The Louisville District Water Quality program prioritizes partnerships with other Federal, state, academic, and county agencies. Agency partners include (but are not limited to):

- United States Environmental Protection Agency (USEPA)
- United States Geological Service (USGS)
- Kentucky Division of Water (KDOW)
- Indiana Department of Environmental Management (IDEM)
- Indiana Department of Natural Resources (IDNR)
- Ohio Environmental Protection Agency (OEPA)
- Ohio Department of Natural Resources (ODNR)
- Ohio River Sanitation Commission (ORSANCO)

Figure 4. USGS equipment platform installed in Rough River Lake.

Figure 5. Water Quality limnologist poses with a Blue Sucker (*Cycleptus elongatus*) collected from the Ohio River while working with ORSANCO.

Figure 2. Water Quality biologist works with Rough River Lake personnel to select sample sites for a HAB special study that was coordinated with KY agencies.

Figure 3. Water Quality limnologist discusses opportunities to partner with Kentucky agencies.

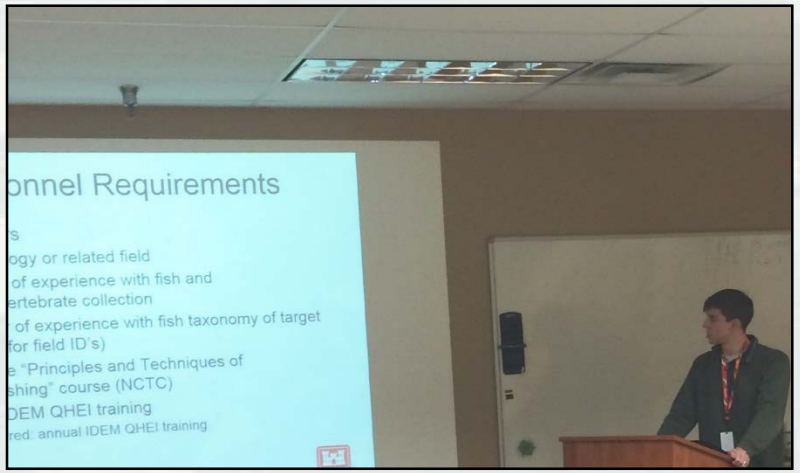

Figure 6. Water Quality biologist presents sampling plans to IDEM and IDNR.

Water Quality Program 2017 Plans

Figure 1. *Daphnia lumholtzi*, a zooplankton collected from Nolin River Lake.

Summary

In 2017, the Water Quality Program intends to conduct project profiles, ambient surveys, intensive surveys, and special studies in accordance with program objectives.

- Project profiles will be collected approximately every two weeks at each lake.
- Ambient surveys will be conducted at all twenty lakes during the summer.
- Intensive surveys will be directed at Brookville (BVR) and Harden (CHL) lakes.
- Special studies will be coordinated regarding Nolin River Lake HABs, the East Fork Watershed Cooperative (Harsha Lake) and any unforeseen incident response.

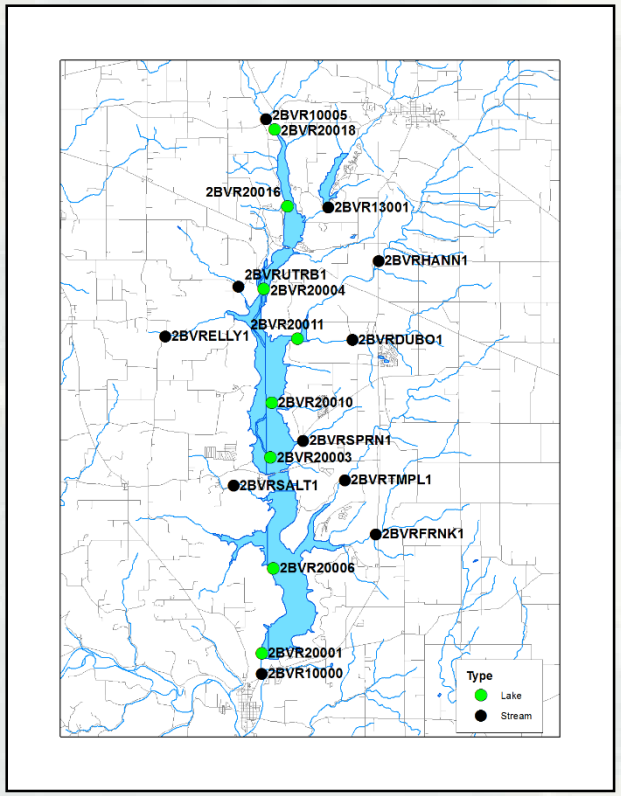

Figure 4. Map of Brookville Lake intensive survey sample sites.

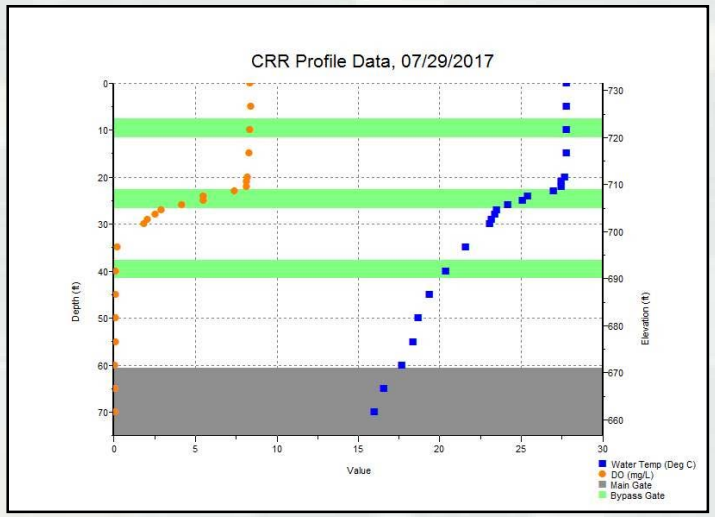

Figure 2. Profile data collected from Cave Run Lake.

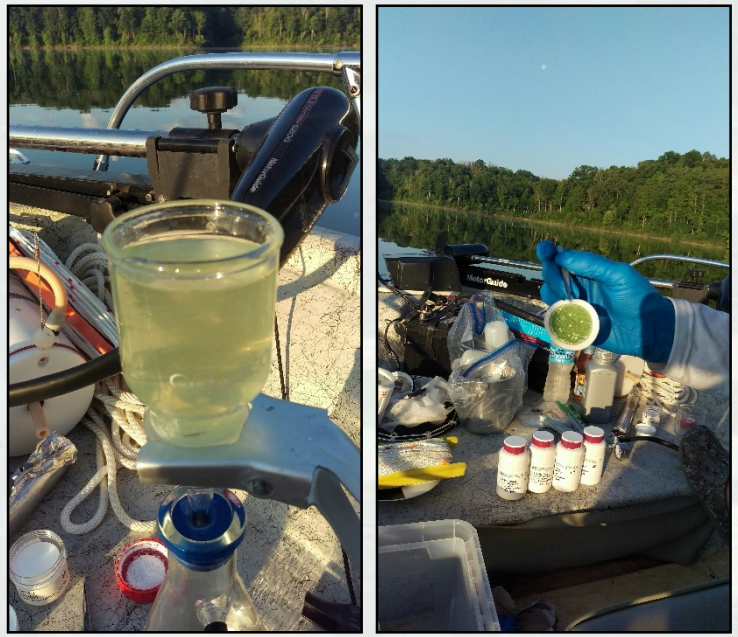

Figure 3. Water Quality Program contractors collect a chlorophyll sample from Harsha Lake.

2017 HAB Response:

- OH HAB Response is to report any visual indicators to the state lead agencies via submission of the state provided Bloom Report.
- KY HAB Response is to report any visual indicators to the lead state agency via email. State lead agency will request sampling report as needed and provide sampling supplies, specific location, and analysis.
- IN HAB Response changes in 2017 to be consistent with support offered in other states. Visual HAB indicators will be reported to the state lead agencies by submitting an agency approved Bloom Report and coordinating said report with lead agencies.