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Characterization of Water Quality, Biology, and Habitat of the Pearl River and Selected Tributaries Contiguous To and Within Tribal Lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, 2017–18

Scientific Investigations Report 2022–5090

U.S. Department of the Interior
U.S. Geological Survey

Cover. Wolf Creek near U.S. Geological Survey station 02481960, Wolf Creek at Industrial Drive near Pearl River, Mississippi. Photograph by Matthew B. Hicks, U.S. Geological Survey.

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At the time of publication, macroinvertebrate and habitat data for stream sites considered to be least disturbed by the Mississippi Department of Environmental Quality (MDEQ), including Lukfapa Creek, were not available in a published format and were obtained upon request from the MDEQ Office of Pollution Control.

Contents

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic meter (m^3)	6.290	barrel (petroleum, 1 barrel = 42 gal)

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F = (1.8 × °C) + 32.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C = (°F – 32) / 1.8.

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter (µg/L).

Concentrations of chemical constituents in sediment are given in milligrams per kilogram (mg/kg).

Abbreviations

AHTN	acetyl hexamethyl tetrahydro naphthalene
BMI	benthic macroinvertebrate
DEET	N,N-diethyl-*meta*-toluamide
DO	dissolved oxygen
DS	downstream
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
HHCB	hexahydrohexamethyl cyclopentabenzopyran
MBCI	Mississippi Band of Choctaw Indians
M-BISQ	Mississippi-Benthic Index of Stream Quality
MDEQ	Mississippi Department of Environmental Quality
N	nitrogen
NMDS	nonmetric multidimensional scaling
OWC	organic wastewater compound
P	phosphorus
PAH	polycyclic aromatic hydrocarbon

PEC	probable-effect concentration
PRC	Pearl River Community
QHA	qualitative habitat assessment
RL	reporting level
RPD	relative percent difference
SC	specific conductance
TEC	threshold-effect concentration
TN	total nitrogen
TP	total phosphorus
US	upstream
USGS	U.S. Geological Survey
WWTP	wastewater treatment plant
WY	water year

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By Lucas J. Driver, Matthew B. Hicks, and Amy C. Gill

Abstract

The U.S. Geological Survey, in cooperation with the Mississippi Band of Choctaw Indians (MBCI), conducted a baseline assessment of the physical, chemical, and biological quality of selected streams and rivers within and contiguous to the Pearl River Community (PRC) in 2017 and 2018. The MBCI is a federally recognized tribe with territories in Mississippi and Tennessee. MBCI Tribal government and communities have sovereign authority over their natural resources and are responsible for protecting the quality of waters within the Tribal lands from sources of pollution and restoring impaired waters. The quality of these surface waters has a profound effect upon the health and welfare of MBCI Tribal members. Data generated from this study may be used with other relevant water-quality data for comparison and development of Tribal water-quality standards.

The PRC territory is drained by the Pearl River and associated tributaries. Water-quality and biological samples were collected and habitat surveys were conducted at sites on the mainstem of the Pearl River and major tributaries of the Pearl River—Wolf Creek, Beasha Creek, Jones Creek, and Kentawka Creek. The selected stream sites represent a range of land use/land cover and potential sources of alteration and contamination from within their respective drainage areas. In particular, Wolf Creek watershed has the highest relative percentage of developed land.

Ambient physicochemical properties, major ions, nutrients, and organic wastewater compounds (OWCs) were analyzed quarterly from surface-water samples from October 2017 through August 2018. Physicochemical properties were also measured in June 2018 over a continuous 48-hour period. Trace elements and polycyclic aromatic hydrocarbons were analyzed from streambed sediments in August 2018. Biological samples included the collection of periphyton algae (August 2018), benthic macroinvertebrate (March 2017 and March 2018), and fish communities (April 2018). Physical stream habitat characteristics were assessed using qualitative (March 2017 and March 2018) and quantitative surveys (August 2018).

While not directly applicable, the State of Mississippi Water Quality Standards were used as reference to evaluate Tribal water quality. Physicochemical water-quality constituents—water temperature, specific conductance (SC), pH, and dissolved oxygen (DO)—were generally within natural ranges among sites and samples, with a few exceptions that exceeded existing Mississippi water-quality standards. pH and DO periodically were below the minimum State standards at some sampled sites. Specific conductance was also relatively high at both Wolf Creek sites but did not exceed the existing maximum standard for recreational waters.

The surface water among stream sites was predominantly calcium bicarbonate type, with a shift toward sodium-bicarbonate water type at the downstream Wolf Creek (Wolf DS) site. Major ion concentrations were generally highest at the Wolf Creek sites. Nutrient concentrations were also often highest at Wolf DS, but total nitrogen and total phosphorus periodically exceeded recommended State and Federal nutrient criteria thresholds among most sampled sites. Twenty-nine OWCs, including 10 known or suspected endocrine disruptors, were detected among sites. Concentrations of OWCs were relatively low, and only 19 percent of all detections were above the reporting level.

Concentrations of copper and nickel in streambed sediments were detected above consensus-based threshold-effect concentrations (TECs) at one site each, and arsenic and chromium exceeded TECs at most sites. Concentrations of all polycyclic aromatic hydrocarbons in streambed sediments were low and well below TECs at all sites.

The periphyton, macroinvertebrate, and fish communities at most sampled sites appear typical of central Mississippi streams; however, the diversity, composition, and abundance of taxa sampled from Wolf DS were particularly distinctive compared to other sampled stream sites. Periphyton taxa richness was low at both Wolf Creek sites, and both sites had greater abundances of diatom taxa, which are indicative of high nutrient concentrations, than of soft-algae taxa. Similarly,

Wolf DS had relatively low macroinvertebrate diversity, the fewest Ephemeroptera, Plecoptera, and Trichoptera taxa, a high abundance of Tubificid taxa, and the lowest overall Mississippi-Benthic Index of Stream Quality score. Fish species richness was also relatively low at Wolf DS compared to some other sampled sites.

Habitat characteristics also appeared to be generally typical of most central Mississippi streams. Qualitative habitat assessment scores were at or above the regional least disturbed streams for Wolf DS, the upstream Wolf Creek (Wolf US) site, and Jones Creek. Habitat scores among the remaining sites indicate fair conditions. Quantitative and qualitative habitat characteristics indicate relatively lower habitat quality at the two Beasha Creek sites.

Introduction

The Mississippi Band of Choctaw Indians (MBCI) Tribal government and communities have sovereign authority over their natural resources and thus are responsible for protecting the quality of surface waters within Choctaw Trust land boundaries from point and nonpoint sources of pollution, identifying impaired waters, and for developing strategies to restore the health of impaired waters (Jerry Cain, Mississippi Band of Choctaw Indians, Environmental Manager, oral commun., 2018). The quality of the surface waters has a profound effect on the health and welfare of MBCI Tribal members, along with wildlife, fish, and other aquatic life. Tribal members depend on the river for supplemental sustenance from fish and game that normally inhabit the riverine areas, and they utilize other natural resources for cultural practices. For example, use of river cane (*Arundinaria* spp.) in the production of functional and decorative baskets is a culturally significant art form among the Choctaw and is still practiced by the MBCI (MBCI, 2020). Dense cane thickets (canebrakes) were once abundant in riparian and floodplain river bottoms throughout the southeast, but canebrake ecosystems are now considered critically endangered (Noss and others, 1996). The quality of MBCI's waters may also affect domestic, agricultural, industrial, and recreational water-use activities.

In 2006, the MBCI addressed several point-source pollution issues within the Pearl River Community (PRC) by replacing wastewater lagoons with centralized wastewater treatment systems and initiating a water-quality monitoring program to assess lakes, streams, wetlands, and community ponds (Jerry Cain, MBCI Environmental Manager, written commun., 2021). The centralized wastewater treatment systems operate under U.S. Environmental Protection Agency (EPA) National Pollution Discharge Elimination System permits. In 2012, the MBCI collaborated with the U.S. Geological Survey (USGS) to develop a biological monitoring strategy for streams and rivers within the PRC and perform training in field, laboratory, and data management protocols. In 2017, the MBCI received a Section 319 Grant through the EPA to address nonpoint-source pollution issues through the development of a watershed-based management plan for the PRC. The watershed management plan, completed in 2020, identified priority streams and sub-watersheds in need of protection or restoration from nonpoint-source pollution. Subsequently, a pilot project was implemented in the Wolf Creek subwatershed to address nonpoint-source pollution through the implementation of best management practices. In addition, further upgrades to the Pearl River wastewater treatment plant (WWTP) occurred and were completed in 2021.

During 2017 and 2018, the USGS, in cooperation with the MBCI, conducted a baseline study on streams and rivers within and contiguous to the PRC (fig. 1). This baseline study included collection and analysis of physical (streamflow and habitat), chemical (nutrients, major ions, trace elements, and organic compounds), and biological (periphyton algae, macroinvertebrates, and fish) properties. Data from this study can be used to (1) determine ranges in the water quality, streambed-sediment quality, and biological community health at selected sampling sites, (2) identify locations of stream reaches potentially affected by nonpoint-source pollution, (3) describe baseline conditions to provide a pre- and post-comparison for measures of success after the implementation of best management practices, and (4) provide a foundation of data for use in achieving future surface-water-quality program goals. Analyses of the physical characteristics and chemical properties of surface water and streambed sediment will provide information about the potential effects of anthropogenic activities on the water quality of streams. Biological assessments will determine the relative condition of aquatic life in streams within the settlement and inform potential biological responses to chemical water quality and habitat conditions.

Purpose and Scope

This report describes the range of baseline surface-water-quality and biological conditions at eight stream sites within and contiguous to the PRC Tribal lands. This effort is in support of an EPA Section 319 Grant to assist in identifying and correcting nonpoint-source pollution and to evaluate the effectiveness of solutions employed to address water-quality issues. These data can be used as a foundational reference for other water programs in the PRC and MBCI Tribal lands. The report presents and summarizes analyses of baseline data, including streamflow, surface-water-quality (October 2017 to August 2018) and streambed-sediment samples (August 2018), and biological and habitat assessments (March 2018 to August 2018). Streamflow data include continuous discharge measurements from four USGS streamflow-gaging stations (hereinafter referred to as streamgages): two main-stem sites on the Pearl River and two tributaries to the Pearl River (fig. 2). Water-quality analyses were conducted on samples collected periodically during base-flow and intermediate-flow conditions; stormflow samples were not collected during this study. All water-quality data for physicochemical,

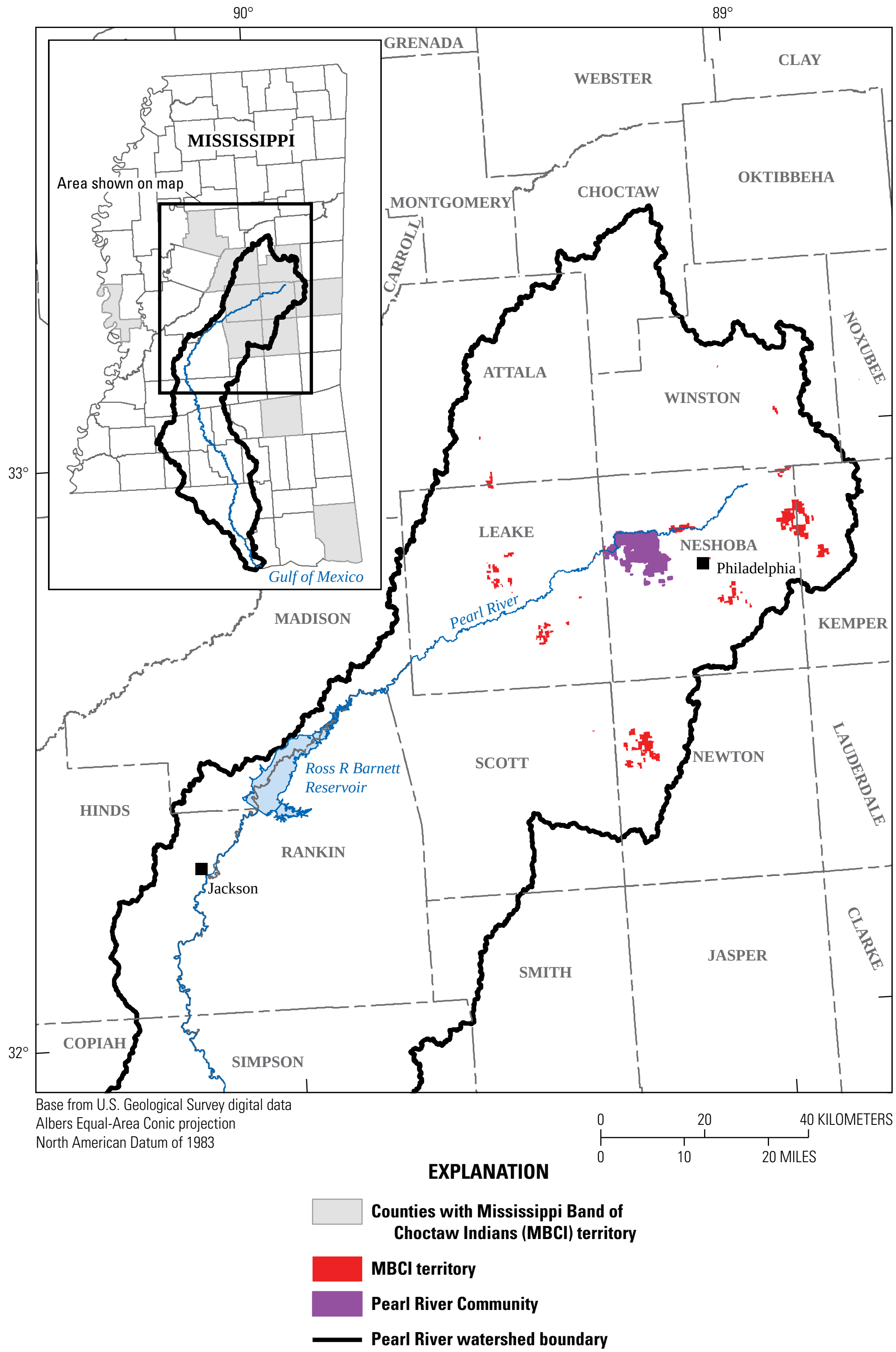

Figure 1. Locations of the Mississippi Band of Choctaw Indians territories in central Mississippi, including the Pearl River Community.

surface-water, and bed-sediment samples, as well as continuous streamflow records, are publicly accessible through the USGS National Water Information System (USGS, 2018b). In addition, biological and stream habitat data are available from a USGS data release (Driver and Hicks, 2022).

Study Area

The MBCI is a federally recognized Native American Tribe. The MBCI territory was established in 1945 on lands in 11 counties in Mississippi (Attala, Winston, Leake, Neshoba, Kemper, Scott, Newton, Jones, Carroll, Issaquena, and Jackson) (fig. 1). Collectively, the MBCI has more than 10,000 members and claims approximately 35,000 acres of land holdings in 13 different areas with 8 official Tribal communities within Mississippi and Tennessee (MBCI, 2020).

The PRC, located about 9.5 kilometers west of Philadelphia, Miss. (fig. 1), encompasses about 62.3 square kilometers (km^2; 15,400 acres) of land and is the seat of the MBCI Tribal government. With approximately 3,100 members, the PRC is the largest MBCI Tribal community. The Pearl River flows from east to west along the northern border of the PRC and is the major waterway in the area (fig. 1). The PRC Tribal lands are drained by the main stem of the Pearl River and several small to moderately sized tributaries.

Physiographic Setting

The PRC lies within the North Central Plateau physiographic district of the East Gulf Coastal Plain Section and Coastal Plain Province in central Mississippi. The North Central Plateau is underlain by predominantly sandy units of the Eocene-Paleocene Wilcox Group and the Eocene Claiborne Group (Cushing and others, 1964; Dockery and Thompson, 2019). The North Central Plateau physiographic district has an altitude of about 600 feet, with some areas of rugged and steep escarpments (cuestas) created by erosion (Cushing and others, 1964; Dockery and Thompson, 2019).

Climate

The climate in the Pearl River watershed is generally warm and humid, ranging from temperate at higher elevations to subtropical near the coast. Average annual air temperature for the Jackson, Miss., region between 1981 and 2010 (climate normals) was 18.1 degrees Celsius (°C) (64.6 Fahrenheit [°F]), and average monthly temperatures range from 7.6 °C (45.7 °F) during January to 27.6 °C (81.6 °F) during July (National Weather Service, 2020). Mean annual precipitation for the same period was 137.5 centimeters (cm) (54.1 inches [in.]), with average monthly precipitation ranging from about 7.6 cm (3.0 in.) in September and October to about 12.7 cm (5.0 in.) in the winter and spring months (National Weather Service, 2020). The land-surface altitude and distance from the Gulf of Mexico are major factors influencing climate in the watershed. In the summer months, the Gulf of Mexico produces warm, humid air masses that move inland and provide precipitation in the form of thunderstorms, which may produce an overabundance of rainfall and periodic flooding. Arctic fronts that move south from the midwestern part of the continent contribute most of the precipitation in the winter months. Snowfall accumulation is rare, with annual averages generally less than 2.5 cm (1 in.) (National Weather Service, 2020).

Land Use

The National Land Cover Database (2011) was used to assess general land-cover and land-use practices within PRC Tribal lands (Homer and others, 2015). Land cover within the PRC is predominantly forested pine and hardwood with small areas of pastureland. Developed land makes up a relatively small percentage of land use (table 1), and PRC Tribal lands are predominantly used for rural residential, agricultural, recreational, commercial, and conservation purposes. Significant commercial, infrastructural, and entertainment developments began in the 1990s and continued through the early 2000s. Much of the developed land within the PRC is associated with Tribal owned and (or) operated entertainment, recreational, and tourism facililties, such as golf course facilities, casinos, and hotels.

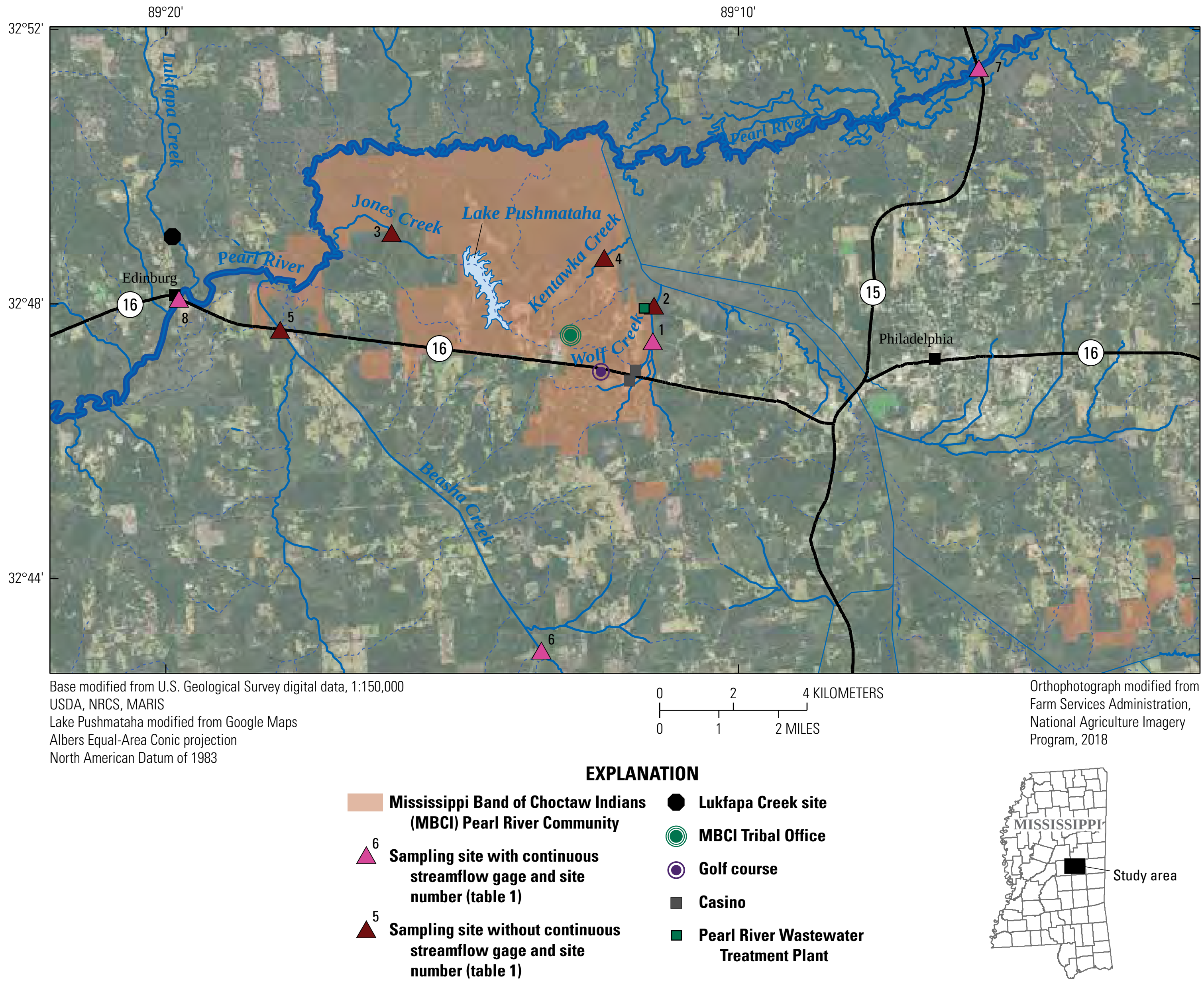

Figure 2. Map showing the boundary of Pearl River Community of the Mississippi Band of Choctaw Indians and locations of sampling sites on the Pearl River and selected tributaries in central Mississippi.

Table 1. Information and watershed characteristics for sites on the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, 2017–18.

[USGS, U.S. Geological Survey; km², square kilometer; %, percent; Miss., Mississippi; US, upstream; DS, downstream]

Site number (fig. 2)	USGS station name (USGS, 2018b)	USGS station number	Site	Latitude (decimal degrees)	Longitude (decimal degrees)	Drainage area (km²)	Forest (%)[1]	Agriculture (%)[1]	Developed (%)[1]
1	Wolf Creek at Industrial Drive near Pearl River, Miss.	02481960	Wolf US	32.78064	−89.19825	19.7	61.63	7.77	18.68
2	Wolf Creek near Pearl River, Miss.	02481961	Wolf DS	32.78921	−89.19712	21.3	60.69	7.43	19.21
3	Jones Creek at Black Jack Road near Pearl River, Miss.	02481970	Jones	32.81144	−89.27196	8.9	56.86	6.92	11.86
4	Kentawka Creek Tributary near Pearl River, Miss.	02481962	Kentawka	32.80169	−89.21058	2.5	81.07	2.81	8.45
5	Beasha Creek near Edinburg, Miss.	02481998	Beasha DS	32.78988	−89.30635	140.0	58.67	22.45	4.59
6	Beasha Creek near Coldwater, Miss.	02481984	Beasha US	32.70745	−89.23707	19.2	61.63	7.77	12.80
7	Pearl River at Burnside, Miss.	02481880	Pearl US	32.84115	−89.09762	1,317.9	42.36	21.74	4.83
8	Pearl River at Edinburg, Miss.	02482000	Pearl DS	32.79906	−89.33511	2,342.7	46.79	18.87	5.37

[1]Land-cover data from National Land Cover Database 2011 (Homer and others, 2015).

Approach and Methods

Watershed Characterization and Site Selection

Prior to selecting sites, watershed drainage areas were delineated by using USGS StreamStats (USGS, 2018a). Watershed characteristics (drainage area, land cover) were summarized by using the Analytical Tools Interface for Landscape Assessments (ATtILA), an Esri ArcGIS toolbox created by the EPA that calculates landscape metrics (EPA, 2018). Selected sampling sites represent combinations of natural and human factors thought to collectively affect the physical, chemical, and biological characteristics of surface-water quality on the settlement.

After geographic information system analysis, eight sampling sites were selected for inclusion in this study (table 1; fig. 2). Two sites were located on the Pearl River main channel at USGS streamgages: Pearl River at Burnside (hereinafter referred to as Pearl US) and Pearl River at Edinburg (Pearl DS). Two sites were located on Wolf Creek, the most developed and urbanized watershed in the PRC. The upstream Wolf Creek site, Wolf Creek at Industrial Drive near Pearl River (Wolf US), is just below the Dancing Rabbit Golf Club and Resort and was selected to evaluate potential effects of point- and nonpoint-source runoff from the surrounding commercial developments. Retention ponds and a centrifugal drain pump are located adjacent to casino facilities to reduce stormwater effects on Wolf Creek. Reduced efficacy of at least one of the retention ponds, however, has occurred in the past due to lack of periodic maintenance. The downstream Wolf Creek site, Wolf Creek near Pearl River (Wolf DS), is just below the Pearl River WWTP. This site was chosen to evaluate the potential combined effects of point- and nonpoint-source pollution from the developed area in and around two casinos.

Four of the eight sites were located on streams that represent conditions in the predominantly rural areas of the PRC. Kentawka Creek Tributary near Pearl River (Kentawka; table 1) is a tributary of Kentawka Canal and is also known locally as James Billie Creek. Kentawka has the smallest drainage area of the four rural sites and often goes dry in late summer and early fall months. The site on Jones Creek at Black Jack Road near Pearl River (Jones) is approximately 3.2 km downstream of Lake Pushmataha. The two remaining sites were located on Beasha Creek, which has a relatively large watershed that drains to the Pearl River near Edinburg. Much of the Beasha Creek watershed is outside the boundary of the PRC. The downstream Beasha Creek site, Beasha Creek near Edinburg (Beasha DS), is near the confluence with the Pearl River. The upstream Beasha Creek site, Beasha Creek near Coldwater (Beasha US), is located approximately 12 km upstream of the confluence of Beasha Creek with the Pearl River and is outside of the PRC boundary.

Sampling Design

The intent of this study was to characterize current streamflow, physical and chemical properties of water, chemical properties of streambed sediment, biological communities, and physical habitat of the Pearl River and selected tributaries to the Pearl River that lie within MBCI lands. Streamgages equipped to collect continuous stage readings and compute continuous discharge were established at four of the eight sites. Instantaneous field measurements of physical and chemical properties (specific conductance [SC], pH, temperature, and dissolved oxygen [DO]) and water samples for laboratory analysis of chemical properties (nutrients, major ions, and wastewater compounds) were obtained quarterly (unless the stream reach was dry) between October 2017 and August 2018 (table 2). In addition, continuous field measurements of physical and chemical properties were collected in June 2018 at six of the eight sites during a 48-hour period. Streambed-sediment samples were collected once in August 2018 at all sites. Biological community data were collected for periphyton, benthic macroinvertebrates (BMI), and fish. Periphyton community samples were collected once in August 2018 at all sites except for Kentawka, which was dry at the time of collection. BMI samples were collected once at six of the eight sites during a winter index period of January–March. Methods for collection and assessment of BMI are only applicable for wadable streams; therefore, samples were not collected at the two Pearl River sites, which were both nonwadable during that time. Three sites were sampled for BMI in 2017 and the other three sites were sampled in 2018. Fish community samples were collected once in April 2018 at all sites. Quantitative physical habitat characteristics were collected during the periphyton community sample collection (Fitzpatrick and others, 1998). Qualitative habitat assessments (Mississippi Department of Environmental Quality [MDEQ], 2020) were made during the benthic macroinvertebrate community sample collection. A summary of data collected by site and date is given in table 2.

Hydrology

Continuous stage data were collected, and periodic streamflow measurements were made by USGS personnel at Pearl US, Pearl DS, Wolf US, and Beasha US from October 2017 to September 2018 (table 1; fig. 2). Continuous stage data were used to estimate continuous streamflow using a stage-discharge relation described by Turnipseed and Sauer (2010). Streamflow records for October 1, 2017, through September 30, 2018, were computed according to methods described in Rantz and others (1982) and are available online (USGS, 2018b).

Table 2. Summary of datasets and samples collected from the Pearl River and selected tributaries within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, 2017–18.

[US, upstream; DS, downstream; –, no data]

Site (table 1)	Continuous stage and streamflow	48-Hour continuous physical properties	Surface-water quality	Bed sediment	Periphyton	Benthic macro-invertebrates	Fish	Quantitative habitat	Qualitative habitat
Wolf US	x	x	x	x	x	x	x	x	x
Wolf DS	–	x	x	x	x	x	x	x	x
Jones	–	x	x	x	x	x	x	x	x
Kentawka	–	x	x[1]	–	–	x	x	–	x
Beasha DS	–	x	x	x	x	x	x	x	x
Beasha US	x	x	x	x	x	x	x	x	x
Pearl US	x	–	x	x	x	–	x	–	–
Pearl DS	x	–	x	x	x	–	x	x	–
Relative dates of sampling	Oct. 2017–Sep. 2018	June 2018	Oct. 2017, Jan. 2018, Apr. 2018, Aug. 2018	Aug. 2018	Aug. 2018	Feb.–Mar. 2017 or Mar. 2018	Apr. 2018	Aug. 2018	Feb.–Mar. 2017 or Mar. 2018

[1]Samples were not collected at Kentawka during October 2017 or August 2018 due to lack of surface flow.

Field Measurements

Instantaneous and continuous field measurements of water temperature, SC, pH, and DO were made by using a hand-held Yellow Springs Instrument (YSI) 6920 V2-1 multiparameter water-quality sonde. Instantaneous measurements were collected at the mid-point of the stream channel and from approximately mid-depth of the water column. Continuous field measurements (measured at 30-minute intervals) were collected over a 48-hour period by using sondes that were placed in the water column facing upstream and secured in place by using a metal fence post and plastic ties. Calibration and monitoring procedures for water-quality sondes followed standardized guidelines (Wagner and others, 2006; Gibs and others, 2007).

Water-Quality Sampling

Water-quality samples were collected at all sites by using standardized methods in the USGS National Field Manual (USGS, 2006). Samples were collected approximately every 3 months (hereinafter referred to as quarterly samples) between October 1, 2017, and September 30, 2018, to evaluate seasonal variability and to establish baseline water-quality conditions for each of the sites.

At sites that were wadable at the time of sample collection (Wolf US, Wolf DS, Jones, Kentawka, and Beasha US), grab samples were collected from multiple points in a cross section of the stream and composited into plastic containers. At nonwadable sites (Beasha DS, Pearl US, and Pearl DS), samples were collected from multiple points in a cross section of the stream using a depth integrated dip sampler and composited. Samples were collected either before the streamflow measurement was made or upstream of the streamflow measurement section to avoid sample contamination from measuring equipment or resuspended streambed sediment. Samples for analysis of nutrients and major ions were collected and processed following USGS surface-water sample protocols for raw (unfiltered) and dissolved (filtered) constituents (USGS, 2006). Samples for analysis of wastewater compounds were filtered through 0.7-micrometer pore-size glass fiber filters stored in baked glass bottles. Water samples were preserved and placed on ice for shipment and analysis at the USGS National Water Quality Laboratory (Lakewood, Colorado).

Streambed-Sediment Sampling

Streambed-sediment samples were collected once, in August 2018, at seven of the eight sites (fig. 2) for analyses of trace elements and PAHs. Kentawka was dry in August 2018, so no streambed-sediment sample was collected. Streambed-sediment samples were collected by wading into the stream and scooping material from multiple depositional zones (areas of low velocity where fine-grained particles accumulate) with plastic/Teflon spoons. At each location, the top layer (about 1.0 centimeter [cm]) of fine sediment was carefully removed and composited. Composited sediment samples were processed and subsampled and placed on ice for shipment and laboratory analysis at the USGS Geology, Geophysics, and Geochemistry Science Center (Lakewood, Colorado). Sample collection and processing were performed in accordance with USGS protocols (Shelton and Capel, 1994; Radtke, 2005).

Biological Community Sampling

Biological community samples were collected at study sites by using two sets of protocols. Periphyton and fish were sampled by using protocols developed by the USGS National Water-Quality Assessment Project (Moulton and others, 2002). Macroinvertebrates were sampled according to protocols adopted by the MDEQ (Caton, 1991; Barbour and others, 1999; MDEQ, 2020).

Biological communities were collected to document and compare baseline ecological conditions and to assess potential ecological responses to environmental stressors. Total abundance and richness of identified periphyton, macroinvertebrate, and fish taxa were used to summarize and compare general biological characteristics at each site. Shannon's diversity index (*H*), a metric of taxa richness and abundance where higher values indicate relatively greater community diversity, was also calculated for each taxa group for each site (Magurran, 2004). Ordination of community structure among sites was performed by using nonmetric multidimensional scaling (NMDS) from log-transformed (log10+1) site-by-species (taxa) matrices (McCune and Grace, 2002). NMDS was performed with R-statistical software (R Core Team, 2020).

Periphyton Sampling

Periphyton samples were collected during August 2018 from seven of the eight study sites (table 2). Snags were sampled as the richest-targeted habitat because study streams lacked riffles and had fine-grained substrates and because epidendric habitat was common across all study streams (Moulton and others, 2002). Reach-scale composite samples of epidendric periphyton for analysis of community structure were collected by removing material from the surface of five woody snags located throughout a 150-meter (m) reach following methods outlined in Moulton and others (2002). Periphyton samples were preserved with 5 percent formalin and shipped to Rhithron Associates, Inc., in Missoula, Montana, for laboratory processing and taxonomic identification. Identification of taxa to the lowest taxonomic level possible and cell density calculations were performed by trained personnel following methods described in Charles and others (2002). Taxa cell density data were used to create site × taxa/species matrices and calculate selected trait metrics considered to be indicators of nutrient enrichment.

Benthic Macroinvertebrate Sampling

BMI samples were collected during a winter index period (January–March) along wadable reaches of six of the eight study sites (table 2). Kentawka, Jones, and Beasha DS were sampled in February or March 2017, and Beasha US, Wolf US, and Wolf DS were sampled in March 2018. A BMI sample was also collected in 2018 from nearby Lukfapa Creek (fig. 2), considered a least disturbed site by the MDEQ (MDEQ Office of Pollution Control, unpub. data, 2018)[1], for comparison. Samples were collected from multiple habitats along a 100-m reach using a 595-micron mesh D-frame net. Benthic material from locations throughout the reach was composited, preserved with 95 percent ethanol, and shipped to a contract laboratory (Aquatic Resources Center, Inc., Nashville, Tennessee) for taxonomic identification of BMI.

Taxonomic data were used to calculate metrics that represent common elements of the structure and function of the BMI community (for example, measures of diversity, composition, functional feeding groups, and tolerance to pollution) (Bressler and others, 2006; Stribling and others, 2016). Specifically, metrics associated with BMI communities of the East Bioregion of Mississippi (table 3) were used in the calculation of the Mississippi-Benthic Index of Stream Quality (M-BISQ) scores (Stribling and others, 2016). The M-BISQ was initially developed by using statistical analyses of suites of BMI metrics derived from multiple least-disturbed stream sites within each bioregion and from established regional degradation thresholds (Stribling and others 2016). Detailed methods for calculating specific metrics and M-BISQ scores for stream sites within Mississippi bioregions are described in Stribling and others (2016). For each sampling site, individual BMI metrics were scored and averaged to obtain an overall M-BISQ score for each site. Metrics and M-BISQ scores for each sampling site were also compared to those for nearby Lukfapa Creek (fig. 2) and to the regional degradation threshold score reported in Stribling and others (2016).

[1]At the time of publication, data were not available in a published format but are available upon request from MDEQ Office of Pollution Control.

Fish Sampling

Fish communities were sampled during base-flow conditions in April 2018 by using direct-current electrofishing equipment mounted on either a backpack or boat depending on the stream depth (Moulton and others, 2002). All in-stream fish habitats were systematically surveyed along the entire length of the sampling reach. The sample reach length at each site was generally determined by multiplying mean channel width by 20 (Fitzpatrick and others, 1998; Moulton and others, 2002), and reach length ranged between 150 and 500 m among sites. Most fish captured were identified to species, counted, and returned to the stream (outside the sampling reach) alive; however, a small number of individuals were preserved in 10 percent buffered formalin for verification of taxonomic identification. Fish sampling and field and laboratory identification were performed by trained USGS personnel. Species richness and community composition were used to assess and compare the relative state of fish communities among sampling sites. Other biological metrics were calculated for fish species data, representing species richness and composition among feeding and reproductive guilds and tolerance to

Table 3. Benthic macroinvertebrate metrics used in the calculation of the Mississippi-Benthic Index of Stream Quality (M-BISQ) for streams within the East Bioregion and their definitions. Table adapted from Stribling and others (2016).

[%, percent]

Benthic macroinvertebrate metric	Definition	Response to increasing stress	Reference
Number of predator taxa	Number of taxa classified as predators	Decrease	Kerans and Karr (1994)
% of Chironomidae that are *Cricotopus*, *Orthocladius*, and *Chironomus*	Proportion of a subset of tolerant group of midges to the total number of midges in the sample	Increase	Stribling and others (2016)
% Collectors	Percent of collector feeder taxa	Increase	Kerans and Karr (1994)
% Clingers	Percent of insect taxa having fixed retreats or adaptions for clinging to surfaces in swift flowing water	Decrease	Stribling and others (2016)
% Non-insect taxa	Percent of taxa not in Class Insecta	Increase	Stribling and others (2016)
% Tolerant taxa	Percent of taxa that are considered stress tolerant	Increase	Stribling and others (2016)
Beck's Biotic Index	Uses tolerance values to weight abundance in an estimate of overall pollution/organic enrichment	Decrease	Beck (1955)

pollutants (Meador and Carlisle, 2007). An index of biological integrity for fish does not currently exist for the State of Mississippi, and few of these indexes have been developed for fish for the southeast region among coastal plains streams with sandy bottoms.

Physical Habitat Surveys

Quantitative physical habitat measurements were taken at the time of periphyton community sampling in August 2018 at six of the eight sites (table 2). Habitats were not surveyed at Pearl US because the water depth limited the ability to make measurements, and at Kentawka, the channel was dry. Quantitative measures of physical habitat include channel morphology, substrate composition, habitat cover, and riparian canopy density (Fitzpatrick and others, 1998). Eleven equidistant transects perpendicular to the direction of flow were established within each 100-m stream reach. Wetted width, bankfull width, bankfull height, thalweg depth, top bank height, and bank angle were measured at each transect and averaged for the entire reach. Channel depth, substrate firmness, and percent large woody debris were estimated at five locations along each transect (at both edges and at quarter points), and average values were calculated for each study reach. Substrate particle-size distribution was quantified at each transect by using a modified Wolman 100-particle pebble count (Fitzpatrick and others, 1998; MDEQ, 2020). Riparian vegetation canopy cover (percent) was measured at center channel at each transect location by using a hemispherical densiometer.

Qualitative habitat assessments (QHAs) were conducted at six of the eight sites, coinciding with the time of BMI sampling in February–March 2017 and March 2018 (table 2). Additionally, qualitative habitat was also assessed in 2018 at the least-disturbed Lukfapa Creek site (fig. 2). QHAs were not made at the two Pearl River sites because methods were not applicable to nonwadable conditions. QHAs were made at each reach based on MDEQ QHA protocols (MDEQ, 2020). Physical habitat quality was visually assessed for 10 habitat parameters grouped within 3 subcategories (table 4). At each site, habitat parameters were assigned qualitative point values between a minimum of 0 and a maximum of 20 (table 4). For each parameter, lower values indicate poorer quality habitat attributes. QHA scores from Lukfapa Creek and composite scores from the 25th percentile of all least-disturbed streams within the East Bioregion (MDEQ Office of Pollution Control, unpub. data, 2018)[2] were used as local and regional comparisons to sites sampled for this study.

Laboratory Methods for Water and Sediment Samples

Surface-water samples were processed and analyzed at the USGS National Water Quality Laboratory (Lakewood, Colo.) for major ions, nutrients, and OWCs (table 5). Major ions in surface water were analyzed by using atomic absorption spectrometry (Fishman, 1993). Nutrients were analyzed

[2]At the time of publication, data were not available in a published format but are available upon request from MDEQ Office of Pollution Control.

Table 4. Qualitative habitat assessment parameters and their definitions (adapted from Mississippi Department of Environmental Quality, 2020).

Subcategory	Qualitative habitat parameter	Definition	Maximum score
Instream habitat	Epifaunal substrate and available cover	Measure of the availability of instream substrates as refugia for aquatic organisms	20
	Pool substrate characterization	Evaluates the type and condition of bottom substrates within pools	20
	Pool variability	Evaluates the available pool habitats according to size and depth	20
Channel morphology	Channel alteration	Measure of large-scale alteration based on presence of artificial substrates or structures and channel sinuosity	20
	Sediment deposition	Amount of sediment deposition	20
	Channel sinuosity	Measure of channel meander or sinuosity	20
	Channel flow status	Evaluates the amount of wetted channel during base-flow or average annual flow periods	20
Bank and riparian cover	Bank vegetative protection	Measure of the amount of stream bank covered by vegetation[1]	20
	Bank stability	Measure of the existence of or potential for soil erosion from upper and lower banks into the stream channel[1]	20
	Riparian vegetation zone width	Measure of the width of natural vegetation from the edge of the upper stream bank out through the floodplain[1]	20

[1]Parameter scored separately for left and right stream banks: 10 points possible for each bank for a total of score of 20.

by using colorimetric and ion-exchange chromatography (Fishman, 1993; O’Dell, 1993; Patton and Kryskalla, 2003; Patton and Kryskalla, 2011). OWCs were analyzed by using solid phase extraction and gas chromatographic/mass spectrometric methods (Zaugg and others, 2007, 2014). Streambed-sediment samples were analyzed for trace elements at the USGS Geology, Geophysics, and Geochemistry Science Center (Lakewood, Colo.) by using inductively coupled plasma-mass spectrometry (Briggs and Meier, 2002), and polycyclic aromatic hydrocarbons (PAHs) in streambed sediments were analyzed at RTI Laboratories, Inc. (Livonia, Michigan) by using gas chromatography/mass spectrometry (EPA, 2014).

Quality Assurance and Quality Control

Quality-assurance and quality-control procedures for surface-water and bed-sediment samples were followed in accordance with USGS protocols (Radtke, 2005; USGS, 2006). Quality-assurance activities included following standard operating procedures for the collection, handling, and processing of all sample materials and equipment. Quality-control activities included the collection of field blanks and replicate samples to identify, quantify, and evaluate potential bias and variability in water-quality samples. Quality-control samples were collected and analyzed at a frequency of greater than 10 percent of environmental samples over the duration of the study, including two water-quality field blank samples for surface-water constituents (nutrients, major ions, and OWCs); four replicate samples for surface-water nutrients and major ions; and two replicates for OWCs and bed-sediment constituents (trace elements and PAHs).

Field blank samples were collected by processing blank water (water certified to be free of the target constituents) through the same set of collection equipment, filtration, and preservation steps as environmental samples. Detection of target constituents in field blank samples can indicate potential contamination introduced by handling and transportation of equipment or improper cleaning of equipment between sample collections. Among field blank samples, three surface-water constituents (ammonia, bromide, and silica) were detected at concentrations greater than their respective reporting levels (table 6). Because these constituent concentrations were close to the laboratory reporting levels and because the large difference between concentrations detected in environmental samples compared to blank samples did not indicate substantial sample bias, the associated environmental sample data were not adjusted or censored.

Replicate samples were typically obtained by collecting two independent (sequential) samples at a site (one environmental sample and one replicate) or, in some cases, by splitting water from one sample collection into two samples. Comparison of a replicate sample with its paired environmental sample can indicate potential bias in results associated with variability of environmental conditions and (or) the precision of analytical instruments between samples. The variability of constituent concentrations between the replicate sample and its paired environmental sample was evaluated by calculating a relative percent difference (RPD) by using the following equation:

$$RPD = [\text{absolute value } \{(S_1 - S_2)/(S_1 + S_2)/2\}] \times 100, \quad (1)$$

where

S_1 is the concentration from the environmental sample, and

S_2 is the concentration from the replicate sample.

Maximum RPDs among all paired replicate and environmental sample constituents with quantifiable concentrations ranged from 0.08 percent to 40.5 percent. Only three constituents had RPDs greater than 10 percent (table 6). One of these, fluoranthene in streambed sediment, had replicate and environmental sample concentrations that were below the reporting level. RPDs could not be calculated in 23 instances

Table 5. Laboratory analytical methods used in the analysis of samples collected from the Pearl River and tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, 2017–18.

[USGS, U.S. Geological Survey; NWQL, National Water Quality Laboratory]

Group	Medium	Laboratory	Analytical method references
Major ions	Surface water	USGS NWQL	Fishman (1993)
Nutrients	Surface water	USGS NWQL	Fishman (1993); O’Dell (1993); Patton and Kryskalla (2003); Patton and Kryskalla (2011)
Organic wastewater compounds	Surface water	USGS NWQL	Zaugg and others (2007)
Trace elements	Bed sediment	USGS Geology, Geophysics, and Geochemistry Science Center	Briggs and Meier (2002)
Polycyclic aromatic hydrocarbons	Bed sediment	RTI Laboratories, Inc.	U.S. Environmental Protection Agency (2014)

Table 6. Summary of analytical results for field blank and replicate samples for selected analytes from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, 2017–18.

[m/d/yyyy, month/day/year; mg/L, milligrams per liter; N, nitrogen; W, water; DS, downstream; US, upstream; %, percent; RPD, relative percent difference; P, phosphorus; µg/kg, micrograms per kilogram; Sed, sediment; Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Samples with detections greater than the reporting level in field blanks

Constituent	Sample matrix	Site (table 1)	Sample date (m/d/yyyy)	Concentration in field blank (mg/L)	Reporting level (mg/L)	Median concentration in environmental samples (mg/L)
Ammonia, as N	W	Pearl DS	10/4/2017	0.012	0.01	0.03
Bromide	W	Pearl DS	10/4/2017	0.121	0.01	0.02
Silica	W	Pearl DS	10/4/2017	0.025	0.018	12.99
Silica	W	Pearl US	1/25/2018	0.041	0.018	12.99

Replicate samples with 10% or greater relative percent difference

Constituent	Sample matrix	Site (table 1)	Sample date (m/d/yyyy)	Concentration in environmental sample (mg/L)	Concentration in replicate sample (mg/L)	Reporting level	RPD
Dissolved phosphorus (mg/L as P)	W	Kentawka	4/10/2018	0.003	0.005	0.003	12.2
Benzo[a]pyrene (µg/kg)	Sed	Beasha DS	8/2/2018	7.0	2.4	8.1	24.5
Fluoranthene (µg/kg)	Sed	Beasha DS	8/2/2018	2.1	20.0	8.1	40.5

because the constituent concentration of either the environmental sample or the replicate sample was censored below the reporting level (in other words, the constituent was not detected). Among these, only 6 were paired with a quantifiable concentration greater than the reporting level; the remaining 17 instances had a paired concentration that was either quantifiable but below the reporting level or the concentration was unquantifiable (estimated). Overall, comparison of replicate and environmental sample data indicates that variability was often low and did not result in substantial data bias.

Streamflow Data

Streamflow varies seasonally in Mississippi and tends to reflect precipitation patterns as well as land uses. Continuous streamflow data (USGS, 2018b) were collected at four of the sampling sites throughout the study period (table 2). The streamgages at Pearl DS and Pearl US have long periods of record (91 years and 38 years, respectively), whereas gages at Wolf US and Beasha US were established specifically for this study, with records beginning in October 2017. Monthly mean streamflows at the two Pearl River sites during the 2018 water year (WY) (October 1, 2017, through September 30, 2018) generally were lower than the long-term mean monthly streamflows over their periods of record, except during the spring months (fig. 3). Peak streamflow and 7-day low-flow values (the lowest values of mean streamflow computed during any 7 consecutive days during the analysis period) are presented in table 7 for WY 2018. This table includes information on historical hydrologic conditions at the Pearl River sites to provide context for the WY 2018 data. Peak streamflow during WY 2018 occurred in March at Pearl US and in April at Wolf US, Beasha US, and Pearl DS (table 7; fig. 4). Peak streamflow during WY 2018 was substantially less than the long-term period of record peak streamflow at the two Pearl River sites (table 7). The 7-day low flow and minimum daily mean streamflows were in October for Beasha US and in October and November for Wolf US. For the two Pearl River sites, the 7-day low flow and minimum daily mean streamflows recorded during WY 2018 were in September and were greater than historical records (table 7).

Hydrographs of streamflow for WY 2018 were generally similar between Wolf US and Beasha US (fig. 4). Beasha US generally had slightly higher peak flows during overlapping storm-flow events, and Wolf US had localized, high-flow events in June, July, and August that did not occur at Wolf US. The frequency, magnitude, and duration of flow events were mostly similar, suggesting the two creeks behave similarly, which is consistent with the land-use percentages of the two watersheds (table 1).

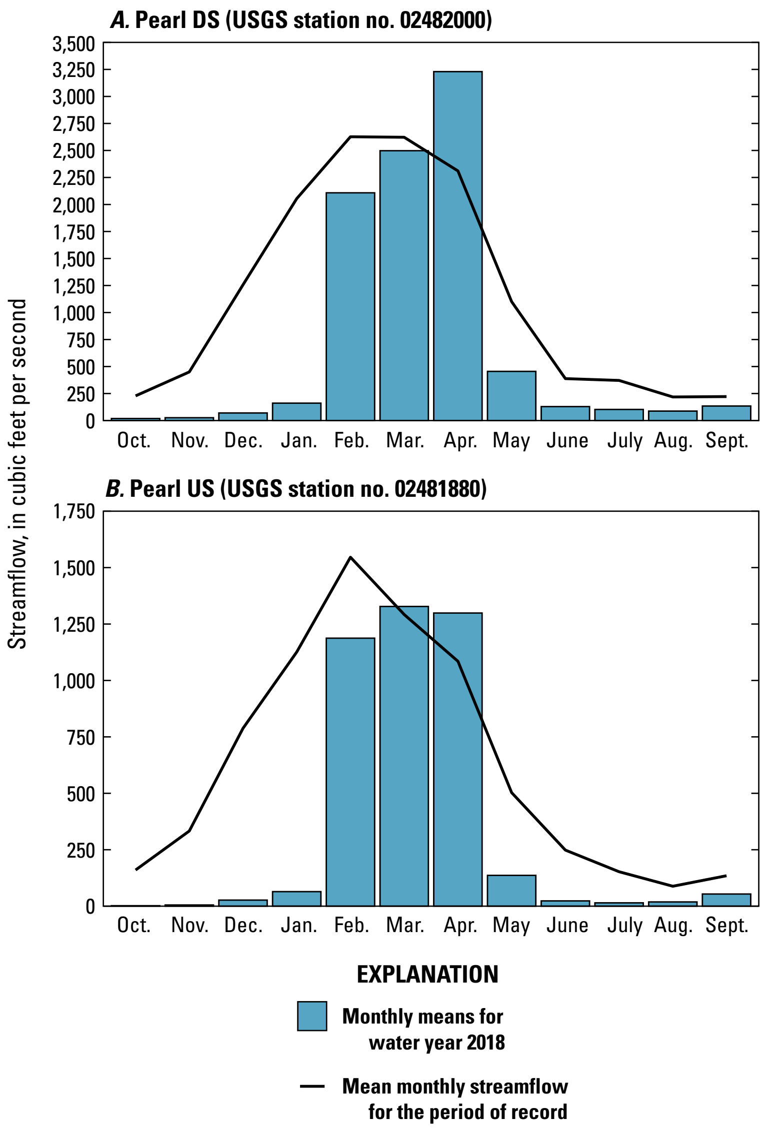

Figure 3. Monthly mean streamflow for water year 2018 (October 2017 to September 2018) and mean monthly streamflow for the entire period of record at *A*, Pearl River at Edinburg (Pearl DS; August 1928 to September 2018) and *B*, Pearl River at Burnside, (Pearl US; January 1980 to September 2018), central Mississippi.

Water-Quality Assessment

Water-Quality Data

Water-quality samples were collected on four occasions (October 2017, January 2018, April 2018, and August 2018) at approximately quarterly intervals. At Kentawka, only two quarterly water-quality samples were collected (January 2018 and April 2018) due to lack of streamflow during October 2017 and August 2018. Water-quality data consist of constituents categorized as physicochemical properties, major ions, nutrients, and OWCs. The high variability of physical, chemical, and biological processes within stream ecosystems often requires that water-quality data be evaluated based on ranges of constituent values that may occur over time and space related to natural or anthropogenic fluxes in climate, streamflow, and land use. Water-quality data are therefore discussed in the context of ranges of constituents and how they may relate to current and historical conditions (if available). Data from this study may be used as a baseline condition for future studies and MBCI programs.

The MDEQ currently regulates water quality within the State through application of narrative standards and numeric criteria based on the designated use of a waterbody in order to protect and prevent degradation of aquatic life and harmful effects to human health (MDEQ, 2016). However, waters within the PRC Tribal lands are not directly regulated under State or Federal water-quality criteria or guidelines (EPA, 2000; MDEQ, 2011, 2016). The surface waters within the Pearl River watershed upstream of the Ross R. Barnett Reservoir (fig. 1) are generally classified by the MDEQ as “Fish and Wildlife” and their designated uses are defined as aquatic life use, fish consumption, and secondary contact recreation (MDEQ, 2016). The mainstem of the Pearl River is also classified as “Recreation” and designated for primary contact recreational use. Primary contact activities include swimming, bathing, skiing, and other water-play activities where full body immersion and ingestion are likely, whereas secondary contact includes activities such as wading, fishing, and boating where contact with the water is incidental and immersion is unlikely. Additionally, nutrient water quality within Mississippi is evaluated by using nutrient (total nitrogen [TN] and total phosphorus [TP]) thresholds proposed by the MDEQ for different bioregions (MDEQ, 2011) and (or) by the EPA for streams within Aggregate Ecoregion IX (EPA, 2000). The EPA established these recommended water-quality criteria for TN and TP on the basis of the upper 25th percentile of nutrient concentrations from reference sites (pristine or minimally impaired waters) within an ecoregion (EPA, 2000). Although the regulatory water-quality standards/criteria (MDEQ, 2016) and recommended nutrient criteria/thresholds (EPA, 2000; MDEQ, 2011) do not directly apply to surface waters within the Tribal land boundaries of the MBCI, water-quality data collected from the eight stream sites within or contiguous to the PRC during this study are evaluated in comparison with these existing sets of water-quality criteria.

Physicochemical Properties

In general, with a few exceptions, results of quarterly and continuous diel physical properties (tables 7 and 8; fig. 5) do not indicate adverse persistent water-quality conditions in the study area. Water temperature varied with seasonal climate,

Table 7. Seven-day low flow, minimum daily mean streamflow, and peak streamflow for water year 2018 and the period of record for streamflow-gaging stations on the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi.

[Water year 2018 is defined as October 1, 2017, through September 30, 2018. ft^3/s, cubic foot per second; US, upstream; –, not calculated; DS, downstream; Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Site	7-day low flow (ft^3/s)		Minimum daily mean streamflow (ft^3/s)			Peak streamflow (ft^3/s)		
	Water year 2018	Period of record	Water year 2018	Period of record	Date	Water year 2018	Period of record	Date
Wolf US	0.03	–	0.03	–	Oct.–Nov., 2017	286	–	April 6, 2018
Beasha US	0.32	–	0.23	–	October 7, 2017	257	–	April 22, 2018
Pearl US	1.75	0.36	1.36	0.29	September 20, 2000	4,030	34,600	March 14, 2018
Pearl DS	16.39	1.40	15.3	1.3	September 5, 2000	5,720	73,500	April 9, 2018

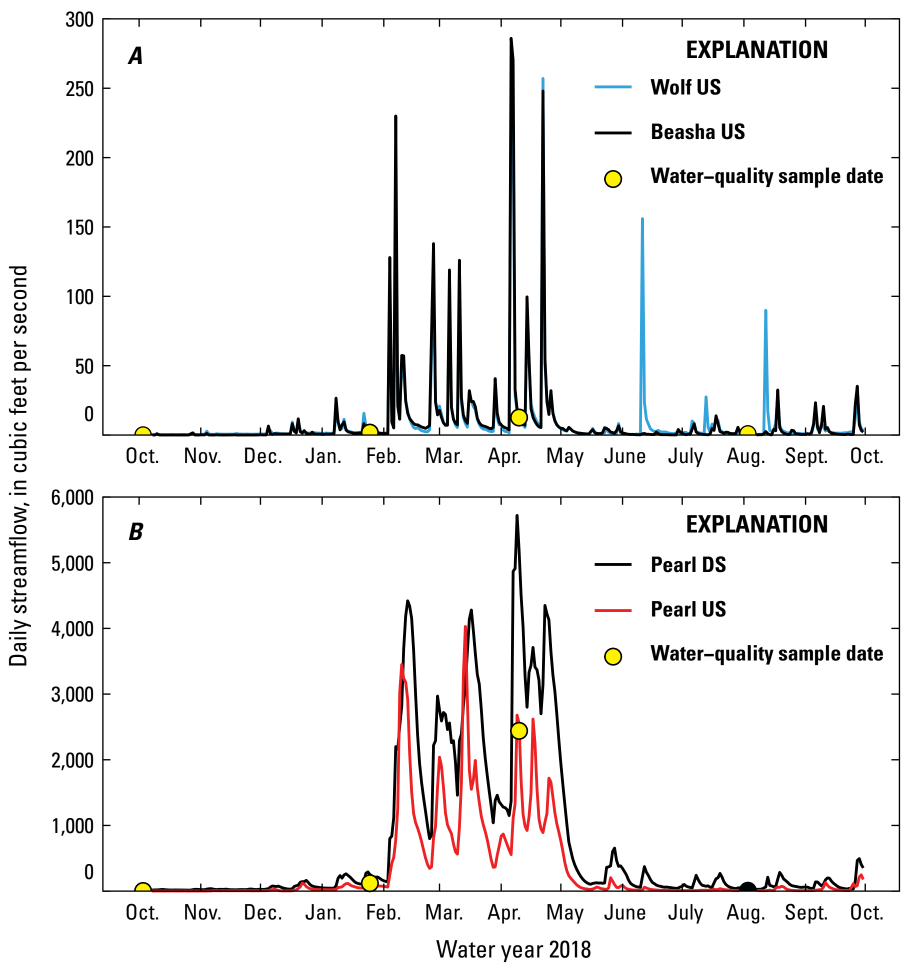

Figure 4. Hydrographs showing the daily streamflow for water year 2018 (October 2017 to September 2018) at *A*, Wolf Creek at Industrial Drive near Pearl River (Wolf US) and Beasha Creek near Coldwater (Beasha US) and *B*, Pearl River at Edinburg (Pearl DS) and Pearl River at Burnside (Pearl US), central Mississippi.

and the range of quarterly temperatures (5.4 to 28.0 °C; table 8) was typical for the times of year when sites were sampled. The mean water temperature at Kentawka was likely biased low because only two quarterly measurements were taken: one in January 2018 and one in April 2018. Continuous 48-hour readings in June 2018, however, also indicated relatively cooler water temperatures at the Kentawka and Jones sites than at the other sites (table 8; fig. 5*A*). Small stream size and potentially higher degree of riparian shading may have contributed to relatively lower temperatures at these two sites. At the Jones site, cold-water release from Lake Pushmataha may have also influenced water temperatures. Despite this, the ranges of water temperatures measured quarterly or continuously were not indicative of thermal stress or impairment.

SC values were low and within expected ranges at most sites, but high values at some sites indicated anthropogenic activities in the respective watersheds. SC values were relatively low and consistent among quarterly samples from six of the eight sites, not including the Wolf US and DS sites, ranging from 33 to 113 microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C), with means between 40 and 85 µS/cm (table 8). SC values were relatively much higher in all quarterly samples from Wolf DS (a high of 548 µS/cm in October 2017 and a mean of 294 µS/cm across the four sampling events) and higher for one sampling event at Wolf US (298 µS/cm in October). Diel 48-hour continuous SC values showed a similar pattern to quarterly values, in which SC values were higher at Wolf US (168–223 µS/cm) and Wolf DS (359–425 µS/cm) compared to other sites (table 9; fig. 5*B*). SC is a measure of the electrical conductivity of water, which varies as a function of the concentration of dissolved solids and ions. Although SC can vary naturally depending on multiple factors (for example, underlying geology, chemical processes, groundwater interactions, and hydrology), increased conductance can be an indication of anthropogenic activity and ecological stress (EPA, 2011). High SC at Wolf DS is likely due to point-source effluent discharge from the Pearl River WWTP located just upstream of this site. Likewise, periodically high SC at Wolf US is likely due to groundwater irrigation runoff from the nearby golf course and other developed Tribal properties (such as casinos or parking lots). The ranges of quarterly and 48-hour continuous SC values at all eight sites were below the MDEQ standard of 1,000 µS/cm for surface waters categorized as “Fish and Wildlife” (MDEQ, 2016). Studies have shown that aquatic organisms can be negatively affected by increased SC, however, and 300 µS/cm is a commonly used benchmark for protecting aquatic insect communities (EPA, 2011; Clements and Kotalik, 2016).

Quarterly pH values showed relatively little seasonal variation within sites and little spatial variation between sites (table 8). Values ranged from 5.8 to 7.4, and mean quarterly pH values were generally between 6.3 and 6.9 among sites, except for Kentawka (table 8). The two quarterly pH measurements collected at Kentawka in January and April 2018 (5.8 and 5.9, respectively) and measurements at Pearl US and Pearl DS in April 2018 (each 5.9) were slightly below the State minimum pH standard of 6.0 (MDEQ, 2016). Continuous 48-hour pH measurements in June 2018 for the six continuous water-quality sampling sites were generally between 6.5 and 7.5, and no measurements were below the State minimum pH standard (table 9; fig. 5*C*). The ranges of quarterly and continuous 48-hour pH values among sites seem unlikely to be a source of ecological stress.

DO concentrations indicate natural fluctuations at most sites, but relatively low DO concentrations at a few sites also indicate disturbed conditions. DO concentrations ranged from 3.5 to 12.5 mg/L across the quarterly measurements from all sites, and mean DO concentrations were between 6.4 and 10.6 mg/L (table 8). The lowest quarterly DO concentrations were measured at Pearl US in October 2017 and August 2018 (3.5 and 3.7 mg/L, respectively) and were below the MDEQ instantaneous DO standard of 4.0 mg/L (MDEQ, 2016). The minimum quarterly DO concentration at Wolf DS in October 2017 was also relatively low (4.6 mg/L) compared to other sites. DO concentrations were relatively lower during October 2017 at all sites compared to other quarterly measurements. Seasonally low DO concentrations at Pearl US may be attributed to low flows, warm surface temperatures, and possible stratification of a pool near where measurements were taken. Except for the two occasions at Pearl US, all quarterly instantaneous DO concentrations from the other sites were above the MDEQ instantaneous standard of 4.0 mg/L (MDEQ, 2016). Instantaneous DO concentrations were not measured at Kentawka in October 2017 or August 2018 because of lack of streamflow. Continuous DO concentrations were measured over a 48-hour period in June 2018 at all sites. However, continuous DO data from Kentawka appeared to be erroneous, likely due to sensor malfunction, and these data were omitted from this report. At Wolf DS, most continuous DO concentrations were between 4.5 and 5.0 mg/L, and the mean and median were below the MDEQ daily average DO standard of 5.0 mg/L (table 9; fig. 5*D*; MDEQ, 2016). At Wolf US, DO concentrations were also relatively low compared to other sites, but concentrations did not fall below the instantaneous or average daily DO standards (MDEQ, 2016). DO varies naturally on a daily and seasonal basis because of associated biological, chemical, and physical stream processes; however, chronic or periodic low DO concentrations can be primary stressors for many aquatic organisms and can be indicators of stream impairment (for example, increased nutrients, organic matter, algal blooms, or bacteria). The relatively low variability of DO concentrations at both Wolf Creek sites, particularly for Wolf DS, over the continuous 48-hour period (fig. 5*D*), however, does not suggest that DO concentrations were strongly related to increased photosynthesis by aquatic plants (algae) in direct response to nutrient enrichment. Instead, relatively low DO concentrations at Wolf DS and Wolf US may be more indicative of relatively higher biological oxygen demand and decomposition related to inputs of organic matter from point and and nonpoint runoff from the Wolf Creek drainage area.

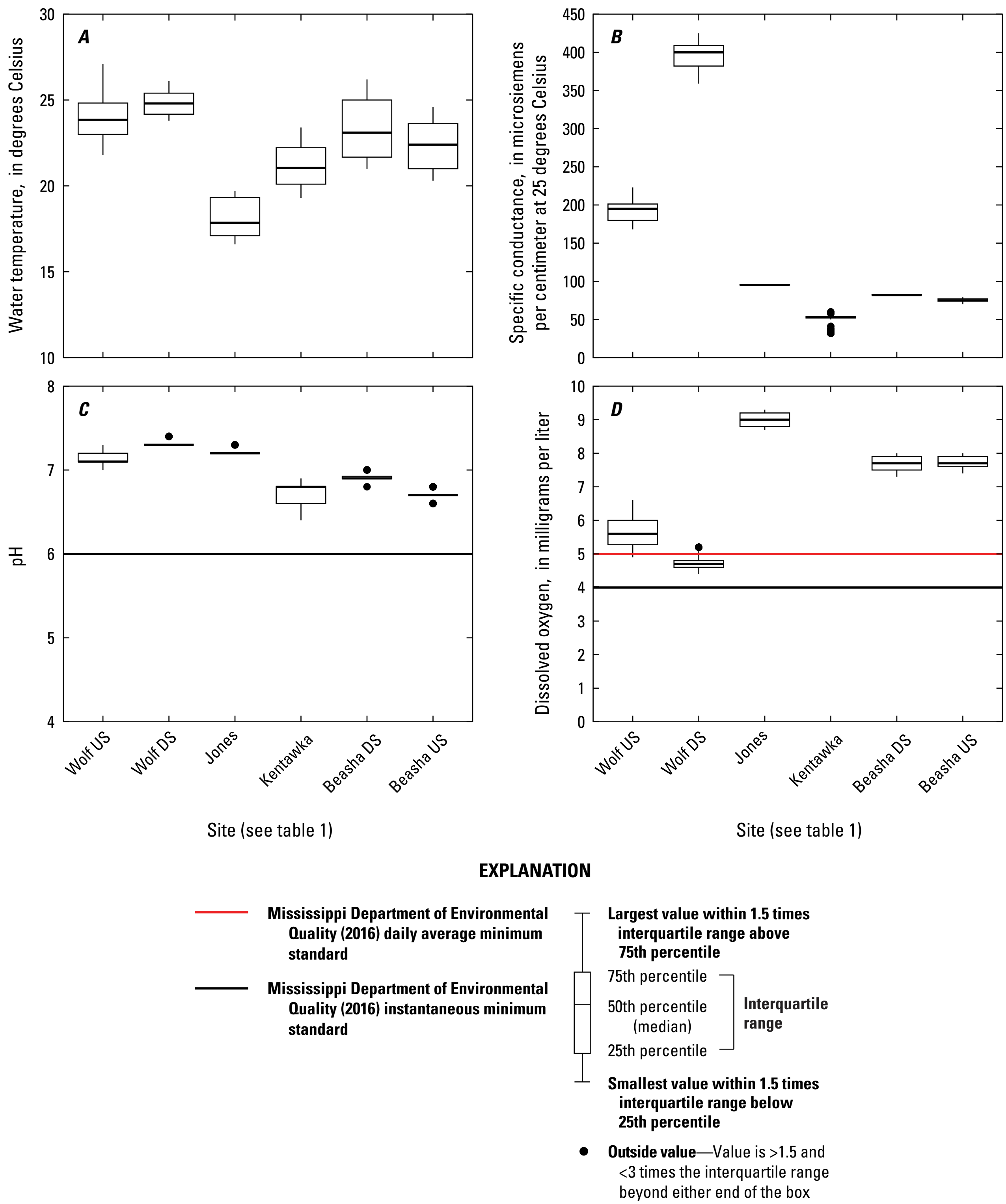

Figure 5. Boxplots showing 48-hour continuous water-quality data collected at six tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, June 2018. [Number of values = 96 measurements]

Table 8. Statistical summary of instantaneous measurements from quarterly sampling of the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, Mississippi, October 2017–August 2018.

[n, number of samples; °C, degree Celsius; SC, specific conductance; µS/cm, microsiemens per centimeter at 25 °C; DO, dissolved oxygen; mg/L, milligrams per liter; min, minimum; max, maximum; US, upstream; DS, downstream; Bold values are below the Mississippi Department of Environmental Quality instantaneous minimum water-quality standards: pH, 6.0 units; DO, 4.0 mg/L (MDEQ, 2016); Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Site	n	Water temperature (°C)				SC (µS/cm)				pH				DO (mg/L)			
		Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max
Wolf US	4	17.9	18.5	11.1	23.6	121	70	54	289	6.6	6.7	6.2	6.8	8.2	8.2	5.5	11.1
Wolf DS	4	19.2	20.0	11.3	25.6	294	248	132	548	6.9	6.9	6.7	7.3	7.8	8.1	4.6	10.4
Jones	4	15.6	16.6	6.0	23.3	85	86	74	96	6.8	6.8	6.5	7.1	9.3	9.3	6.0	12.5
Kentawka	2	10.5	10.5	8.4	12.6	40	40	34	45	**5.9**	**5.9**	**5.8**	**5.9**	10.6	10.6	10.3	10.9
Beasha DS	4	18.0	19.0	8.5	25.4	72	74	49	90	6.6	6.7	6.3	6.8	8.8	8.2	7.4	11.3
Beasha US	4	16.3	18.5	5.4	22.8	72	74	56	84	6.3	6.4	6.0	6.6	9.1	8.8	7.3	11.7
Pearl US	4	17.1	18.5	5.9	25.7	61	68	33	74	6.5	6.5	**5.9**	7.0	6.4	5.6	**3.5**	10.8
Pearl DS	4	18.4	18.5	8.5	28.0	80	86	35	113	6.7	6.8	**5.9**	7.4	7.9	7.3	6.9	10.1

Table 9. Statistical summary of continuous diel measurements (n = 96) from 48-hour sampling of six tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, June 2018.

[°C, degree Celsius; SC, specific conductance; µS/cm, microsiemens per centimeter at 25 °C; DO, dissolved oxygen; mg/L, milligrams per liter; min, minimum; max, maximum; US, upstream; DS, downstream; —, data not available; Bold value is below the Mississippi Department of Environmental Quality minimum daily average DO standard of 5.0 mg/L (MDEQ, 2016). Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Site (table 1)	Water temperature (°C)				SC (µS/cm)				pH				DO (mg/L)			
	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max
Wolf US	24.1	23.9	21.8	27.1	193	195	168	223	7.1	7.1	7.0	7.3	5.7	5.6	4.9	6.6
Wolf DS	24.8	24.8	23.8	26.1	397	400	359	425	7.3	7.3	7.3	7.4	**4.7**	4.7	4.4	5.2
Jones	18.1	17.9	16.6	19.7	95	95	94	96	7.2	7.2	7.2	7.3	9.0	9.0	8.7	9.3
Kentawka	21.2	21.1	19.3	23.4	51	53	32	60	6.7	6.8	6.4	6.9	—	—	—	—
Beasha DS	23.3	23.1	21.0	26.2	82	82	81	83	6.9	6.9	6.8	7.0	7.7	7.7	7.3	8.0
Beasha US	22.4	22.4	20.3	24.6	75	75	70	79	6.7	6.7	6.6	6.8	7.7	7.7	7.4	8.0

Major Ions

Major ions are dissolved constituents that make up the bulk of inorganic dissolved solids in water. Concentrations of major ions in stream water are often used to define water type, identify mixing, and indicate the approximate concentrations of total dissolved solids. Concentrations of the major cations (calcium, magnesium, sodium, and potassium) and major anions (sulfate, chloride, and fluoride) were determined by laboratory analysis. Concentrations of bicarbonate and carbonate anions were determined in the field using tritration methods (USGS, 2012).

Descriptive statistics (minimum, median, and maximum concentrations) for major ions (table 10) indicate that all major ions except carbonate were detected in quarterly water samples at each site. The highest maximum concentrations of major ions were observed in samples from the two Wolf Creek sites. Wolf DS had the highest maximum concentrations for seven of nine major ions—sodium, potassium, bicarbonate, carbonate, chloride, sulfate, and fluoride; Wolf US had highest maximum concentrations of calcium and magnesium (table 10). The median concentrations of major ions at Wolf DS were between 1.2 and 16 times greater than median concentrations of other sites. Carbonate concentrations in freshwater are often low, and the detection of carbonate can be indicative of surface runoff and wastewater contaminants (Griffith, 2014). Detection of carbonate at the two Wolf Creek sites may be also related to groundwater sources from irrigation runoff from the golf course. Runoff from nearby developments such as recreational (Dancing Rabbit Golf Club, Silver Star Hotel and Casino, and Golden Moon Hotel and Casino), municipal, and industrial facilities and associated impervious surfaces in the watershed are likely sources of major ions at Wolf US; however, high ion concentrations at Wolf DS can likely be attributed to point-source discharges from the Pearl River WWTP. In Mississippi, numeric criteria do not exist for major ions for waters designated for fish and wildlife, but the ranges of concentrations of chloride (2.13–72.4 mg/L) and fluoride (0.02–0.76 mg/L) among stream sites (table 10) were below the established standards for waters designated for public water supply (230 mg/L for chloride and 2.0 mg/L for fluoride) (MDEQ, 2016). Toxic effects of major ions on aquatic organisms are highly variable and are generally associated with metabolic stress and osmoregulation (Clements and others, 2012; Clements and Kotalik, 2016). Tolerance indicator values for chloride exposure of many freshwater fish species have been determined to be less than 40 mg/L (Meador and Carlisle, 2007). Chloride concentrations among some quarterly water samples at Wolf DS were greater than 40 mg/L, indicating stressful conditions could exist periodically at this site. Further, the influence that high major ion concentrations have on SC and, relatedly, to some macroinvertebrate taxa, may be of future concern (Clements and Kotalik, 2016).

The concentrations of major ions were converted to standardized milliequivalent units, and the relative percentages of major cations and anions among each quarterly water-quality sample for each site (except for Kentawka) are illustrated in a trilinear Piper diagram (fig. 6) (Hem, 1985). At most sites, the relative percentages of major anions were dominated by bicarbonate, and the major cations were mixed between calcium, magnesium, and sodium, with a slight predominance of calcium, indicating that calcium-bicarbonate was the most common water type among sites (fig. 6). However, Wolf DS had a higher relative percentage of sodium than other sites, indicating a shift toward a sodium-bicarbonate water type downstream of the WWTP.

Nutrients

Nutrients include different compounds, primarily those of nitrogen (N) and phosphorus (P), that can stimulate plant growth. N and P naturally enter freshwater systems through atmospheric deposition, geologic weathering, and biological processes such as nitrification of N by microscopic organisms, and they typically exist in streams at relatively low levels (Dodds and Whiles, 2010). Point (wastewater discharge) and nonpoint sources (for example, runoff from fertilizer and manure applications to lawns and agricultural fields) are major anthropogenic nutrient inputs to freshwater ecosystems. Increased nutrient inputs can lead to excessive plant growth in aquatic environments, which can then result in reduction of DO, which is critical to many aquatic organisms. Therefore, nutrient enrichment is often an indication of stressful and (or) degraded ecologic conditions in freshwaters (Dodds and Whiles, 2010).

Nutrient concentrations from quarterly water-quality samples for selected N (TN, nitrate plus nitrite, and ammonia) and P (TP and orthophosphate) constituents (figs. 7 and 8, respectively) and summary statistics (table 11) indicate that nutrient concentrations varied among sites and across seasons. Concentrations for both constituents ranged across several orders of magnitude among the quarterly water samples collected at the sites. Kentawka generally had the lowest N (fig. 7) and P (fig. 8) constituent concentrations of all sites, and Wolf DS had the highest concentrations. Nutrient concentrations tended to be lower in the fall (October) at most sites but were highest in fall and summer (August) at Wolf DS (figs. 7 and 8). Relatively low nutrients during the fall of 2017 may be related to base-flow conditions at most sites; however, variability of the quarterly (seasonal) nutrient concentrations among sites does not appear to be strongly related to streamflows. Relatively higher ammonia concentrations (maximum of 0.34 mg/L) occurred periodically at Jones and Pearl DS (fig. 7*C*); however, given pH and temperature values, these concentrations should not be harmful to freshwater organisms (EPA, 2013).

Table 10. Statistical summary of major ion concentrations in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–September 2018.

[U.S. Geological Survey parameter code in parentheses in header; n, number of samples; min., minimum; max., maximum; US, upstream; DS, downstream; —, not applicable; All concentrations are in milligrams per liter. See table 1 for site information. Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

	Calcium (00915)	Magnesium (00925)	Sodium (00930)	Potassium (00935)	Bicarbonate (00453)	Carbonate (00452)	Chloride (00940)	Sulfate (00945)	Fluoride (00950)
All sites (n=30)									
Min.	1.41	0.74	2.03	0.83	7.8	0.0	2.13	1.20	0.02
Max.	23.70	5.17	79.70	6.35	134.0	0.5	72.40	19.70	0.76
Median	4.88	1.91	5.06	2.27	28.9	0.0	5.40	4.74	0.06
Wolf US (n=4)									
Min.	3.53	1.35	3.85	1.36	14.5	0.0	3.37	3.42	0.05
Max.	23.70	5.17	26.50	2.66	128.0	0.2	16.90	13.10	0.44
Median	6.11	1.90	5.24	2.03	23.4	0.0	5.03	8.09	0.07
Wolf DS (n=4)									
Min.	6.21	1.91	13.70	2.10	40.7	0.0	9.37	9.08	0.18
Max.	20.00	4.06	79.70	6.35	134.0	0.5	72.40	19.70	0.76
Median	12.25	2.69	32.85	3.88	84.5	0.2	20.85	14.20	0.32
Jones (n=4)									
Min.	4.22	1.18	6.94	1.13	28.9	0.0	5.66	1.20	0.06
Max.	7.07	2.17	8.89	1.59	45.6	0.0	7.96	6.32	0.09
Median	4.70	1.62	7.96	1.33	30.5	0.0	6.62	3.74	0.07
Kentawka (n=2)									
Min.	1.41	0.87	2.28	0.83	—	—	2.49	5.60	0.02
Max.	1.95	1.23	2.99	1.08	—	—	3.63	8.19	0.02
Median	1.68	1.05	2.64	0.96	—	—	3.06	6.90	0.02
Beasha DS (n=4)									
Min.	2.85	1.21	3.00	1.63	13.5	0.0	3.34	2.93	0.03
Max.	7.11	2.59	4.99	3.37	36.3	0.0	5.42	4.42	0.08
Median	5.00	1.88	4.31	2.73	24.2	0.0	5.36	3.88	0.06
Beasha US (n=4)									
Min.	3.58	1.41	2.80	1.86	13.6	0.0	3.86	2.24	0.03
Max.	7.60	2.76	3.69	3.04	31.4	0.0	6.54	7.38	0.06
Median	5.53	2.16	2.97	2.29	13.6	0.0	4.15	4.65	0.04
Pearl River US (n=4)									
Min.	1.91	0.74	2.03	1.73	7.8	0.0	2.13	1.33	0.03
Max.	4.63	2.03	5.83	2.79	25.9	0.0	6.97	7.54	0.05
Median	4.25	1.80	3.67	2.36	21.7	0.0	4.26	1.98	0.05
Pearl DS (n=4)									
Min.	1.92	0.79	2.13	1.84	10.6	0.0	2.21	2.43	0.03
Max.	7.17	2.61	9.00	3.09	40.2	0.0	8.62	6.02	0.12
Median	5.01	1.99	6.72	2.74	26.5	0.0	6.44	4.16	0.08

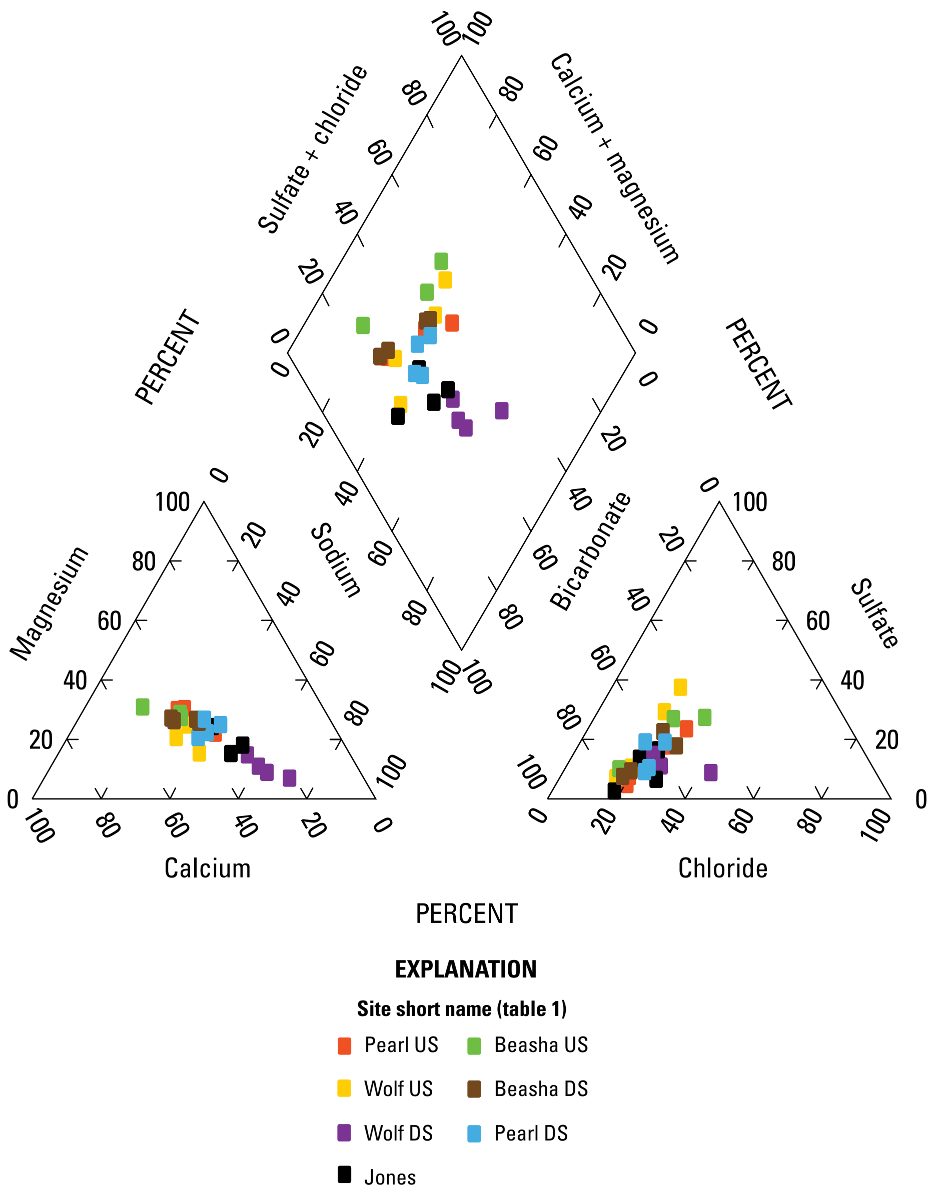

Figure 6. Trilinear Piper diagram showing the relative median compositions of major ions in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–August 2018.

TN and TP concentrations among sites periodically exceeded recommended nutrient thresholds recommended by the MDEQ for the East Bioregion (MDEQ, 2011) and by the EPA for streams in Aggregate Ecoregion IX (EPA, 2000). These exceedances suggest periods of nutrient enrichment among most stream sites, particularly for TP concentrations, in which the minimum TP concentrations among quarterly samples exceeded one or both recommended TP thresholds (fig. 8; table 11) at five of the eight sites (exception of Jones, Kentawka, and Beasha US). At Wolf DS, the median TN concentration of 2.51 mg/L was approximately 3 to 3.5 times higher than the recommended TN thresholds of 0.85 mg/L by the MDEQ or 0.69 mg/L by the EPA. Likewise, the median TP concentration of 0.642 mg/L at Wolf DS was approximately 10 to 17 times higher than the MDEQ and EPA recommended thresholds (0.060 mg/L and 0.037 mg/L, respectively) (table 11). TN and TP concentrations at Pearl DS, which is the downstream-most site and receives confluent flows from all other sites, were generally similar to those at the Pearl US site as well as the other tributary sites. The median and mean TN and TP concentrations for waters exiting MBCI Tribal lands at Pearl DS exceeded the respective recommended nutrient thresholds (table 11). Kentawka was the only site where all quarterly nutrient samples were measured below the recommended thresholds for both TN and TP.

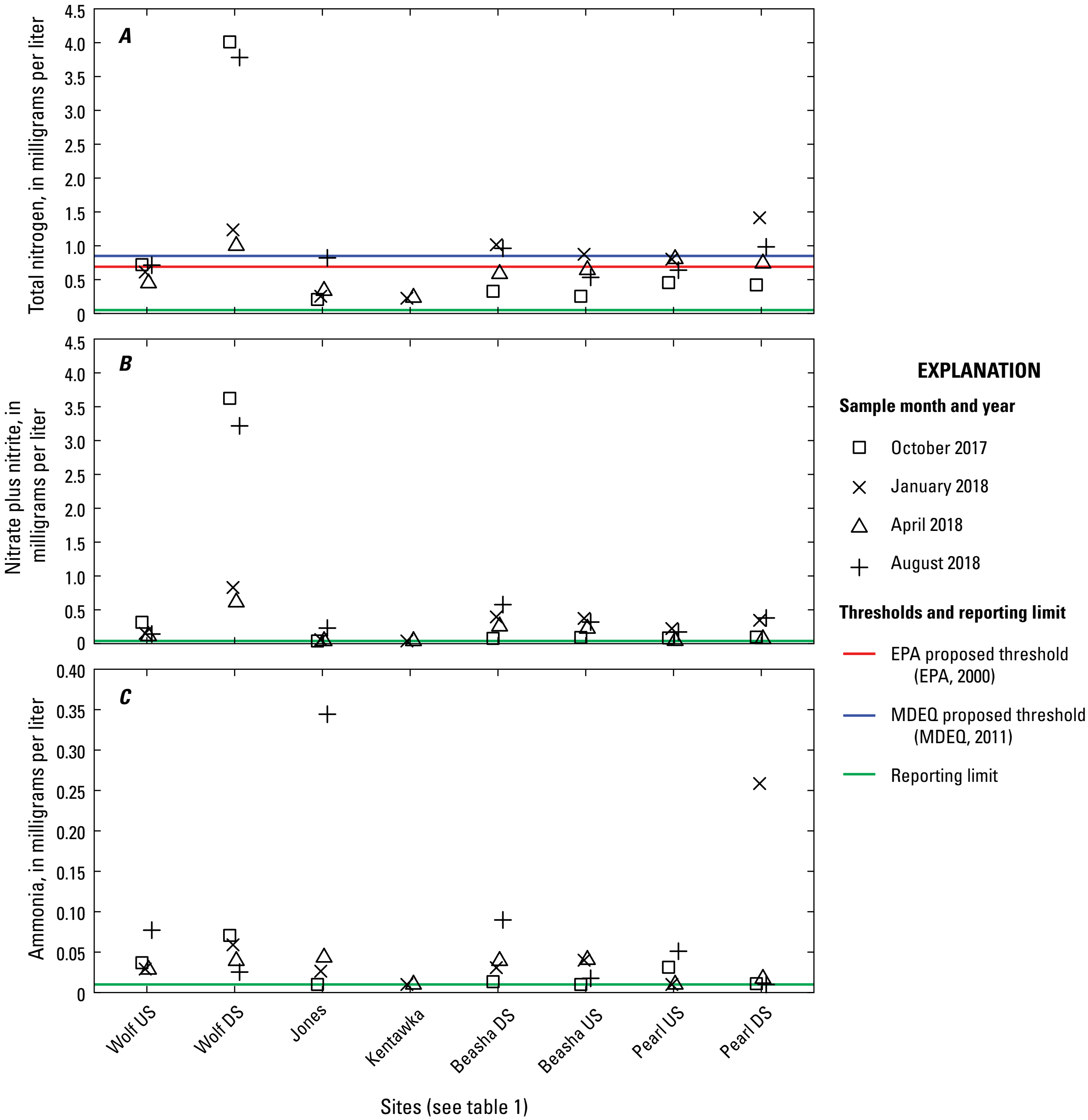

Figure 7. Concentrations of selected nitrogen constituents in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–August 2018. [EPA, U.S. Environmental Protection Agency; MDEQ, Mississippi Department of Environmental Quality]

Organic Wastewater Compounds

OWCs include substances such as disinfectants, flame retardants, pharmaceuticals, and personal care products that persist in the environment and enter surface waters from a variety of sources such as wastewater effluent, landfill leachate, and urban or industrial runoff (Daughton and Ternes, 1999; Kolpin and others, 2002). Twenty-nine of the 60 OWC constituents surveyed were detected (including quantifiable and unquantifiable concentrations) among all sites (table 12). Concentrations of detected OWCs were generally low, and only 19 percent (28 of 145) of laboratory detections were concentrations above the respective reporting level. Camphor, cholesterol, caffeine, beta-sitosterol, hexahydrohexamethyl cyclopentabenzopyran (HHCB), and N,N-diethyl-*meta*-toluamide (DEET) had the highest frequencies of detection (30.0 to 63.3 percent) among all samples collected. Ten OWCs with endocrine-disrupting potential were

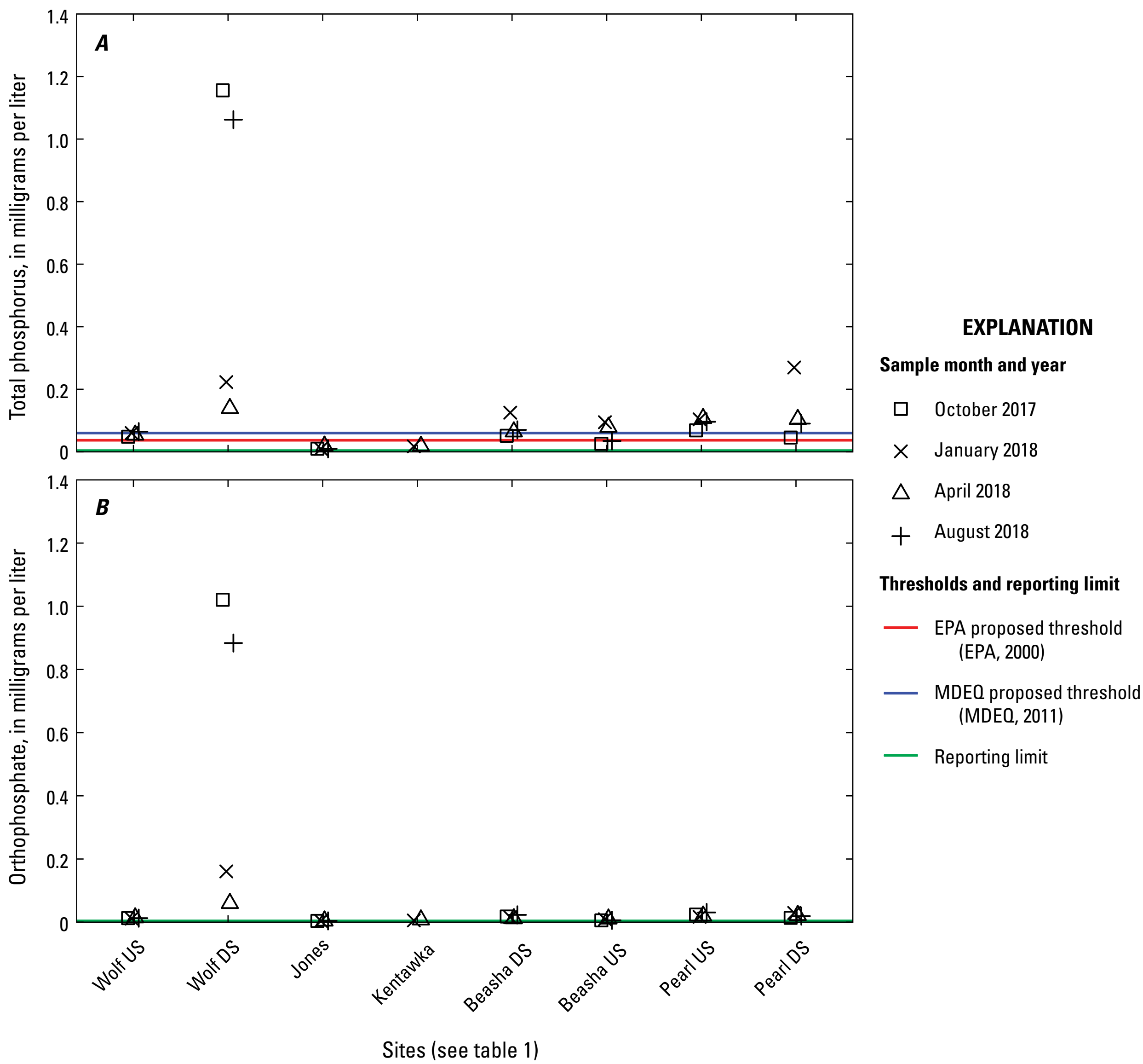

Figure 8. Concentrations of selected phosphorus constituents in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–August 2018. [EPA, U.S. Environmental Protection Agency; MDEQ, Mississippi Department of Environmental Quality]

detected across all samples and sites, but only 5 of these were detected at quantifiable concentrations and only 3—acetyl hexamethyl tetrahydro naphthalene (AHTN), p-Cresol, and 1,4-dichlorobenzene—were detected above the reporting level among all samples (table 12).

Wolf US and Wolf DS had the greatest numbers of individual OWCs detected, overall detections, and detections above the reporting level (RL) (table 13). Caffeine, camphor, HHCB, and DEET were the most frequently detected compounds at the two Wolf Creek sites. Kentawka had the least total number of OWC detections, and none of the detected compounds at this site were quantifiable above their RL. Jones, Beasha US, and Pearl US each had only 1 or 2 detections of any OWC above the reporting level (table 13). Endocrine-disrupting compounds were detected in at least one quarterly water sample at all sites, but concentrations of these compounds were often below the RL (table 12). Endocrine-disrupting compounds were detected above the RL at Wolf US (AHTN and p-Cresol), Wolf DS (AHTN and 1,4-Dichlorobenzene), Pearl US (AHTN), and Jones (p-Cresol).

Table 11. Statistical summary of nutrient concentrations in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–August 2018.

[USGS, U.S. Geological Survey; MRL, minimum reporting level; mg/L, milligrams per liter; n, number of samples; Min., minimum; Max., maximum; N, nitrogen; —, not applicable; P, phosphorus; Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Nutrient (USGS parameter code)	MRL (mg/L)	Site (table 1)	n	Min. (mg/L)	Max. (mg/L)	Median (mg/L)	Mean (mg/L)
Total nitrogen, as N (62855)	0.05	Wolf US	4	0.45	0.72	0.66	0.62
		Wolf DS	4	1.00*+	4.01*+	2.51*+	2.51*+
		Jones	4	0.21	0.82*	0.3	0.4
		Kentawka	2	0.23	0.23	0.23	0.23
		Beasha DS	4	0.33	1.02*+	0.77*	0.72*
		Beasha US	4	0.25	0.87*+	0.59	0.58
		Pearl US	4	0.46	0.81*	0.72*	0.68
		Pearl DS	4	0.42	1.41*+	0.86*+	0.89*+
Nitrate plus nitrite, as N (00631)	0.04	Wolf US	4	0.11	0.32	0.15	0.18
		Wolf DS	4	0.61	3.62	2.02	2.07
		Jones	4	<0.04	0.23	0.05	0.15
		Kentawka	2	<0.04	<0.04	—	—
		Beasha DS	4	0.08	0.58	0.33	0.33
		Beasha US	4	0.09	0.37	0.27	0.25
		Pearl US	4	0.04	0.22	0.13	0.13
		Pearl DS	4	0.07	0.38	0.22	0.22
Ammonia, as N (00608)	0.01	Wolf US	4	0.03	0.08	0.03	0.04
		Wolf DS	4	0.03	0.07	0.05	0.05
		Jones	4	<0.01	0.34	0.04	0.14
		Kentawka	2	<0.01	<0.01	—	—
		Beasha DS	4	0.01	0.09	0.04	0.04
		Beasha US	4	<0.01	0.04	0.03	0.03
		Pearl US	4	<0.01	0.05	0.02	0.04
		Pearl DS	4	<0.01	0.26	0.01	0.1
Total phosphorus, as P (00665)	0.004	Wolf US	4	0.048*	0.065*+	0.057*	0.057*
		Wolf DS	4	0.139*+	1.16*+	0.642*+	0.645*+
		Jones	4	0.009	0.019	0.010	0.012
		Kentawka	2	0.017	0.018	0.0178	0.0178
		Beasha DS	4	0.051*	0.125*+	0.067*+	0.078*+
		Beasha US	4	0.026	0.095*+	0.057*	0.059*
		Pearl US	4	0.069*+	0.107*+	0.100*+	0.094*+
		Pearl DS	4	0.046*	0.270*+	0.097*+	0.127*+
Orthophosphate, as P (00671)	0.004	Wolf US	4	0.011	0.014	0.013	0.013
		Wolf DS	4	0.059	1.021	0.522	0.531
		Jones	4	<0.004	<0.004	—	—
		Kentawka	2	0.006	0.008	0.007	0.007
		Beasha DS	4	0.011	0.023	0.017	0.017
		Beasha US	4	0.006	0.010	0.008	0.008
		Pearl US	4	0.017	0.031	0.022	0.023
		Pearl DS	4	0.014	0.029	0.021	0.021

*Value exceeded U.S. Environmental Protection Agency Aggregate Ecoregion IX recommended nutrient threshold of 0.69 mg/L for total nitrogen or 0.037 mg/L for total phosphorus (U.S. Environmental Protection Agency, 2000).

+Value exceeded Mississippi Department of Environmental Quality Stressor Response East Bioregion recommended threshold of 0.85 mg/L for total nitrogen or 0.060 mg/L for total phosphorus (Mississippi Department of Environmental Quality, 2011).

Sediment-Quality Data

Trace Elements and PAH Compounds

Trace elements occur in stream environments from natural weathering of the underlying geology and soils as well as from deposition from human sources such as industrial waste, mining, agricultural runoff, and burning of fossil fuels/vehicle emissions (Horowitz, 1991; Horowitz and Stephens, 2008). PAHs can occur naturally as the result of incomplete combustion of organic substances; however, PAHs in the environment are predominantly from human sources (burning of fossil fuels and production/processing of petroleum products) (McVeety and Hites, 1988). Because many trace elements and PAHs adsorb to fine sediment particles, contaminant concentrations can often be low and (or) undetectable in the water column but may accumulate in streambed sediments (McVeety and Hites, 1988; Horowitz, 1991; EPA, 2004). Sediment-bound compounds can be ingested by benthic organisms and can move up through higher levels of the food chain. Some elements and compounds can be directly toxic to aquatic organisms, while others may bioaccumulate in animal tissue and pose health risks to humans if ingested (EPA, 2004; Paul and others, 2012). Examination of streambed-sediment quality can help to evaluate susceptibility of aquatic organisms to deleterious or toxic effects of contaminants and potential risks to human health (EPA, 2004).

Most trace elements analyzed from the streambed-sediment samples collected in August 2018 were detected at all sites. Aluminum, calcium, iron, magnesium, potassium, sodium, sulfur, and titanium are often generally abundant in soils and sediments (Shacklette and Boerngen, 1984), and quantities of these elements are reported as percentages of the total sample weight (table 14). Each of these eight common trace elements accounted for less than 6 percent of the sample weight, and collectively, these eight elements accounted for about 9 to 13 percent of the sample weight. Among these, aluminum and iron were measured at relatively greater percentages across the sampling sites (table 14).

The other 35 analyzed trace elements can occur at variable concentrations in the environment and are reported as milligrams per kilogram (parts per million) of dry sample weight (table 14). Trace element concentrations in streambed sediment were compared to available consensus-based sediment quality guidelines, including a threshold-effect concentration (TEC), the concentration at which effects on biota in contact with the sediment are possible, and a probable-effect concentration (PEC), the concentration at which effects on the biota are considered likely (MacDonald and others, 2000) (table 14). TECs and PECs are defined for seven of the trace elements analyzed in this study: arsenic, cadmium, chromium, copper, lead, nickel, and zinc. No concentrations of these seven trace elements exceeded PECs; TECs were exceeded for at least one site for arsenic, chromium, copper, and nickel (table 14). Arsenic concentrations in bed-sediment samples at all sites except Pearl US ranged from 11 to 25 milligrams per kilogram (mg/kg) and were greater than the TEC of 9.8 mg/kg. Concentrations of arsenic among sites were also relatively high compared to numerous bed-sediment samples collected in central Mississippi as part of the USGS National Geochemical Database and Mississippi Geochemical Survey (Thompson, 2005; U.S. Geological Survey, 2021). Concentrations of chromium at all sites ranged from 46 to 75 mg/kg and were greater than the TEC of 43.4 mg/kg. Only the copper concentration at Wolf DS (67 mg/kg) exceeded the TEC of 31.6 mg/kg. The nickel concentration also exceeded the TEC of 22.7 mg/kg at Beasha US.

Eight PAH compounds were detected in streambed-sediment samples, and PAHs were only detected at Wolf US, Wolf DS, Beasha DS, and Pearl US. Concentrations of only 7 of the 19 detections were above the respective RL for each site, and these were concentrations of only 4 compounds: benzo[b]fluoranthene, benzo[ghi]perylene, benzo[k]fluoranthene, and indeno[1,2,3-cd]pyrene. Concentrations of all PAHs detected were well below consensus-based TEC and PEC concentrations for freshwaters (MacDonald and others, 2000; table 15) and other sediment-quality guidelines (McGrath and others, 2019).

Table 12. Summary of organic wastewater compound detections in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–August 2018.

[EDC, endocrine-disrupting compound; RL, reporting level; n, number of samples; µg/L, micrograms per liter; Max., maximum concentration; PAH, polycyclic aromatic hydrocarbon; —, no quantifiable concentrations were detected; na, not applicable because median could not be calculated. Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Wastewater compound	EDC[1]	Total number of quantifiable detections	Number of quantifiable detections above the RL	Number of unquantifiable (estimated) detections	Total number of detections	n	Percentage of samples with detections	Median (µg/L)[2]	Max. (µg/L)[2]	RL (µg/L)	Potential use
Camphor		5	1	14	19	30	63.3	0.024	0.045	0.044	Fragrance/ flavoring
Cholesterol		0	0	16	16	30	53.3	—	—	2.0	Plant/animal steroid
Caffeine		6	6	8	14	30	46.7	0.13	0.27	0.06	Stimulant
beta-Sitosterol	Yes	0	0	10	10	26	38.5	—	—	4.0	Plant steroid
Hexahydrohexamethyl cyclopentabenzopyran (HHCB)		9	8	1	10	30	33.3	0.120	0.287	0.052	Fragrance
N,N-Diethyl-*meta*-toluamide (DEET)		6	5	3	9	30	30.0	0.08	0.29	0.06	Insecticide/ repellent
Acetyl hexamethyl tetrahydro naphthalene (AHTN)	Yes	7	3	0	7	30	23.3	0.022	0.033	0.028	Fragrance
Isophorone		0	0	7	7	30	23.3	—	—	0.032	Solvent
Benzophenone	Yes	0	0	5	5	30	16.7	—	—	0.08	Pesticide/ fragrance additive
Cotinine		0	0	5	5	30	16.7	—	—	0.8	Nicotine metabolite
p-Cresol	Yes	2	2	3	5	30	16.7	0.25	0.38	0.08	Disinfectant/ preservative
Tris(2-butoxyethyl) phosphate		0	0	5	5	30	16.7	—	—	0.8	Plasticizer/ flame retardant
3-beta-Coprostanol		0	0	4	4	30	13.3	—	—	1.8	Fecal steroid
Phenanthrene		1	1	3	4	30	13.3	na	0.018	0.016	PAH/combustion byproduct
beta-Stigmastanol		0	0	3	3	26	11.5	—	—	2.6	Plant steroid
Menthol		0	0	3	3	30	10.0	—	—	0.32	Fragrance/ flavoring
Tributyl phosphate		1	1	2	3	30	10.0	na	0.55	0.16	Flame retardant

Table 12. Summary of organic wastewater compound detections in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–August 2018.—Continued

[EDC, endocrine-disrupting compound; RL, reporting level; n, number of samples; µg/L, micrograms per liter; Max., maximum concentration; PAH, polycyclic aromatic hydrocarbon; —, no quantifiable concentrations were detected; na, not applicable because median could not be calculated. Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Wastewater compound	EDC[1]	Total number of quantifiable detections	Number of quantifiable detections above the RL	Number of unquantifiable (estimated) detections	Total number of detections	n	Percentage of samples with detections	Median (µg/L)[2]	Max. (µg/L)[2]	RL (µg/L)	Potential use
5-Methyl-1H-benzotriazole		0	0	2	2	30	6.7	—	—	1.2	Anticorrosive
9,10-Anthraquinone		0	0	2	2	30	6.7			0.16	Pesticide/repellant
Tris(dichloroisopropyl) phosphate	Yes	1	0	1	2	30	6.7	na	0.13	0.16	Flame retardant
Naphthalene		0	0	2	2	30	6.7	—	—	0.04	PAH/combustion byproduct
1,4-Dichlorobenzene	Yes	1	1	0	1	30	3.3	na	0.06	0.04	Deodorizer
4-Nonylphenol (all isomers)	Yes	0	0	1	1	15	6.7	—	—	2.0	Nonionic detergent metabolite
4-tert-Octylphenol	Yes	0	0	1	1	30	3.3	—	—	0.14	Nonionic detergent metabolite
Tris(2-chloroethyl) phosphate	Yes	1	0	0	1	30	3.3	na	0.05	0.10	Plasticizer/flame retardant
Metalaxyl		1	0	0	1	30	3.3	na	0.10	0.12	Pesticide/herbicide
Triclosan	Yes	0	0	1	1	30	3.3	—	—	0.20	Disinfectant
Triethyl citrate		0	0	1	1	30	3.3	—	—	0.16	Cosmetic/pharmaceutical plastics
Triphenyl phosphate		0	0	1	1	30	3.3	—	—	0.12	Plasticizer
Totals		41	28	104	145						

[1]Known or suspected EDC (Lee and others, 2004; Zaugg and others, 2007).

[2]Median and maximum concentrations of quantifiable detections. Unquantifiable estimates were excluded.

Table 13. Number of samples analyzed and detections of organic wastewater compounds in water samples collected quarterly from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, October 2017–August 2018.

[n, number of samples; RL, reporting level; OWC, organic wastewater compound; US, upstream; DS, downstream; Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Site (table 1)	n	Number of quantifiable detections above RL	Total number of detections	Number of OWCs detected	Number of endocrine-disrupting compounds detected
Wolf US	4	7	30	18	4
Wolf DS	4	10	28	16	5
Jones	4	1	16	12	3
Kentawka	2	0	6	5	1
Beasha DS	4	4	23	15	4
Beasha US	4	1	13	11	5
Pearl US	4	2	8	8	1
Pearl DS	4	3	21	15	3

Table 14. Concentrations of trace elements in streambed-sediment samples collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

[US, upstream; DS, downstream; TEC, threshold-effect concentration; PEC, probable-effect concentration; %, percent; mg/kg, milligrams per kilogram; Bold font indicates trace elements detected at concentrations above consensus-based TEC values; M, constituent detected but not quantified; —, TECs and PECs not available. See table 1 for site information. Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Analyte	Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS	TEC[1]	PEC[1]
Aluminum (%)	4.8	4.1	3.7	4.0	5.2	5.3	4.2	—	—
Antimony (mg/kg)	1.7	1.4	0.7	0.7	1.1	0.6	0.9	—	—
Arsenic (mg/kg)	**20**	**11**	**15**	**10**	**25**	5	**11**	9.8	33.0
Barium (mg/kg)	530	520	770	420	450	480	420	—	—
Beryllium (mg/kg)	2	1	1	1	2	1	2	—	—
Bismuth (mg/kg)	M	2	M	M	M	M	M	—	—
Cadmium (mg/kg)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.99	4.98
Calcium (%)	0.32	0.40	0.35	0.21	0.36	0.15	0.16	—	—
Cerium (mg/kg)	96	83	82	85	94	76	94	—	—
Cesium (mg/kg)	2.98	2.69	2.44	2.55	3.55	3.25	2.90	—	—
Chromium (mg/kg)	**64**	**50**	**46**	**50**	**75**	**69**	**54**	43.4	111.0
Cobalt (mg/kg)	20	12	19	8	17	11	11	—	—
Copper (mg/kg)	12	**67**	7	9	10	12	10	31.6	149.0
Gallium (mg/kg)	12	10	10	9	13	13	12	—	—
Indium (mg/kg)	0.05	0.04	0.04	0.04	0.06	0.04	0.04	—	—
Iron (%)	4.2	3.5	3.9	2.5	5.2	1.9	2.9	—	—
Lanthanum (mg/kg)	44	39	38	41	45	37	45	—	—
Lead (mg/kg)	21	19	16	17	26	22	19	35.8	128.0
Lithium (mg/kg)	23	22	19	20	25	27	21	—	—
Magnesium (%)	0.32	0.27	0.22	0.23	0.42	0.24	0.23	—	—
Manganese (mg/kg)	2,300	1,100	18,000	660	1,400	1,100	980	—	—
Molybdenum (mg/kg)	2	1	2	M	2	M	1	—	—
Nickel (mg/kg)	17	14	15	15	**26**	16	19	22.7	48.6
Niobium (mg/kg)	14	12	12	12	13	14	13	—	—
Phosphorus (mg/kg)	740	2,700	420	440	840	470	580	—	—
Potassium (%)	1.2	1.1	1.1	1.1	1.2	1.1	1.1	—	—
Rubidium (mg/kg)	62.2	54.0	49.7	53.8	64.8	63.4	59.5	—	—
Scandium (mg/kg)	8	7	6	7	10	8	8	—	—
Silver (mg/kg)	0.2	0.2	0.2	0.2	0.2	0.3	0.3	—	—
Sodium (%)	0.34	0.34	0.33	0.34	0.31	0.25	0.29	—	—
Strontium (mg/kg)	97	135	102	71	83	62	62	—	—
Sulfur (%)	0.04	0.09	0.03	0.02	0.03	0.04	0.03	—	—
Tantalum (mg/kg)	M	M	M	M	M	M	M	—	—
Tellurium (mg/kg)	0.0	0.0	0.1	0.0	0.1	0.0	0.0	—	—
Terbium (mg/kg)	0.83	0.69	0.64	0.73	0.85	0.63	0.81	—	—
Thallium (mg/kg)	0.44	0.39	0.40	0.40	0.46	0.54	0.45	—	—
Thorium (mg/kg)	12	10	10	11	12	10	12	—	—
Tin (mg/kg)	2	5	1	1	2	2	2	—	—
Titanium (%)	0.41	0.41	0.38	0.39	0.38	0.44	0.40	—	—

Table 14. Concentrations of trace elements in streambed-sediment samples collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.—Continued

[US, upstream; DS, downstream; TEC, threshold-effect concentration; PEC, probable-effect concentration; %, percent; mg/kg, milligrams per kilogram; Bold font indicates trace elements detected at concentrations above consensus-based TEC values; M, constituent detected but not quantified; —, TECs and PECs not available. See table 1 for site information. Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Analyte	Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS	TEC[1]	PEC[1]
Tungsten (mg/kg)	1	1	M	M	1	1	1	—	—
Uranium (mg/kg)	3.1	2.6	2.6	2.8	3.2	2.7	2.8	—	—
Vanadium (mg/kg)	84	62	56	64	110	62	72	—	—
Zinc (mg/kg)	74	120	37	43	70	59	57	121	459

[1]Consensus-based TECs and PECs from MacDonald and others (2000).

Table 15. Concentrations of polycyclic aromatic hydrocarbons (PAH) compounds in streambed-sediment samples collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

[All concentrations are in micrograms per kilogram; US, upstream; DS, downstream; TEC, threshold effect concentration; PEC, probable effect concentration; <, indicates concentrations less than the specific reporting level established by the laboratory for each sample; —, TECs and PECs not available. See table 1 for site information. Data are stored in the U.S. Geological Survey National Water Information System and are available upon request]

Analyte	Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS	TEC[1]	PEC[1]
2-Methylnaphthalene	<	<	<	<	<	<	<	—	—
9H-Fluorene	<	<	<	<	<	<	<	77.4	536
Acenaphthene	<	<	<	<	<	<	<	—	—
Acenaphthylene	<	<	<	<	<	<	<	—	—
Anthracene	<	<	<	<	<	<	<	57.2	845
Benzo[a]anthracene	<	<	<	<	<	<	<	108	1,050
Benzo[a]pyrene	4.1	<	<	7	<	<	<	150	1,450
Benzo[b]fluoranthene	12	10	<	14	<	<	<	—	—
Benzo[ghi]perylene	3.3	<	<	9.1	<	<	<	—	—
Benzo[k]fluoranthene	7.8	6.6	<	9.5	<	<	<	—	—
Chrysene	<	<	<	<	<	<	<	166	1,290
Dibenzo[a,h]anthracene	<	<	<	<	<	<	<	33	—
Fluoranthene	7.8	3.5	<	2.1	<	11	<	423	2,230
Indeno[1,2,3-cd]pyrene	9.4	<	<	12	<	<	<	—	—
Naphthalene	<	<	<	5.8	<	<	<	176	561
Phenanthrene	<	<	<	<	<	<	<	204	1,170
Pyrene	7	2.6	<	<	<	<	<	195	1,520
Reporting level	8.2	8.8	8.3	8.3	8.4	43	8.6		

[1]Consensus-based TECs and PECs from MacDonald and others (2000).

Biological Assessment

Periphyton Community

Benthic periphyton (algae) are primary producers and are important to stream food webs (Mulholland and Rosemond, 1992). Periphyton communities are subject to and affected by physical, chemical, and biological disturbances that occur in the local stream reach during the time in which the communities develop (Bernhardt and Likens, 2004). Periphyton communities respond predictably and quickly (days to weeks) to changes in environmental conditions at a large range of spatial scales. Because of the often-direct relations between nutrient condition and periphyton taxa and community metrics (biomass, taxa abundance, nutrient tolerance, community composition), periphyton are commonly used as indicators of water quality, habitat stability, and nutrient enrichment (Mulholland and Rosemond, 1992; Hill and others, 2003; Charles and others, 2019).

Periphyton communities sampled from the seven stream sites in August 2018 consisted of a variety of diatom and soft-algae taxa (blue-green algae, green algae, red algae, and flagellated algae) (table 16). Collectively, 189 taxa were identified (table 16; table 1.1). Diatoms were represented by 61 genera and 170 taxa, and soft algae were represented by 18 identified genera and 19 taxa groups (table 16). Among diatoms, taxa within the genera *Navicula*, *Sellaphora*, and *Nitzschia* were the most abundant (fig. 9) and collectively represented approximately 52 percent of the total diatom cells counted across all stream sites and approximately 47 percent of all diatom and soft-algae units counted. Among soft-algae types, cyanobacteria (blue-green) were most abundant (table 16), and taxa within the genera *Leptolyngbya*, *Phormidium*, and *Heteroleibleinia* collectively represented approximately 93 percent of all soft-algae natural units counted (fig. 10). The diversity and abundance of diatoms and soft-algae taxa in this study are generally similar to those reported among smaller order streams in Mississippi (Anzola, 2010). However, algal data reported in Anzola (2010) were predominantly from pelagic phytoplankton communities rather than benthic or epidendric periphyton communities and thus showed a generally greater diversity of green algae within the genus *Chlorophyta* among streams.

The richness, composition, and abundance of periphyton taxa differed among stream sites (table 17; fig. 11). Taxa richness was highest at Pearl DS (82 taxa), followed by Beasha DS (74) and Beasha US (71). Taxa richness was lowest at the Wolf US (53) and Wolf DS (52) (table 17). Although periphyton taxa richness was highest at Pearl DS and Beasha DS, Shannon's *H* was highest at Beasha US and followed by Beasha DS (table 16), indicating a more even distribution of algae taxa abundance. The spatial distribution of algae taxa across the seven sampling sites was often low, with 123 taxa out of 189 total (65 percent) occurring at two or fewer sites. Only 26 taxa (14 percent) were common among five or more sites, and only 4 taxa (3 diatom and 1 blue-green) were distributed across all seven sites (table 1.1).

Ordination of periphyton community structure using nonmetric multidimensional scaling (NMDS) indicated that community structures were generally similar among Pearl River sites (Pearl US and Pearl DS) and Beasha Creek sites (Beasha US and Beasha DS); in other words, the ordinated site scores for these sites plotted closely together (fig. 12). These four sites shared generally similar patterns of taxa presence and (or) abundances, particularly the diatoms *Nitzschia acicularioides*, *Navicula canalis*, *Sellaphora atomoides*, and *Craticula* sp. 3 SESQA (table 1.1). The community structures in the Jones, Wolf DS, and Wolf US periphyton samples were more distinct than those in the Pearl River and Beasha Creek samples (fig. 12). The Jones community was distinguished from other sites by higher abundances of the diatoms *Achnanthidium minutissimum* and *Brachysira microcephala*, which are both considered low-nutrient indicators (Potapova and Charles, 2007). Also, the Jones community consisted of a relatively greater number of taxa occurring at two or fewer of the other sites (table 1.1). The Wolf US community was generally distinguished by greater abundances of the diatoms *Navicula ingenua*, *Nitzschia amphibia*, and *Sellaphora nigri*,

Table 16. Richness and total abundance of periphyton taxa collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

[#, number; —, not applicable because no taxa were identified to the genus level; Raw data available in Driver and Hicks (2022)]

Algal group	Algal type	Genera richness (# of genera)	Overall taxa richness (# of taxa)	Cell count	Natural unit count
Diatom	Diatom	61	170	3,954	
Soft algae	Blue-green	8	8		339
	Green	3	3		5
		5	5		24
	Red	—	1		3
	Flagellated	2	2		3
	Totals	79	189	4,328	

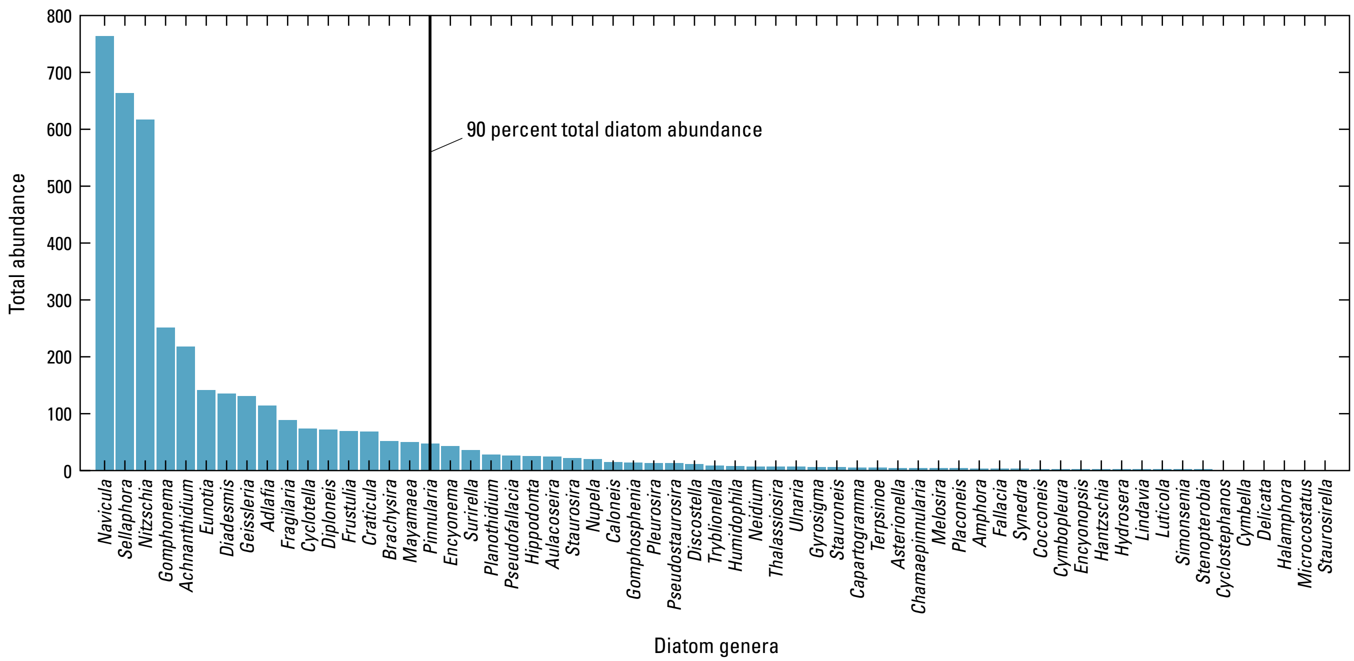

Figure 9. Ranked total abundance of diatom genera collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

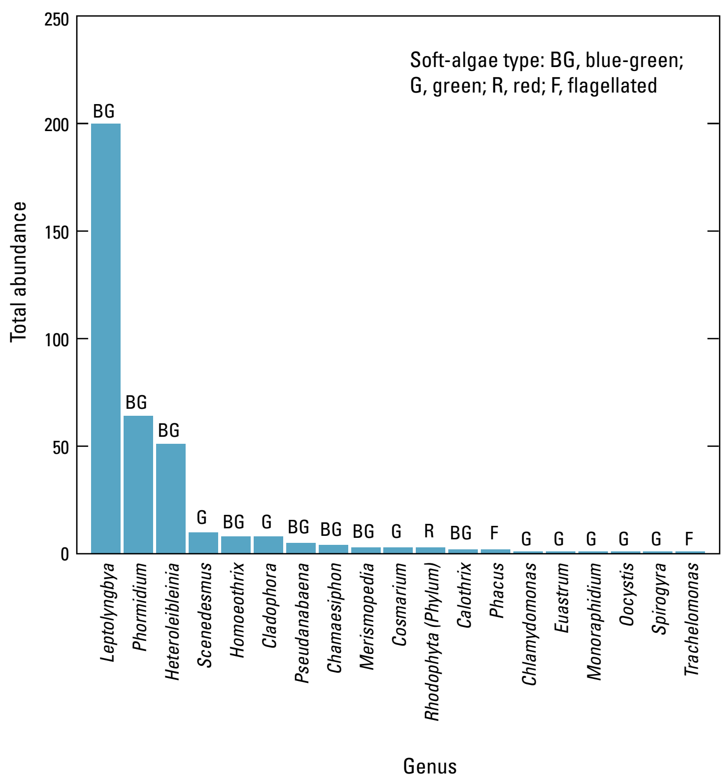

Figure 10. Ranked total abundance of soft-algae genera collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

and the community at Wolf DS had generally greater abundances of *Diadesmis confervacea* (diatom) and *Nitzschia amphibia* (diatom) (table 1.1). Diatom taxa that are considered indicators of high nutrients (Potapova and Charles, 2007) were collected in greater abundances at Wolf Creek sites compared to other sites (for example, *Navicula ingenua*, *Nitzschia amphibia*, and *Diadesmis confervacea*) (table 1.1). The presence and abundance of these high-nutrient indicator taxa, coupled with overall lower taxa richness and diversity at the two Wolf Creek sites, suggest that nutrient enrichment could be influencing periphyton communities at Wolf US and Wolf DS.

Benthic Macroinvertebrate Community

BMI samples collected from 6 of the 8 study sites contained a total of 116 unique taxa (predominantly identified to genus level) from 21 orders (fig. 13; table 18; table 1.2). Taxa within order Diptera were the most abundant and represented 35.4 percent of the total macroinvertebrate abundance across sites, followed by order Tubificida which represented approximately 19 percent. Collectively, taxa within the orders Ephemeroptera (14.9 percent), Plecoptera (11.4 percent), and Trichoptera (1.2 percent), referred to as EPT taxa, represented 27.6 percent of total macroinvertebrate abundance across the six sites.

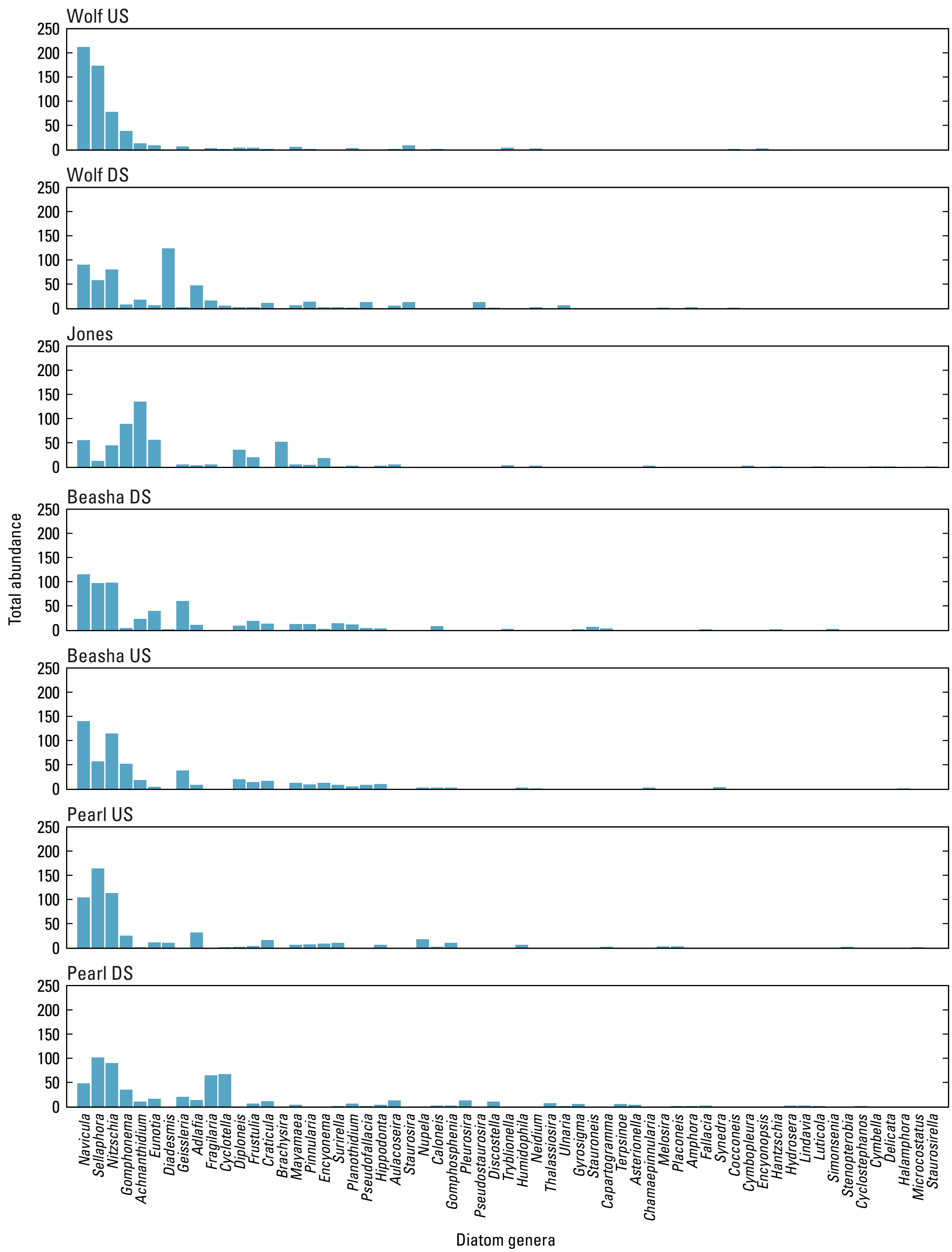

Figure 11. Abundance of diatom genera collected, by site, from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018. Genera are ordered/sorted according to summed total abundance across sites (see fig. 9).

Table 17. Site richness and taxa diversity index of periphyton algae collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

[*H*, Shannon's diversity index; US, upstream; DS, downstream; See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Site (table 1)	Taxa richness				Shannon's *H*
	Diatoms (all taxa)	Diatoms (genera)	Soft algae (genera)	Total taxa	
Beasha DS	70	27	4	74	3.62
Beasha US	64	26	7	71	3.65
Jones	58	28	4	62	3.15
Pearl DS	75	34	7	82	3.55
Pearl US	63	26	5	68	3.56
Wolf DS	47	29	5	52	3.11
Wolf US	45	22	8	53	2.80

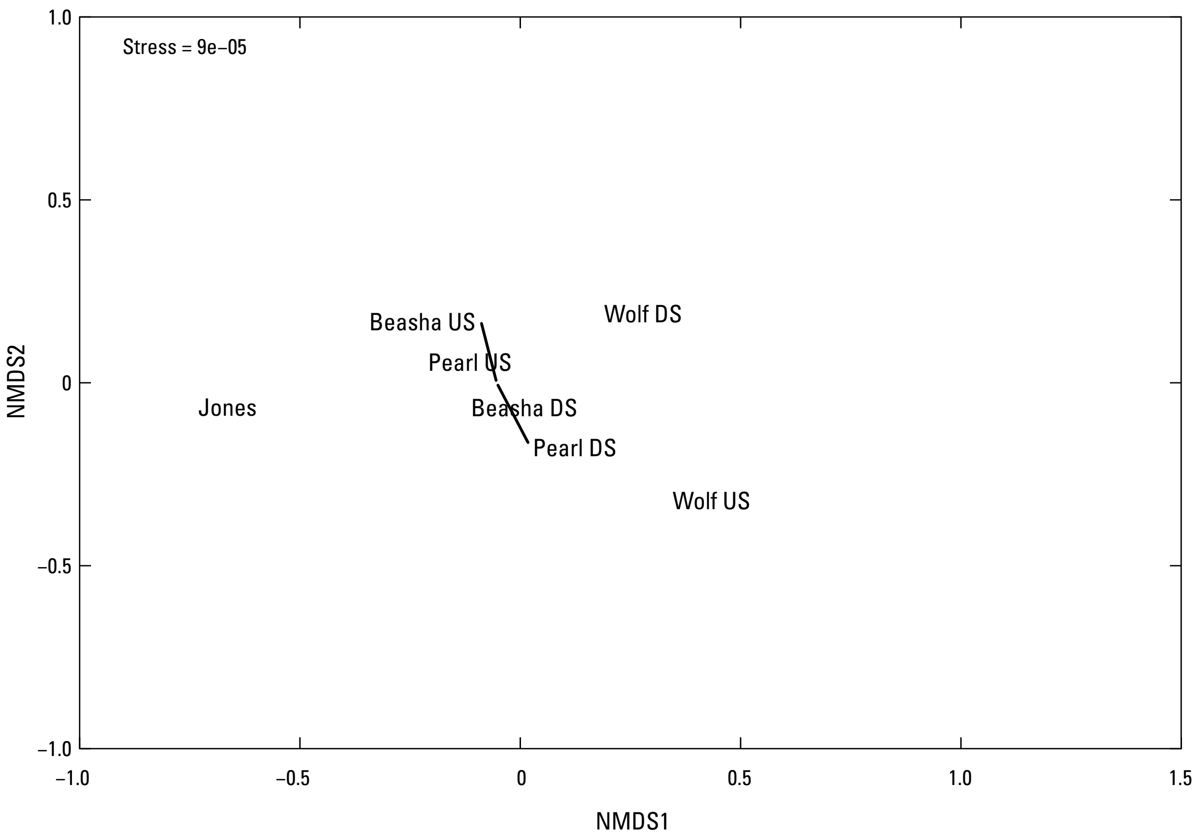

Figure 12. Nonmetric multidimensional scaling (NMDS) ordination of periphyton communities collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018. Lines lead to artificially spaced communities/site labels that would otherwise overlap in ordination space.

Table 18. Site richness and taxa diversity index of benthic macroinvertebrates collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.

[*H*, Shannon's diversity index; EPT, taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera; US, upstream; DS, downstream; Raw data available in Driver and Hicks (2022)]

Site (table 1)	Taxa richness	Order richness	Shannon's *H*	EPT richness
Wolf US	48	15	3.05	7
Wolf DS	36	13	2.31	3
Jones	42	13	3.25	7
Kentawka	27	11	2.21	6
Beasha DS	41	10	2.99	9
Beasha US	55	14	3.49	13
Totals	115 unique taxa	21 unique orders		

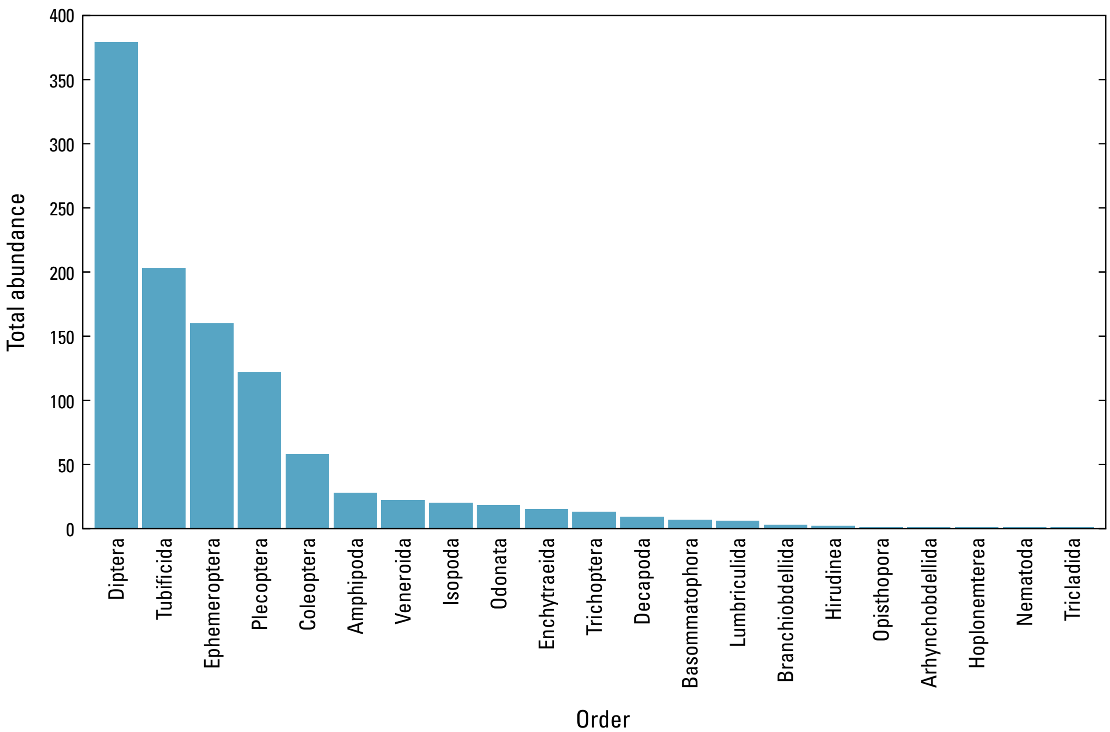

Figure 13. Ranked total abundance of benthic macroinvertebrate orders collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.

Among stream sites, Wolf US was represented by the most orders (15) and Beasha DS by the fewest (10) (table 18). Taxa from orders Odonata and Decapoda were not collected at Beasha DS but were collected at all other sampled sites (fig. 14). Beasha US and Wolf US had the greatest taxa richness with 55 and 48 individual taxa, respectively. Wolf DS and Kentawka had the lowest taxa richness with 36 and 27 taxa, respectively (table 18). Shannon's *H* values followed a similar pattern as taxa richness and indicated highest relative diversity of BMI at Beasha (3.49) and lowest at Kentawka (2.21).

Macroinvertebrate taxa have varying tolerances to environmental stressors and are often useful indicators of the relative water quality among sites (Lenat, 1993; Barbour and others, 1999; Bressler and others, 2006). The percentage of EPT taxa richness was highest among Beasha US (23.6 percent), Beasha DS (22.5 percent), and Kentawka (22.2 percent), and the percentage of EPT abundance was highest at Kentawka (fig. 15), indicating potentially more favorable water quality at these sites. The relatively higher richness and abundance of EPT at Kentawka was driven primarily by Plecoptera taxa

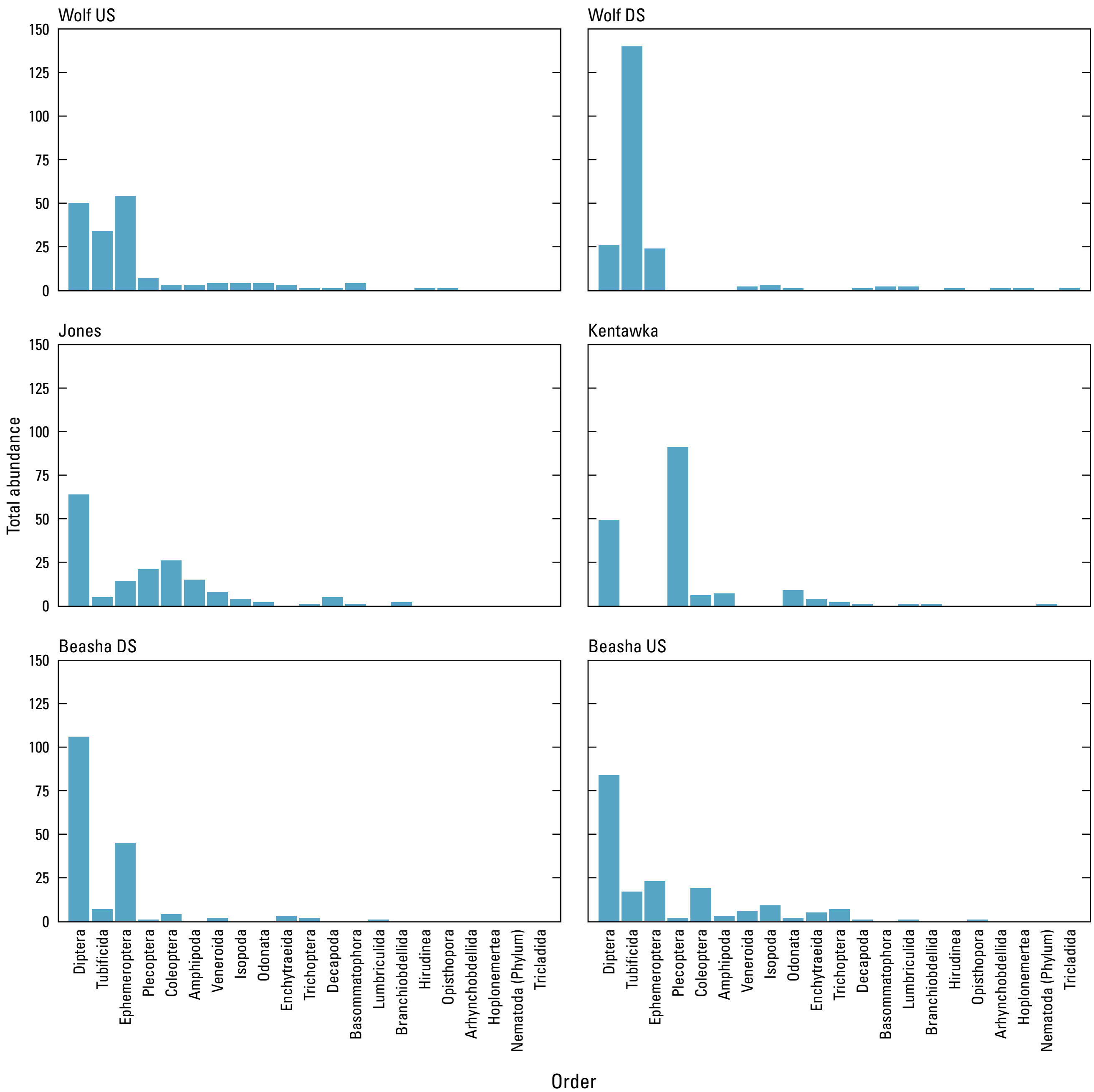

Figure 14. Total abundance of benthic macroinvertebrate orders collected, by site, from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018. Orders are sorted according to summed total abundance across sites (see fig. 13).

(table 1.2). Plecoptera taxa typically have very low tolerance for organic pollution (Lenat, 1993; Bressler and others, 2006), and the richness and abundance of EPT at Kentawka suggest that the low overall taxa richness observed at this site is likely not primarily related to water quality but rather related to other environmental factors, such as stream size and [or] habitat availability. Percentages of EPT richness and abundance were each lowest at Wolf DS, and EPT richness was relatively low at Wolf US compared to other sites, indicating the influence of relatively poor water quality on macroinvertebrate populations and diversity in the Wolf Creek watershed.

Tubificid worms accounted for nearly 70 percent of the total BMI abundance at Wolf DS and nearly 20 percent at Wolf US compared to between 0 and 10 percent total abundance at each of the other sampling sites (fig. 14; table 1.2). Taxa within order Tubificida are often tolerant of low dissolved

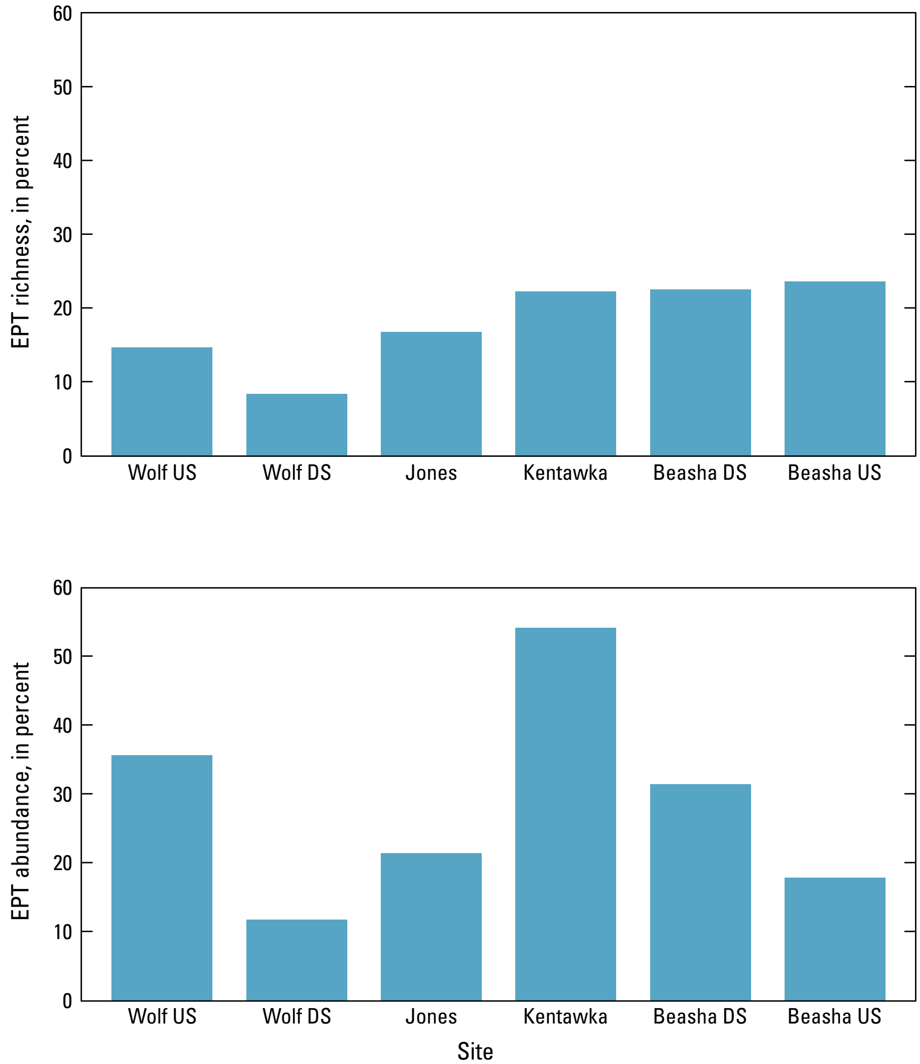

Figure 15. (*A*) Percent richness and (*B*) percent abundance of total Ephemeroptera, Plecoptera, and Trichoptera taxa (EPT) collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.

oxygen and are commonly found in high abundances in polluted waters, such as wastewater effluents, and are strong indicators of poor water quality (Aston, 1973; Lin and Yo, 2008).

M-BISQ scores ranged from 26.6 to 74.6 among sampled sites and were lowest at Wolf DS and Wolf US (table 19). None of the sites had M-BISQ scores above that of the Lukfapa Creek reference site (81.1), and Beasha US (74.6) was the only site that scored above the East Bioregion degradation threshold of 71.6 (table 19). M-BISQ scores indicate relatively degraded BMI communities for five of the six sites sampled. In particular, the score for Wolf DS was substantially lower than the score for any other site, indicating considerable degradation of the BMI community downstream from the Pearl River WWTP.

NMDS ordination indicated distinction of macroinvertebrate communities among some sites (fig. 16). The separation of Wolf DS (and Wolf US to a lesser degree) along the negative values of NMDS1 axis and positive values of NMDS2 axis appeared to be, again, associated with the abundance and richness of Tubificida taxa (table 1.2). Beasha US and Beasha DS communities ordinated close together, indicating generally similar community structures despite differences in stream size and habitat characteristics. In particular, the occurrence and abundance of Simuliidae taxa—filter feeders that attach to hard/fixed substrates (Carlsson, 1967; Morin and Peters, 1988)—may indicate the importance of benthic substrates (such as gravel), flow, and fine particulate matter at Beasha US and Beasha DS. Distinctions of Kentawka and Jones (the two smallest stream sites) along NMDS1 (fig. 16) appeared to be

Table 19. M-BISQ scores and individual metric values (prior to scoring) for macroinvertebrate communities collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.

[M-BISQ, Mississippi-Benthic Index of Stream Quality; % percent; US, upstream; DS, downstream; Raw macroinvertebrate data available in Driver and Hicks (2022)]

Site (table 1)	M-BISQ score	Number of predator taxa	% Cricotopus/ Orthocladius/ Chironomus to total Chironomidae	% Collectors	% Clingers	% Non-insect taxa	% Tolerant taxa	Beck's Biotic Index
Wolf US	51.1	14	11.8	56.0	31.9	32.0	20.0	16
Wolf DS	26.6	8	27.3	84.2	7.7	51.4	16.2	7
Jones	63.2	11	0.0	29.4	24.6	27.3	9.1	16
Kentawka	59.1	9	3.7	24.0	57.4	29.6	18.5	10
Beasha DS	59.6	6	9.0	37.1	45.7	19.5	9.8	13
Beasha US	74.6	12	1.8	35.9	30.4	23.2	1.7	28
Data from least-disturbed sites:								
Lukfapa Creek[1]	81.1	14	0.0	16.8	52.0	17.5	5.0	17
East Bioregion degradation threshold[2]	71.6							

[1]At the time of publication, data were not available in a published format but were obtained upon request from MDEQ Office of Pollution Control.

[2]Stribling and others, 2016.

driven by occurrence of sensitive taxa and (or) taxa with high spatial turnover among sites, particularly Plecoptera taxa at Kentawka, relatively greater abundances of some Coleoptera and Amphipoda taxa at Jones, and the occurrence of taxa collected at Jones that were only collected at two or fewer of the other sites (table 1.2). BMI communities in these smaller stream sites may differ from those at larger stream sites due to multiple potential factors, such as the variability of streamflow (flow intermittency and high flows), relatively lower habitat availability (shallow depths and more frequent stream drying), availability of coarse organic material, and perhaps reduced predation (Vannote and others, 1980; Meyer and others, 2007). For example, occurrence and abundance of Plecoptera and Amphipoda at Kentawka may be related to lower fish density and predation compared to other sites.

Fish Community

A total of 832 fish, representing 42 species and 14 fish families, were collected among the 8 stream sites (table 20; table 1.3). Cyprinidae (minnows; 11 species) and Centrachidae (sunfishes; 10 species) were the most abundant families (table 1.3), and individuals collected from these families represented 40 percent and 38 percent of the total fish abundance, respectively. Six species—*Lepomis megalotis* (longear sunfish), *Cyprinella venusta* (blacktail shiner), *Fundulus olivaceus* (blackspotted topminnow), *Lepomis macrochirus* (bluegill), *Micropterus punctulatus* (spotted bass), and *Lepomis gulosus* (warmouth)—were collected at five or more sites and represented 59 percent of the total fish abundance across sites (fig. 17; table 1.3). Collectively, the longear sunfish and blacktail shiner were the most frequently collected fish species. Twenty-three species (about 55 percent of the total fish abundance) were relatively rare and were collected from 2 or fewer sampling sites, of which 7 species were represented by only a single individual from a single sampling site (table 1.3). Among the fish species collected, none are currently considered threatened and endangered or are being tracked by the Mississippi Natural Heritage Program as species of concern (Mississippi Natural Heritage Program, 2018).

Among the sampling sites, the most fish species and individuals were collected from Wolf US (23 species, 240 individuals) and Pearl US (20 species, 163 individuals; table 20; fig. 17). Only 10 fish species were collected at Pearl DS, and 12 species were collected at Beasha DS (table 20); however, the relatively lower species richness and abundance at these sites are likely due to lower electrofishing efficiency at the time of sampling related to relatively deep and (or) swift waters or the presence of instream obstacles (woody snags). Wolf DS also had relatively lower richness and abundance compared to Wolf US. Kentawka had the lowest richness and abundance (only 3 species and 11 individuals), but Kentawka also has the smallest drainage area and often goes dry for extended periods during normal annual conditions. Jones had relatively high species richness (18), despite also having a relatively small drainage area.

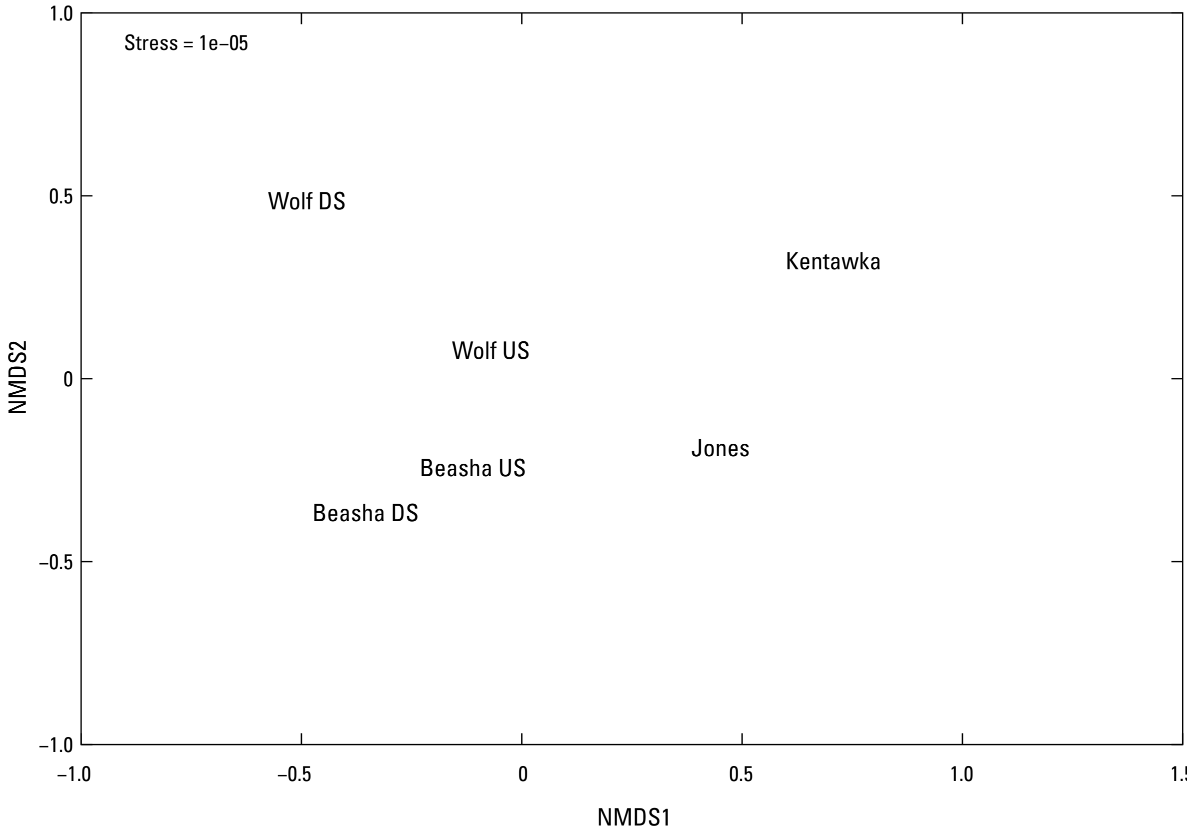

Figure 16. Nonmetric multidimensional scaling (NMDS) ordination of benthic macroinvertebrate communities collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.

Table 20. Total abundance, taxa richness, and taxa diversity index of fish communities collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, April 2018.

[H, diversity index; DS, downstream; US, upstream; Raw data available in Driver and Hicks (2022)]

Site (table 1)	Total abundance	Family richness	Species richness	Shannon's *H*
Wolf US	240	9	23	2.21
Wolf DS	82	5	12	1.66
Jones	87	9	18	1.97
Kentawka	11	3	3	0.86
Beasha DS	38	4	12	1.79
Beasha US	118	7	18	2.15
Pearl US	163	9	20	1.99
Pearl DS	93	4	10	1.59
Totals	832	14	42	

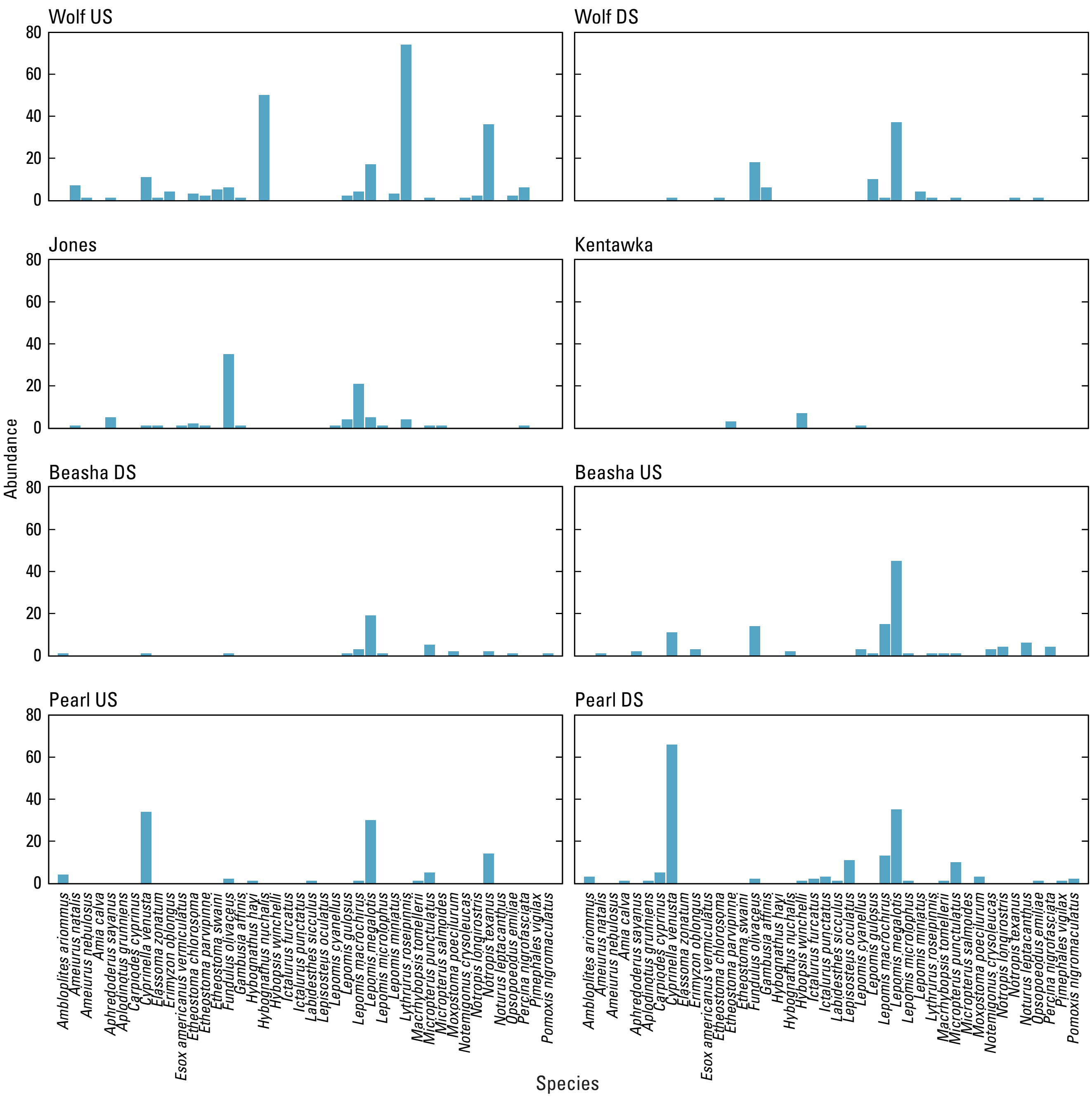

Figure 17. Abundance of fish species collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, April 2018.

NMDS ordination of fish communities among sites indicated differences in community structure, predominantly related to relative stream size and habitat. Specifically, fish communities from sites with the largest drainage areas (Pearl US, Pearl DS, and Beasha DS) ordinated along the negative values along NMDS1. Nine species and 4 families, many of which are larger bodied species and typical of larger streams such as *Carpiodes cyprinus* (quillback), *Ictalurus punctatus* (channel catfish), *Ictalurus furcatus* (blue catfish), *Lepisosteus oculatus* (spotted gar), and *Aplodinotus grunniens* (freshwater drum), were collected only at Pearl US and (or) Pearl DS (table 1.3). The community at Beasha DS also ordinated close to the Pearl River sites, in part, because of the shared occurrence of *Moxostoma poecilurum* (blacktail redhorse) and *Pomoxis nigromaculatus* (black crappie), which are most often collected in generally deeper and lower velocity stream habitats (Ross, 2001).

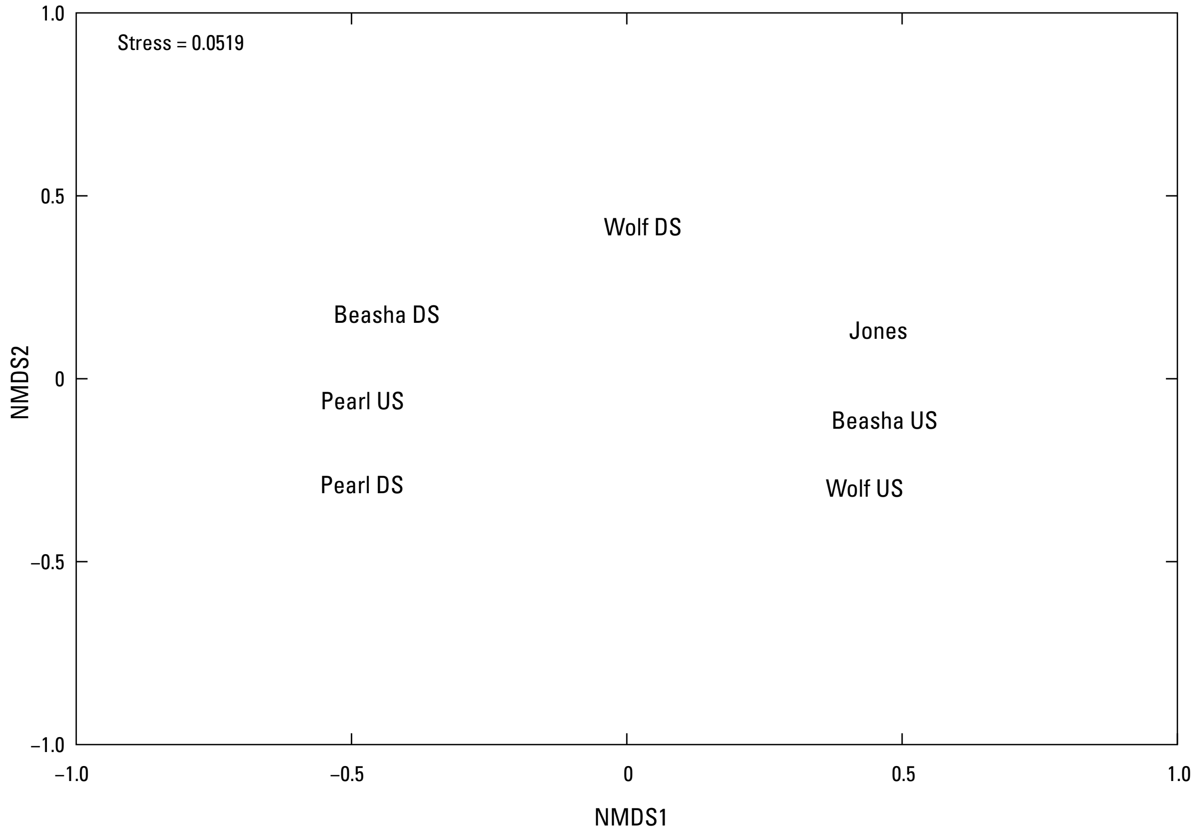

Figure 18. Nonmetric multidimensional scaling (NMDS) ordination of fish communities collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, April 2018. The Kentawka fish community was excluded because the low number of species and individuals distorted the ordination.

In contrast, communities from Beasha US, Jones, and Wolf US (with drainage areas ranging from 8.9 to 19.7 km^2; table 1) were ordinated along the positive values of NMDS1 (fig. 18) and were each generally characterized by occurrence and abundances of fish species typical of smaller and low gradient streams, such as *Aphredoderus sayanus* (pirate perch), *Ameiurus natalis* (yellow bullhead), *Percina nigrofasciata* (blackbanded darter), *Erimyzon oblongus* (creek chubsucker), and *Elassoma zonatum* (banded pygmy sunfish) (Ross, 2001). The Wolf US fish community was further distinguished from other sites by relatively greater occurrence and abundances of minnow species (family Cyprinidae) (fig. 17; table 1.3). Additionally, *Ameiurus nebulosus* (brown bullhead) and *Etheostoma swaini* (gulf darter) were collected only at Wolf US. Despite some evidence of somewhat degraded water quality at Wolf US, the relatively high habitat quality at Wolf US (discussed in later report sections) may explain why this site contained a greater diversity of fish species, especially compared to Wolf DS. The fish community at Wolf DS ordinated near the middle of NMDS1 (fig. 18) and consisted predominantly of relatively common and tolerant species (Meador and Carlisle, 2007) and lacked most of the minnow and darter (family Percidae) species that were present at Wolf US. The relatively low diversity and abundance of fish at Wolf DS and the lack of 11 species collected a relatively short distance upstream at Wolf US may indicate effects of water quality from wastewater effluent (table 1.3).

Although it can sometimes be difficult to distinguish between the effects of physical and chemical factors on biological communities, fish data collected in this study generally suggest that fish communities had stronger relations to stream size and habitat than to water quality. Given the range in stream sizes sampled for this study and that different types of equipment with different sampling efficiencies were needed in order to sample fish, the fish community data were generally less useful than the periphyton and benthic macroinvertebrate community data for assessing the influence of differing water quality at these particular sites.

Physical Habitat

The importance of physical habitat assessment when evaluating the overall condition of a river or stream is well documented, and the distribution and abundance of aquatic organisms and communities can often be related to aspects of stream habitat (Karr and others, 1986; Barbour and others, 1999; Maddock, 1999; Allan, 2004; Frimpong and others, 2005). Results of reach-scale quantitative physical habitat measures from six of the eight sites are given in table 21. Results of QHAs from the six wadable sites are given in table 22.

Quantitative Habitat Measures

Most of the quantitative habitat variable values among sampled sites were characteristic of perennial streams within the region. For example, each of the stream sites had relatively low elevational reach gradients (0.0003 to 0.0021 meter per meter) and consisted of predominantly sandy bottom substrates (table 21). Differences in several physical habitat characteristics among streams could be largely attributed to differences in stream size and drainage area. For example, aspects of stream width, depth, and volume were greater in streams with larger drainage areas. Specifically, Pearl DS is the largest stream by drainage area and had greater channel and bankfull wetted widths, channel and thalweg depths, and volume than the other sites. At Beasha US and Beasha DS, the relatively lower wetted volumes (107 and 359 cubic meters, respectively), higher width to depth ratios (84 and 132, respectively), and higher degrees of channel incision indicate relatively lower amounts of available wetted habitat compared to the other sampled sites. However, taxa richness and diversity (Shannon's *H*) metrics at Beasha US and Beasha DS were relatively high among algae, benthic invertebrate, and fish samples (tables 17, 18, and 20) and do not readily indicate low habitat availability or quality at these sites.

Except for Pearl DS, all surveyed stream sites had relatively high percentages of canopy cover (table 21). The relatively low percentage of canopy cover observed at Pearl DS is predominantly due to the large stream width rather than lack of riparian buffer. Higher percentages of canopy cover can be indicative of the health and function of the riparian vegetative buffer which stabilizes stream banks, reduces soil erosion and contamination from surface runoff, provides food and habitat structure for stream organisms in the form of leaf litter and woody debris, and mitigates seasonal temperature extremes through shading of the stream channel (Allan, 2004).

All sites had relatively small percentages of woody debris and aquatic macrophytes, all less than 10 percent of overall wetted area (table 21), indicating relatively low amounts of

Table 21. Results of quantitative habitat assessments for Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

[DS, downstream; US, upstream; m/m, meter per meter; m, meter; m^3, cubic meter; %, percent. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Variable (units)	Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl DS
Reach gradient (m/m)	0.0003	0.0007	0.0019	0.0017	0.0021	0.0018
Mean channel wetted width (m)	13.7	15.1	11.4	21.8	9.5	31.1
Mean channel bankfull width (m)	21.0	22.0	15.1	30.3	17.3	35.3
Mean thalweg depth (m)	0.87	1.36	0.76	0.54	0.42	1.18
Mean channel depth (m)	0.41	0.52	0.33	0.17	0.11	0.58
Width/depth ratio	34	29	35	132	84	54
Wetted volume (m^3)	559	778	372	359	107	1798
Mean top bank height (m)	8.5	8.1	4.9	17.1	17.3	15.0
Mean bank angle (degrees)	103.8	99.8	104.0	103.5	98.3	108.0
Channel incision	0.405	0.232	0.322	0.564	0.997	0.424
Canopy cover (%)	97	65	96	94	95	22
Mean large woody debris (%)	5.5	3.5	0.9	5.5	2.0	0.8
Mean macrophyte cover (%)	0.0	2.1	0.0	0.3	0.0	2.7
Mean substrate depth (m)	0.54	0.64	0.32	0.67	0.59	0.25
Sand (%)	35	75	88	64	52	86
Silt (%)	7	22	9	36	38	14
Gravel (%)	0	0	0	0	6	0
Hardpan (%)	57	3	3	0	4	0

Table 22. Composite and total scores of the qualitative habitat assessment for Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.

[QHA, qualitative habitat assessment; DS, downstream; US, upstream; Raw data available in Driver and Hicks (2022)]

Site	Instream habitat score	Channel morphology score	Bank and riparian cover score	QHA total score
Wolf US	50	39	38	127
Wolf DS	43	57	38	138
Jones	42	52	28	122
Kentawka	47	28	32	107
Beasha DS	30	38	29	97
Beasha US	32	44	37	113
Data from local and regional least-disturbed sites[1]				
Lukfapa Creek	44	69	48	161
East Bioregion 25th percentile	36	53	32	122

[1]At the time of publication, data were not available in a published format but were obtained upon request from MDEQ Office of Pollution Control.

available habitat cover and refugia for macroinvertebrates and fish. Although not quantified in this study, low, over-hanging vegetation and undercut banks were present at each study site reach and may contribute additional structural habitat.

Although sand was the predominant substrate type among streams, silt-sized particles (<2-millimeter diameter) accounted for more than 10 percent of the substrate composition at four of the six surveyed sites (table 21). Beasha US and Beasha DS had the highest percentage of silt-sized particles, both greater than 30 percent, and Jones and Wolf US had the lowest percentages of silt. Increased sedimentation and silt deposits can degrade benthic habitat for macroinvertebrates and fish by filling interstitial spaces and smothering habitat required for foraging and reproduction (Lenat and others, 1981). Beasha US was the only site where gravel substrate was observed (table 21), indicating a relatively greater degree of substrate complexity and availability compared to other sites.

Qualitative Habitat Assessment

QHAs were made by using a modified version of the rapid bioassessment protocol recommended by the EPA (Barbour and others, 1999; MDEQ, 2020). The 10 individual habitat assessment parameters (table 4) were grouped into 3 categories, and scores were totaled by category and summed for an overall QHA score, where higher scores indicate better habitat quality (table 22). See Driver and Hicks (2022) for assessment scores by site and parameter. Scores among study sites were also compared to the nearby least-disturbed Lukfapa Creek site and the 25th percentile of the ranges of scores from all least-disturbed stream sites within the East Bioregion (table 22).

Results of the QHA suggest that each of the surveyed sites was in relatively fair or good condition compared to the least-disturbed sites (table 22). Overall QHA scores for Wolf DS, Wolf US, and Jones were equal to or greater than the 25th percentile QHA scores among least-disturbed stream sites throughout the East Bioregion. However, QHA scores for these sites were each less than the score for nearby Lukfapa Creek (table 22). Wolf DS and Wolf US had the highest overall QHA scores despite being more heavily influenced by surface runoff and (or) wastewater contaminants than the other four sites. The apparent good habitat quality at Wolf US also supports relatively high macroinvertebrate and fish diversity despite relatively poorer water quality. For Wolf DS, channel morphology and overall QHA scores may be artificially inflated due to effluent discharge from the Pearl River WWTP, which caused higher streamflow values than reported at the other sites. Beasha DS had the lowest overall QHA score (table 22), resulting from relatively low values of pool variability, channel sinuosity, bank vegetative protection, and bank stability and a relatively high degree of channel alteration and sediment deposition (table 4; Driver and Hicks, 2022). Beasha US scored only slightly higher than Beasha DS, and the relatively lower QHA scores at both Beasha Creek sites are supported by quantitative habitat characteristics, particularly for parameters related to channel morphology (depth, width, and incision; table 21; Driver and Hicks, 2022). Kentawka had the second lowest QHA score and was assessed as having the lowest flow status and greatest relative degree of channel alteration (despite having the smallest drainage area of any site) (Driver and Hicks, 2022). Intermittent flow and altered channel habitat are likely contributors to the relatively low diversity of macroinvertebrate and fish communities observed at Kentawka.

Summary and Conclusions

The U.S. Geological Survey, in cooperation with the Mississippi Band of Choctaw Indians (MBCI), conducted baseline assessments of surface-water and streambed-sediment quality, biological communities, and physical habitat at selected streams within and contiguous to the Pearl River Community (PRC) in central Mississippi. The results of these monitoring efforts may be used by water resource managers to protect surface waters, biological communities, and cultural resources. Any regulatory standards or metrics referenced in this report are for the purpose of comparison in order to place the range of baseline conditions within relevant context and to indicate potential areas of impairment in the PRC.

Field constituents measured as part of this study (water temperature, specific conductance [SC], dissolved oxygen [DO], and pH) were generally within natural ranges and in most instances were not considered to be stressful for aquatic life among any of the sampling sites; however, exceptions were noted for pH, SC, and DO. pH values among some quarterly samples at the Kentawka, Pearl upstream (US), and Pearl downstream (DS) sites (5.8–5.9) were just below the State minimum pH standard of 6.0, suggesting potential periodic stressful conditions, although slight, for some aquatic organisms. SC values were also periodically high at both Wolf Creek sites, particularly Wolf DS (maximum of 548 microsiemens per centimeter at 25 degrees Celsius [µS/cm at 25 °C]), but all measured SC values were well below the State standard of 1,000 µs/cm. However, some values were near or above 300 µS/cm, which is a commonly used threshold for protection of some aquatic insect communities. Some quarterly DO concentrations at Pearl US were measured below the Mississippi Department of Environmental Quality (MDEQ) instantaneous minimum standard of 4.0 milligrams per liter (mg/L), and the daily mean at Wolf DS (4.8 mg/L), which was derived from a continuous 48-hour period in June 2018, was below the MDEQ mean daily DO standard of 5.0 mg/L.

Low DO concentrations can be harmful to aquatic communities and result in physiological stress and increased mortality. The relatively low DO variability and the abundance of Tubificid worms at Wolf DS suggest that periodic or chronic low DO concentrations were likely related to decomposition of organic material from point and non-point runoff from the Wolf Creek watershed rather than strong algal response (photosynthesis and respiration) to nutrient enrichment. Major ion concentrations, related to SC, at Wolf DS were likely indicative of both upstream nonpoint-source runoff and wastewater effluent from the Pearl River wastewater treatment plant (WWTP). Chloride concentrations within some Wolf DS samples were above the tolerance indicator value of 40 mg/L determined for some fish species. Surface water was predominantly a calcium-bicarbonate type, but samples from Wolf DS indicated a shift toward sodium-bicarbonate type.

Nutrient concentrations were also often higher at Wolf DS compared to the other sites, likely related to wastewater effluent from the Pearl River WWTP as well as nonpoint-source runoff from within the Wolf Creek watershed. Concentrations of total nitrogen (TN) and total phosphorus (TP) often exceeded State and regional Federal nutrient criteria at seven of the eight sampled stream sites, indicating that nutrient enrichment may be common seasonally among streams within the PRC Tribal lands. Although nutrient concentrations can be strongly influenced by seasonal streamflows and periodic high flows, specific relations between nutrients and streamflow were not apparent during this study.

Approximately half of the 60 organic wastewater compounds (OWCs) analyzed were detected among the sampled sites, but concentrations of OWC constituents were relatively low. Only 19 percent of the detected and quantifiable concentrations were above their respective reporting level. Among the compounds with endocrine-disrupting potential, only 1,4-dichlorobenzene at Wolf DS, p-Cresol at Wolf US and Jones, and acetyl hexamethyl tetrahydro naphthalene (AHTN) at Wolf US, Wolf DS, and Pearl US were detected above the reporting limit.

Trace elements were commonly detected in streambed-sediment samples from all sites, but concentrations were generally low. Arsenic and chromium were notable exceptions, however, and were above the consensus-based threshold-effect concentration at most stream sites. The copper concentration at Wolf DS and the nickel concentration at Beasha US were also each above the threshold-effect concentration. Eight polycyclic aromatic hydrocarbon compounds were detected in streambed sediments among the sampled sites, but only four—benzo[b]fluoranthene, benzo[ghi]perylene, benzo[k]fluoranthene, and indeno[1,2,3-cd]pyrene—were detected above their reporting level. Those compounds were detected at Wolf US, Wolf DS, or Beasha DS, but concentrations were well below established sediment quality guidelines.

Periphyton, benthic macroinvertebrates (BMI), and fish were sampled to establish baseline records of biological communities and to evaluate their potential for assessing overall ecological conditions with specific regard to water quality. Taxonomic and community metrics were calculated and compared among sites and, if available, compared to local, regional, or national indices of biotic integrity. Periphyton algal communities were mostly composed of diatom taxa among sampled sites. The greatest diversity of algal taxa was collected from Pearl DS. Low taxa richness and diversity coupled with the presence and high relative abundance of some diatom taxa that are considered indicators of nutrient-enriched waters at Wolf US and Wolf DS suggest that nutrients are influencing periphyton communities in Wolf Creek.

BMI communities were most diverse at Beasha US and Wolf US and least diverse at Kentawka and Wolf DS. Wolf DS had relatively high abundance of taxa within the order Tubificida, which are strong indicators of organic material. Wolf DS also received the lowest Mississippi-Benthic Index of Stream Quality score, indicating a substantially altered BMI community relative to other sites sampled for BMI and relative to a previously established least-disturbed site within the East Bioregion.

Forty-two species of fish were collected among the 8 sampled sites, with the greatest fish species richness (23 species) collected from Wolf US. The fewest number of species (three) was collected at Kentawka, which has the smallest drainage area of the sampling sites and experiences intermittent flow conditions annually. The relatively low richness (10 species) at Pearl DS (compared to 20 species at Pearl US) was likely due, in part, to difficult sampling conditions and low electrofishing sampling efficiency. In contrast, low fish richness and abundance at Wolf DS were likely related to diminished water quality downstream from the Pearl River WWTP.

In support of the other biological metrics (abundance, richness, indicator taxa, Shannon's diversity index), multivariate ordinations (nonmetric multidimensional scaling) of the periphyton, macroinvertebrate, and fish communities among stream sites each consistently indicated that the abundance and composition of taxa at Wolf DS were relatively distinct from that at other sites.

Quantitative habitat characteristics indicated that Beasha US and Beasha DS had less wetted habitat (depth, width, and volume) compared to other sites. Likewise, both sites had low overall qualitative habitat assessment scores. Despite this, Beasha US and Beasha DS supported relatively diverse biological communities. Both Wolf Creek sites were found to have relatively high-quality habitat condition, which may help support biological communities despite evidence of altered chemical water quality.

Since 2012, cooperative efforts between MBCI and USGS have focused on capacity building of water-quality and biological assessments of Tribal lands. Data and results from this study can be used by the MBCI as a benchmark or baseline of the physical, chemical, and biological conditions of streams within or near MBCI Tribal lands by which to compare future data collection efforts, as a guide for directing effective intensive data collection and assessment efforts based on the identification of potential stressors and ecological responses, and as a guide for targeting areas for future implementation of best management practices.

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Appendix 1

The following are summarized and condensed tables of periphyton (table 1.1), benthic macroinvertebrate (table 1.2), and fish (table 1.3) taxa and abundances collected during this study from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, 2017–18. Raw data associated with each table are available in Driver and Hicks (2022).

Table 1.1. Periphyton taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.

[DS, downstream; US, upstream; sp., undetermined species designation; SESQA, Southeast Stream Quality Assessment; var., species variant; subsp., subspecies; spp., undetermined designation including multiple species. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Type	Genus	Taxon name	Abundance[1]						
			Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS
Diatom	*Achnanthidium*	*Achnanthidium exiguum*	13	15	3	8	4		4
		Achnanthidium gracillimum		3		1			
		Achnanthidium minutissimum[2]			132	14	14	1	6
	Adlafia	*Adlafia* sp. 3 SESQA[4]		47	3	10	8	32	14
	Amphora	*Amphora bicapitata*		2					
		Amphora minutissima							1
	Asterionella	*Asterionella formosa*[3]							4
	Aulacoseira	*Aulacoseira alpigena*	1		5				2
		Aulacoseira ambigua							11
		Aulacoseira italica		4					
		Aulacoseira pusilla		1					
	Brachysira	*Brachysira brebissonii*[2]			2				
		Brachysira microcephala[2]			50				
	Caloneis	*Caloneis bacillum*						2	
		Caloneis hyalina	1			8	2		2
	Capartogramma	*Capartogramma crucicula*				3		2	
	Chamaepinnularia	*Chamaepinnularia mediocris*[2]			2		2		
	Cocconeis	*Cocconeis placentula*	1	1					
	Craticula	*Craticula accomoda*					4		2
		Craticula sp. 3 SESQA[4]				13	12	15	8
		Craticula subminuscula	1	11				1	1
	Cyclostephanos	*Cyclostephanos tholiformis*[3]							1
	Cyclotella	*Cyclotella meneghiniana*[3]	1	5				1	67
	Cymbella	*Cymbella aspera*			1				
	Cymbopleura	*Cymbopleura naviculiformis*			2				
	Delicata	*Delicata*			1				
	Diadesmis	*Diadesmis confervacea*[3]		124				10	
		Diadesmis perpusilla				1			
	Diploneis	*Diploneis* sp. 2 SESQA[4]	4	2	35	9	20	2	

Table 1.1. Periphyton taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.—Continued

[DS, downstream; US, upstream; sp., undetermined species designation; SESQA, Southeast Stream Quality Assessment; var., species variant; subsp., subspecies; spp., undetermined designation including multiple species. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Type	Genus	Taxon name	Abundance[1] Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS
	Discostella	*Discostella pseudostelligera*[3]							10
		Discostella stelligera		1					
	Encyonema	*Encyonema minuta* var. *pseudogracilis*			11			1	
		Encyonema minutum[2]		2		2	12	8	
		Encyonema neogracile			5				
		Encyonema silesiacum[2]			2				
		Encyonopsis subminuta	2						
	Eunotia	*Eunotia bilunaris*[2]			1			1	
		Eunotia boomsma			3				
		Eunotia incisa			5			7	7
		Eunotia metamonodon			21	23			1
		Eunotia minor	9	6	24	5		3	8
		Eunotia naegelii			1				
		Eunotia papilioforma				9	2		
		Eunotia perpusilla					1		
		Eunotia tenella[2]			1	2			
		Eunotia varioundulata					1		
	Fallacia	*Fallacia insociabilis*							2
		Fallacia monoculata				1			
	Fragilaria	*Fragilaria capucina* var. *gracilis*			4				
		Fragilaria crotonensis[2]			1				
		Fragilaria tenera[2]	3						
		Fragilaria vaucheriae		16					65
	Frustulia	*Frustulia crassinervia*[2]	4	2	15	18	12	2	6
		Frustulia inculta			3	1	1	2	
		Frustulia latita			2		1		
	Geissleria	*Geissleria acceptata*	2						
		Geissleria decussis				8	2		1

Table 1.1. Periphyton taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.—Continued

[DS, downstream; US, upstream; sp., undetermined species designation; SESQA, Southeast Stream Quality Assessment; var., species variant; subsp., subspecies; spp., undetermined designation including multiple species. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Type	Genus	Taxon name	Abundance[1]						
			Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS
		Geissleria kriegeri[2]			5				3
		Geissleria lateropunctata	3			18	17		2
		Geissleria punctifera	1	2		34	19		14
	Gomphonema	*Gomphonema affine*				2	1		
		Gomphonema exilissimum			38	1	16		
		Gomphonema kobayasii	9	2					6
		Gomphonema louisiananum	27			1	2	20	4
		Gomphonema parvulum	2	6	51		33	5	25
	Gomphosphenia	*Gomphosphenia lingulatiformis*					2	10	2
	Gyrosigma	*Gyrosigma acuminatum*[3]				1			5
	Halamphora	*Halamphora coffeaeformis*					1		
	Hantzschia	*Hantzschia amphioxys*			1				
		Hantzschia distinctepunctata				1			
	Hippodonta	*Hippodonta capitata*[3]				3		4	4
		Hippodonta capitata subsp. *iberoamericana*			2		10	2	
	Humidophila	*Humidophila contenta*					2	6	
	Hydrosera	*Hydrosera whampoensis*							2
	Lindavia	*Lindavia* sp.							2
	Luticola	*Luticola mutica*			1				1
	Mayamaea	*Mayamaea agrestis*		6		5	10	4	4
		Mayamaea atomus	5		5	7	2	2	
	Melosira	*Melosira varians*		1				3	
	Microcostatus	*Microcostatus krasskei*						1	
	Navicula	*Navicula aitchelbee*		3				4	
		Navicula angusta	9		3				
		Navicula antonii	2	12		10	6		
		Navicula canalis				17	28	32	13
		Navicula cryptocephala	14		15	12	3	13	3

Table 1.1. Periphyton taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.—Continued

[DS, downstream; US, upstream; sp., undetermined species designation; SESQA, Southeast Stream Quality Assessment; var., species variant; subsp., subspecies; spp., undetermined designation including multiple species. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Type	Genus	Taxon name	Abundance[1]						
			Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS
		Navicula cryptotenella						7	2
		Navicula escambia	2	3		33	19	2	1
		Navicula geitleri		1	1	3	2		1
		Navicula germainii[3]	15	10		4	8	5	8
		Navicula gregaria[3]		9		1			
		Navicula ingenua[3]	154	50					2
		Navicula kotschyi			3				
		Navicula latelongitudinalis					1	7	
		Navicula longicephala	1		12	11	4	11	1
		Navicula notha[2]	8		19	7	47	4	7
		Navicula pseudoreinhardtii	2						1
		Navicula rostellata[3]	1		1	17	22	7	8
		Navicula schmassmannii		2				1	
		Navicula symmetrica	2						
		Navicula tridentula			1				
		Navicula trivialis							1
		Navicula vilaplanii	2					5	
		Navicula viridulacalcis subsp. *neomundana*						6	
	Neidium	*Neidium affine* var. *amphirhynchus*	2	2			1		
		Neidium bisulcatum			2				
	Nitzschia	*Nitzschia acicularioides*				2	2	12	7
		Nitzschia amphibia[3]	60	30		4			
		Nitzschia clausii	2		1	7	6	6	1
		Nitzschia compressa var. *vexans*						7	
		Nitzschia dissipata var. *media*					4		
		Nitzschia draveillensis				4	4		4
		Nitzschia frustulum			16			14	

Table 1.1. Periphyton taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.—Continued

[DS, downstream; US, upstream; sp., undetermined species designation; SESQA, Southeast Stream Quality Assessment; var., species variant; subsp., subspecies; spp., undetermined designation including multiple species. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Type	Genus	Taxon name	Abundance[1]						
			Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS
		Nitzschia gessneri				4	1		
		Nitzschia linearis			4				
		Nitzschia linearis var. *tenuis*[3]			2				
		Nitzschia lorenziana				1			
		Nitzschia minuta	1						
		Nitzschia montanestris		2	2				2
		Nitzschia palea[3]	15	5	7	9	6	6	2
		Nitzschia palea var. *debilis*[3]		41	12	65	63	42	61
		Nitzschia palea var. *tenuirostris*					28	22	2
		Nitzschia paleacea							1
		Nitzschia recta							6
		Nitzschia subacicularis				2		4	1
		Nitzschia subtilis							3
		Nitzschia tubicola		2					
	Nupela	*Nupela neglecta*						11	
		Nupela wellneri					2	7	
	Pinnularia	*Pinnularia mesogongyla*	1		3	1			
		Pinnularia saprophila			1	2	3	6	
		Pinnularia subcapitata var. *paucistriata*		14		9	6	1	
	Placoneis	*Placoneis neglecta*						3	1
	Planothidium	*Planothidium apiculatum*				1	5		
		Planothidium biporomum[3]				1			
		Planothidium daui				5			4
		Planothidium frequentissimum[3]	1		2				
		Planothidium rostratum	2	1		4			2
	Pleurosira	*Pleurosira laevis*							13
	Pseudofallacia	*Pseudofallacia tenera*		13		4	8		1
	Pseudostaurosira	*Pseudostaurosira trainorii*		13					

Table 1.1. Periphyton taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.—Continued

[DS, downstream; US, upstream; sp., undetermined species designation; SESQA, Southeast Stream Quality Assessment; var., species variant; subsp., subspecies; spp., undetermined designation including multiple species. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Type	Genus	Taxon name	Abundance[1]						
			Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS
	Sellaphora	*Sellaphora atomoides*				20	11	1	3
		Sellaphora crassulexigua		6				11	2
		Sellaphora difficillima	9	12	8	4	23	86	36
		Sellaphora hustedtii		1		2	3	16	6
		Sellaphora japonica	29						
		Sellaphora laevissima[2]					2		
		Sellaphora nigri	122	35		59	4	32	48
		Sellaphora pupula[3]	4			4	2		1
		Sellaphora saugerresii	9	4		7	10	14	5
		Sellaphora subfasciata					2	2	
		Sellaphora wallacei			4	1		2	1
	Simonsenia	*Simonsenia delognei*				2			
	Stauroneis	*Stauroneis kriegeri*				6			
	Staurosira	*Staurosira construens* var. *venter*	9	13					
	Staurosirella	*Staurosirella* sp.			1				
	Stenopterobia	*Stenopterobia delicatissima*						2	
	Surirella	*Surirella angusta*		2		2			
		Surirella atomus					1		
		Surirella bohemica				2	6		
		Surirella minuta				1			
		Surirella stalagma			1	5		4	1
		Surirella suecica				4			
		Surirella tenera					1	6	
	Synedra	*Synedra* spp.					3		
	Terpsinoe	*Terpsinoe musica*							5
	Thalassiosira	*Thalassiosira lacustris*							4
		Thalassiosira weissflogii[3]							3
	Tryblionella	*Tryblionella debilis*	4		2				

Table 1.1. Periphyton taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, August 2018.—Continued

[DS, downstream; US, upstream; sp., undetermined species designation; SESQA, Southeast Stream Quality Assessment; var., species variant; subsp., subspecies; spp., undetermined designation including multiple species. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Type	Genus	Taxon name	Abundance[1]						
			Wolf US	Wolf DS	Jones	Beasha DS	Beasha US	Pearl US	Pearl DS
		Tryblionella littoralis			1	2			
	Ulnaria	*Ulnaria ulna*		6					1
Blue-green	*Calothrix*	*Calothrix* spp.			2				
	Chamaesiphon	*Chamaesiphon* spp.					2		2
	Heteroleibleinia	*Heteroleibleinia* spp.	27	2		14	8		
	Homoeothrix	*Homoeothrix* spp.		8					
	Leptolyngbya	*Leptolyngbya* spp.	60	1	45	67	6	7	14
	Merismopedia	*Merismopedia* spp.	1			1	1		
	Phormidium	*Phormidium* spp.		7				57	
	Pseudanabaena	*Pseudanabaena* spp.			2			1	2
Green	*Chlamydomonas*	*Chlamydomonas* spp.	1						
	Cladophora	*Cladophora* spp.			7		1		
	Cosmarium	*Cosmarium* spp.	1				2		
	Euastrum	*Euastrum* sp.						1	
	Monoraphidium	*Monoraphidium* sp.							1
	Oocystis	*Oocystis* sp.							1
	Scenedesmus	*Scenedesmus* spp.	3			2	1		4
	Spirogyra	*Spirogyra* sp.		1					
Red		Rhodophyte (phylum)	2					1	
Flagellated	*Phacus*	*Phacus* spp.							2
	Trachelomonas	*Trachelomonas* sp.	1						
		Genus richness	30	34	32	31	33	31	41
		Taxa richness	53	52	62	74	71	68	82

[1]Diatom abundance = number of cells counted; soft-algae (blue-green, green, red, flagellated) abundance = number of natural units counted.

[2]Diatom taxa known to be an indicator of low nutrients (total phosphorus and [or] total nitrogen) in Eastern Plains rivers (Potapova and Charles, 2007).

[3]Diatom taxa known to be an indicator of high nutrients (total phosphorus and [or] total nitrogen) in Eastern Plains rivers (Potapova and Charles, 2007).

[4]Diatom taxa identification and voucher reference from U.S. Geological Survey Southeastern Stream Quality Assessment (Bishop and others, 2017).

Table 1.2. Benthic macroinvertebrate taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.

[DS, downstream; US, upstream. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Order	Family	Taxon name	Abundance					
			Wolf US	Wolf DS	Jones	Kentawka	Beasha DS	Beasha US
Amphipoda	Crangonyctidae	*Crangonyx*			3	3		
		Synurella	1		12	4		
	Hyalellidae	*Hyalella*	2					3
Arhynchobdellida	Erpobdellidae	*Erpobdella*		1				
Basommatophora	Lymnaeidae	Lymnaeidae	1					
	Physidae	Physidae	2	1	1			
	Planorbidae	*Menetus*	1	1				
Branchiobdellida	Branchiobdellidae	Branchiobdellidae			2	1		
Coleoptera	Dytiscidae	*Neoporus*			21	6		1
	Elmidae	*Ancyronyx variegatus*	1		1		1	4
		Dubiraphia			2		1	1
		Macronychus glabratus			1		1	4
		Stenelmis	1				1	7
	Gyrinidae	*Dineutus*			1			
	Scirtidae	*Scirtes*	1					2
Decapoda	Cambaridae	Cambaridae	1	1	5	1		1
Diptera	Ceratopogonidae	Ceratopogonidae		3	1		1	4
	Chironomidae	*Ablabesmyia*	1		4		3	1
		Chironomus					1	
		Corynoneura			1		1	
		Cricotopus	4	3				1
		Cricotopus/ Orthocladius		3		1	5	
		Cryptochironomus						1
		Dicrotendipes					1	
		Diplocladius				1		
		Eukiefferiella					1	
		Heterotrissocladius		1				
		Limnophyes				1		
		Microtendipes	1	2	1	6		1

Table 1.2. Benthic macroinvertebrate taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.—Continued

[DS, downstream; US, upstream. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Order	Family	Taxon name	Abundance					
			Wolf US	Wolf DS	Jones	Kentawka	Beasha DS	Beasha US
		Nanocladius		1				
		Neostempellina						1
		Orthocladius				1		
		Parachironomus	1					
		Parakiefferiella	1	2				
		Parametriocnemus	1			21	1	2
		Paraphaenocladius			1			1
		Paratanytarsus					2	2
		Paratendipes	2	3			1	
		Phaenopsectra	2		1			
		Polypedilum	7		15	2	12	24
		Procladius		1				
		Pseudorthocladius						3
		Rheotanytarsus	4	1	1		6	1
		Stempellinella		1	3		4	1
		Stenochironomus			2			
		Tanytarsini						1
		Tanytarsus	6	2	13	4	20	2
		Thienemannimyia	1		12	8	8	7
		Tribelos					2	5
		Tvetenia	1			1		
		Xylotopus			1			
		Zavrelimyia	2	2		2	3	2
	Dixidae	*Dixella*			3			
	Empididae	*Hemerodromia*			1			
	Simuliidae	Simuliidae	11				31	14
	Tabanidae	*Chrysops*	2		1			
	Tipulidae	*Brachypremna*	2					
		Erioptera				1	2	5
		Gonomyia	1				1	

Table 1.2. Benthic macroinvertebrate taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.—Continued

[DS, downstream; US, upstream. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Order	Family	Taxon name	Abundance					
			Wolf US	Wolf DS	Jones	Kentawka	Beasha DS	Beasha US
		Pilaria						5
		Tipula		1	3			
Enchytraeida	Enchytraeidae	Enchytraeidae	3			4	3	5
Ephemeroptera	Baetidae	*Acentrella*						1
		Acerpenna					17	
		Baetis					1	1
		Labiobaetis		2	1			
		Plauditus	3					
	Caenidae	*Caenis*	47	21			18	14
	Ephemeridae	*Hexagenia*			7			
	Heptageniidae	*Maccaffertium*		1			7	2
		Stenacron	4				1	5
	Leptophlebiidae	Leptophlebiidae			6		1	
Hirudinea	Erpobdellidae	*Mooreobdella*	1					
	Piscicolidae	Piscicolidae		1				
Hoplonemertea	Tetrastemmatidae	*Prostoma*		1				
Isopoda	Asellidae	Asellidae					1	
		Caecidotea		2				1
		Lirceus	4	1	4			8
Lumbriculida	Lumbriculidae	Lumbriculidae		2		1	1	1
Nematoda (phylum)		Nematoda				1		
Odonata	Aeshnidae	*Boyeria*						1
	Calopterygidae	*Calopteryx*	1		1			1
	Coenagrionidae	*Argia*	1					
		Enallagma	1					
	Corduliidae	Corduliidae				9		
	Gomphidae	*Gomphus*		1	1			
	Libellulidae	Libellulidae	1					
Opisthopora	Lumbricidae	Lumbricidae						1
	Sparganophilidae	*Sparganophilus*	1					

Table 1.2. Benthic macroinvertebrate taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, February–March 2017 and March 2018.—Continued

[DS, downstream; US, upstream. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Order	Family	Taxon name	Abundance					
			Wolf US	Wolf DS	Jones	Kentawka	Beasha DS	Beasha US
Plecoptera	Nemouridae	*Amphinemura*	2		7	78		1
	Perlidae	*Perlesta*	3			5		1
	Perlodidae	*Clioperla*			5	2		
		Isoperla	2		9	6	1	
Trichoptera	Dipseudopsidae	*Phylocentropus*						1
	Hydroptilidae	*Hydroptila*						1
	Leptoceridae	*Oecetis*						2
		Triaenodes	1					1
	Limnephilidae	*Ironoquia*				1		
	Philopotamidae	*Chimarra*						1
	Phryganeidae	*Ptilostomis*			1			
	Polycentropodidae	*Plectrocnemia*					1	
		Polycentropus						1
	Psychomyiidae	*Lype*					1	
	Rhyacophlidae	*Rhyacophila*				1		
Tricladida	Planariidae	Planariidae		1				
Tubificida	Naididae	Tubificinae		2	1		1	
		Aulodrilus		3			1	
		Dero	13	8				1
		Limnodrilus	1	68			2	2
		Nais	2	4				
		Slavina						2
		Spirosperma		1				
		Stylaria	18	54	3		3	1
		Varichaetadrilus			1			11
Veneroida	Corbiculidae	Corbiculidae	1		4		2	6
	Sphaeriidae	Sphaeriidae	3	2	4			
Order richness			15	13	13	11	10	14
	Family richness		29	18	25	15	17	27
		Taxa richness	48	36	42	27	41	55

Table 1.3. Fish taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, April 2018.

[DS, downstream; US, upstream. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Family	Scientific name	Common name	Wolf US	Wolf DS	Jones	Kentawka	Beasha DS	Beasha US	Pearl US	Pearl DS
Lepisosteidae	*Lepisosteus oculatus*	Spotted Gar							11	
Amiidae	*Amia calva*	Bowfin							1	
Cyprinidae	*Cyprinella venusta*	Blacktail Shiner	11	1	1		1	11	66	34
	Hybognathus hayi	Cypress Minnow								1
	Hybognathus nuchalis	Mississippi Silvery Minnow	50					2		
	Hybopsis winchelli	Clear Chub				7			1	
	Lythrurus roseipinnis	Cherryfin Shiner	74	1	4			1		
	Macrhybopsis tomellerii	Gulf Chub						1	1	1
	Notemigonus crysoleucas	Golden Shiner	1					3		
	Notropis longirostris	Longnose Shiner	2					4		
	Notropis texanus	Weed Shiner	36	1			2			14
	Opsopoeodus emiliae	Pugnose Minnow	2	1			1		1	
	Pimephales vigilax	Bullhead Minnow							1	
Catostomidae	*Carpiodes cyprinus*	Quillback							5	
	Erimyzon oblongus	Creek Chubsucker	4					3		
	Moxostoma poecilurum	Blacktail Redhorse					2		3	
Aphredoderidae	*Aphredoderus sayanus*	Pirate Perch	1		5			2		
Ictaluridae	*Ameiurus natalis*	Yellow Bullhead	7		1			1		
	Ameiurus nebulosus	Brown Bullhead	1							
	Ictalurus furcatus	Blue Catfish							2	
	Ictalurus punctatus	Channel Catfish							3	
	Noturus leptacanthus	Speckled Madtom						6		
Esocidae	*Esox americanus vermiculatus*	Grass Pickerel			1					
Fundulidae	*Fundulus olivaceus*	Blackspotted Topminnow	6	18	35		1	14	2	2
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	1	6	1					
Atherinopsidae	*Labidesthes sicculus*	Brook Silverside							1	1
Centrarchidae	*Ambloplites ariommus*	Shadow Bass					1		3	4
	Lepomis cyanellus	Green Sunfish			1	1		3		
	Lepomis gulosus	Warmouth	2	10	4		1	1		
	Lepomis macrochirus	Bluegill	4	1	21		3	15	13	1

Table 1.3. Fish taxa and abundances collected from the Pearl River and selected tributaries contiguous to and within Tribal lands of the Pearl River Community of the Mississippi Band of Choctaw Indians, central Mississippi, April 2018.—Continued

[DS, downstream; US, upstream. See table 1 for site information. Raw data available in Driver and Hicks (2022)]

Family	Scientific name	Common name	Wolf US	Wolf DS	Jones	Kentawka	Beasha DS	Beasha US	Pearl US	Pearl DS
	Lepomis megalotis	Longear Sunfish	17	37	5		19	45	35	30
	Lepomis microlophus	Redear Sunfish			1		1	1	1	
	Lepomis miniatus	Redspotted Sunfish	3	4						
	Micropterus punctulatus	Spotted Bass	1	1	1		5	1	10	5
	Micropterus salmoides	Largemouth Bass			1					
	Pomoxis nigromaculatus	Black Crappie					1		2	
Percidae	*Etheostoma chlorosoma*	Bluntnose Darter	3	1	2					
	Etheostoma parvipinne	Goldstripe Darter	2		1	3				
	Etheostoma swaini	Gulf Darter	5							
	Percina nigrofasciata	Blackbanded Darter	6		1			4		
Sciaenidae	*Aplodinotus grunniens*	Freshwater Drum							1	
Elassomatidae	*Elassoma zonatum*	Banded Pygmy Sunfish	1		1					
		Species richness	23	12	18	3	12	18	20	10
		Family richness	9	5	9	3	4	7	9	4
		Total abundance	240	82	87	11	38	118	163	93

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