

**MISSOURI INTEGRATED WATER QUALITY REPORT
AND SECTION 303(d) LIST, 2020**

Clean Water Act Sections 303(d), 305(b), and 314



**Missouri Department of Natural Resources
Water Protection Program**

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EXECUTIVE SUMMARY

The Missouri Integrated Water Quality Report was prepared by the Missouri Department of Natural Resources to meet requirements stated in Sections 303(d), 305(b), and 314 of the federal Clean Water Act (CWA). Section 303(d) requires states to submit a list of waters not meeting water quality standards (WQS). Section 305(b) requires an assessment of surface water quality and summary of monitoring and pollution control activities. Section 314 requires a status and trends assessment of publicly owned lakes. The primary purpose of this report is to provide the U.S. Environmental Protection Agency (EPA) and the residents of Missouri with an update on the condition of surface water quality in the state.

Data used in this report were generated through the Department's monitoring activities and the work of other agencies and organizations operating in conjunction with the Department or independently. Data were assessed using procedures contained in the Department's 2020 Listing Methodology Document (LMD). Monitoring and assessment mainly focused on classified lakes (321,736 acres) and streams (115,701 miles) throughout Missouri.

The 2020 Section 303(d) List of impaired waters requiring Total Maximum Daily Load (TMDL) studies was approved by the Missouri Clean Water Commission (CWC) on April 2, 2020. This list includes 481 water body-pollutant pairs for both classified and unclassified waters. Forty-four water body-pollutant pairs listed in the 2018 Section 303(d) were removed from the 2020 List. For the 2020 reporting cycle, data were available to assess approximately 11,673 miles of the 115,150 classified stream miles and 267,386 acres of the 319,550 acres of classified lakes in the state. Of the streams assessed, data indicated 4,898 miles, or 4 percent, fully supported their designated uses, while 5,090 miles, or 4 percent, were found to be impaired for at least one designated use. Major causes for impairment included bacteria, low dissolved oxygen, mercury in fish tissue, heavy metals, and limited aquatic macroinvertebrate communities. Major sources of impairment included urban and rural nonpoint source pollution, municipal point sources, and mining activities. For assessed classified lakes, 171,797 acres, or 54 percent, fully supported their designated uses, while 90,941 acres, or 28 percent, were impaired for one or more designated use. Primary causes of impairment in lakes included nutrients, chlorophyll-a, and mercury in fish tissue. Major pollutant sources included urban and agricultural nonpoint source pollution, atmospheric deposition, and municipal point sources.

Trophic status was summarized for a total of 234 lakes (269,449 acres), where 11 lakes (1,056 acres) were classified as oligotrophic; 63 lakes (83,678 acres) as mesotrophic; 145 lakes (182,423 acres) as eutrophic; and 15 lakes (2,292 acres) as hypereutrophic.

PART A: INTRODUCTION

A.1. Reporting Requirements

The *Missouri Integrated Water Quality Report for 2020* was prepared by the Department to fulfill reporting requirements contained in Sections 303(d), 305(b), and 314(a) of the federal CWA. CWA Section 303(d) requires each state to identify waters not meeting established WQS, and those which are also lacking an approved TMDL study or a permit requiring adequate pollution control. Water bodies that are on the 303(d) list are commonly known as “impaired waters.” CWA Section 305(b) requires states to submit information pertaining to the overall status of its surface waters, and to provide a description of its water quality monitoring, management, and pollution abatement programs. It also provides an opportunity to include a description of the state’s groundwater quality, as well as any related monitoring and protection programs. Under Section 314(a), each state is required to provide an assessment of the water quality of all publicly owned lakes, including a description of their status and trends.

The 2020 Missouri Integrated Report is based on EPA’s *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act* supplemented by memorandums from the Office of Wetlands, Oceans, and Watersheds concerning CWA Sections 303(d), 305(b), and 314 integrated reporting and listing decisions. Under the CWA, the Department is required to report the quality of the state’s waters every two years to the EPA. The EPA compiles all state reports and prepares a summary for the United States Congress on the nation’s waters. The report may then be used for rulemaking, budget appropriations, and program evaluations by federal legislators.

Missouri has a large network of water resources that contributes greatly to the quality of life in the state. This network of streams, lakes, and wetlands helps support state energy needs, sustains farming and industrial operations, provides habitat to wildlife, offers a variety of recreational opportunities for residents as well the state’s tourism industry. Therefore, the efficacy of the Department’s regulatory and conservation work is imperative. In addition to fulfilling federal reporting requirements, information provided herein is intended to help guide future water resource management efforts in the state.

A.2. Changes from Previous Report

The processes for assessing and interpreting water quality data did not change during the 2020 reporting cycle. Therefore, any changes since the last reporting cycle only include updates to the state’s LMD (<http://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm>).

The 2020 LMD describes the data that may be used for stream and lake assessments, as well as the assessment methods used to interpret WQS for 303(d) and 305(b) reporting. The Department is responsible for developing the LMD, which includes methods supported by sound science and advocated for by leading experts in a variety of aquatic science fields. In accordance with the Code of State Regulations (CSR) at 10 CSR 20-7.050(4)(A), the 2020 LMD underwent a 60-day public comment period and was ultimately approved by the Missouri CWC. During the public comment period, two public availability meetings were held. The final 2020 LMD was approved by the CWC on July 22, 2019.

Several revisions were made in the 2020 LMD to reflect recent changes in Missouri's WQS. First, hardness-based metals calculations were changed to use the median hardness rather than the 25th percentile. Second, the chronic cadmium hardness based acute and chronic equations were changed. Third, the method of selecting small candidate reference streams for purposes of assessing macroinvertebrate communities was updated. Finally, in the time since the 2018 LMD, new lake nutrient criteria were approved by EPA. Missouri's Nutrient Criteria Implementation Plan (NCIP¹) was incorporated into the 2020 LMD as an appendix. Under the NCIP, lakes are judged as impaired if they exceed the ecoregional Chlorophyll-a (Chl-a) Response Impairment Threshold, or if they exceed one of several Response Assessment Endpoints. For additional information, please see Section C.2.4 *Changes to the Listing Methodology Document*.

A.3. General Overview of the Assessment Approach

The Department's Water Protection Program (WPP) administers several water monitoring programs with the goal of generating sufficient data to assess all waters of the state. Monitoring is centered on three general approaches: (1) fixed station monitoring; (2) intensive surveys; and (3) screening level monitoring. WPP monitoring may also be used to support various Department initiatives and respond to problematic issues that emerge. In addition, the Department partners with and coordinates monitoring among outside agencies, organizations, and universities to obtain the comprehensive set of information needed for assessing state waters. While this approach does not cover all waters of the state, its goal is to provide the greatest scope and quality of coverage possible given the resources available. Detailed information regarding the monitoring programs used to satisfy CWA reporting requirements can be found in Section C.1. *Monitoring Program*.

Designated uses were assessed whenever sufficient data of reliable quality were available, and previous assessments were updated whenever an adequate amount of new information became available. In some cases, errors that were discovered in previous assessments were corrected. For assessing use attainment, recent data (i.e., less than seven years old) were preferred. Due to resource limitations, however, data older than 10 years were used for assessments if the data were considered to represent present conditions.

In general, surface water assessments were largely based on data collected through October 31, 2018, concerning fish and macroinvertebrate communities, water quality, physical habitat, fish tissue contaminants, and water or sediment toxicity. Monitoring predominantly utilized a targeted sampling design that focused on selected waters, and which provided the majority of data used in the reported assessments. To a lesser extent, a probabilistic sampling design was used as a secondary approach for assessing state waters. These data were derived from fish community surveys conducted by the Missouri Department of Conservation's (MDC) Rapid Assessment Monitoring (RAM) Program. The Department, through EPA's Section 319 Nonpoint Source Grant Program, provided funding to the University of Missouri-Columbia (UMC) to support two lake monitoring programs, the Statewide Lakes Assessment Program (SLAP) and the Lakes of Missouri Volunteer Program (LMVP). These data were used to assess

¹ <https://dnr.mo.gov/env/wpp/rules/documents/nutrient-implementation-plan-final-072618.pdf>

the aquatic life designated use, track lake trophic status throughout Missouri, and evaluate water quality trends for lakes with sufficient data.

While surface water assessments were the focus of this report, groundwater information was also included. The Department's Public Drinking Water Branch is the lead state entity responsible for monitoring groundwater quality in Missouri. Groundwater monitoring information is provided along with a summary of groundwater contamination and an overview of the programs available to prevent or remediate such problems. For additional information about the Public Drinking Water Branch beyond what is presented in this report, please see the Department's website at <http://dnr.mo.gov/env/wpp/dw-index.html>.

A.4. Organization of Report

Subsequent sections of this report are separated into four general categories. [Part B](#) provides background information on Missouri's streams and lakes, describes the Department's water management approach and any programs that protect or improve surface water quality, gives an overview of costs and benefits of water management in the state, and provides a summary of important issues affecting water quality and associated management programs. [Part C](#) describes the Department's ongoing water monitoring programs, methodologies used to make assessment determinations for Section 303(d) listings, and major findings resulting from the assessment process. [Part D](#) focuses on the status of Missouri's groundwater resources as well as its related protection and monitoring efforts. [Part E](#) discusses Department procedures for public participation and stakeholder involvement in the development of the Section 303(d) list. Appendices at the end of this report are reserved for listing water body-specific water quality and other important supporting documents. [Appendix B](#) contains the recently approved 2020 Missouri Section 303(d) List of impaired waters.

PART B: BACKGROUND

B.1. Total Surface Waters

Missouri is home to slightly more than 6 million people with approximately one-half of the state's population residing in the metropolitan areas of Kansas City and St. Louis (US Census Bureau 2016). These cities were settled on the Missouri and Mississippi rivers – two of the nation's great rivers – which are essential to the economies of the regions. Beyond the two great rivers, Missouri's landscape contains a network of streams and lakes. These waters are expected to meet the needs of municipal, industrial, and agricultural operations and simultaneously serve as sources of safe drinking water, recreational sites, and wildlife habitats.

Missouri's classified streams total approximately 115,701 miles and classified lakes cover an estimated area of 321,736 acres (Table 1). Classified streams and lakes include those waters listed in Tables G and H of Missouri's WQS at 10 CSR 20-7.031. Classified waters are given priority under the Department's current water monitoring program. Unclassified streams contribute another 136,236 miles to Missouri's stream network, while unclassified lakes provide an additional 382,429 acres of surface area. Unclassified streams and lakes refer to waters not listed in Tables G and H of Missouri's WQS, but that are still considered waters of the state. Unclassified waters are afforded protection under Missouri's WQS, albeit to a lesser extent than

classified waters. In order to be considered a classified wetland under Missouri’s WQS 10 CSR 20-7.031(1)(F), wetlands must meet criteria established in the *United States Army Corps of Engineers Wetlands Delineation Manual 1987*; however, a defined set of classified wetlands does not exist at this time. Previous work by the Department’s Division of Geology and Land Survey estimated wetland coverage in the state to be approximately 624,000 acres (Epperson 1992). In comparison, the United States Fish and Wildlife Service’s (USFWS) National Inventory of Wetlands currently estimates approximately 1.4 million acres of wetlands exist in Missouri. This estimate is based on palustrine wetland types that include classified and unclassified streams and lakes, or portions of such. Regardless of the source, only estimates of wetland coverage exist for Missouri at this time, and a more precise measurement will not be available until a classified set of wetlands is formally adopted by the state.

Table 1. Overview of Missouri surface waters.

Topic	Value	Scale	Source
State population (people)	6,093,000	N.A.	US Census Bureau, 2016 estimate
State surface area (sq. miles)	68,742	N.A.	US Census Bureau
River sub-basins (8-digit HUCs)	66	1:24,000	USGS NHD & USDA NRCS WBD
Classified stream (miles)	115,701	1:24,000	WPP MUDD
Perennial (miles)	13,360	1:24,000	WPP MUDD
Intermittent (miles)	102,341	1:24,000	WPP MUDD
Losing streams (miles)	37,027	1:24,000	MGS
Great Rivers (miles)	1,053	1:24,000	WPP MUDD
Springs (number mapped)	4,487	1:100,000	MGS
Classified lakes (acres)	321,736	1:24,000	WPP MUDD
Unclassified streams (miles)	136,236	1:24,000	USGS NHD
Unclassified lakes (acres)	382,429	1:24,000	USGS NHD
Freshwater wetlands (acres)	624,000	1:24,000	MGS

USGS NHD - United States Geological Survey, National Hydrography Data Set;
USDA NRCS WBD – United States Department of Agriculture, National Resources Conservation Service, Watershed Boundary Dataset;
WPP MUDD – Water Protection Program, Missouri Use Designation Dataset;
MGS – Missouri Geological Survey;
HUC – Hydrologic Unit Code.

B.2. Overview of Missouri’s Waters

Natural lakes in Missouri are limited to oxbow lakes, sinkhole ponds in karst areas, and open water systems in the wetlands of southeastern Missouri (Nigh and Schroeder 2002). Man-made lakes and ponds are common throughout the state. These systems range in size from large reservoirs created for hydroelectric generation and water supply to small ponds used for livestock watering and recreation. The two largest reservoirs in the state are Lake of the Ozarks (59,520 acres) and Harry S. Truman Reservoir (55,600 acres).

The state’s stream systems are diverse, and their physical characteristics reflect those of their watersheds. Missouri’s streams can be grouped into three aquatic subregions: the Central Plains, the Ozark Plateau, and the Mississippi Alluvial Basin (Figure 1; Sowa *et al.* 2005). The

subregions are distinct with regard to terrain and geology, historical and present-day land cover, and stream morphology. Streams in each aquatic subregion generally have similar structural features and functional processes, which result in unique aquatic assemblages and ecological compositions.

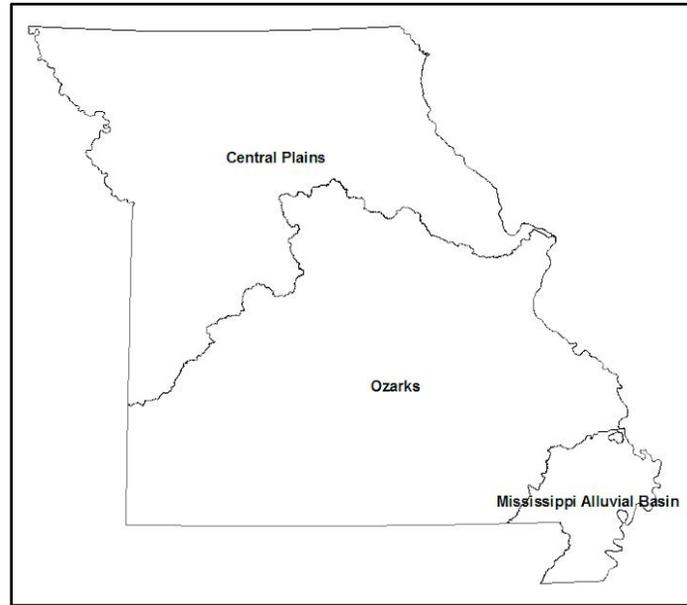


Figure 1. Missouri aquatic subregions

Central Plains of Northern and Western Missouri

The Central Plains cover the northern section of Missouri and extend down to the state’s west-central region. This western area formerly consisted of broad expanses of prairie, while the northern section contained smaller tracts of prairies separated by forests in valleys and on steeper slopes. The land is underlain by bedrock containing several relatively impermeable shale and clay layers. Today, this land is dominated by row crops on the flattest areas with the richest soils, pastures on irregular surfaces, and forests on some of the roughest tracts. Northern Missouri forests are more abundant today than they were historically (Nigh and Schroeder 2002).

Surface waters are generally turbid and affected by high rates of sediment deposition. Soil erosion induced sediment deposition, degrades aquatic habitat, and stresses aquatic life. Up to 8,000 miles of classified streams may be affected by these processes or other types of aquatic habitat degradation, such as flow modification or channelization.

Rivers and reservoirs used as drinking water supplies sometimes experience contamination from herbicides. Several reservoirs that served as public drinking water reservoirs exceeded drinking water standards for the herbicide atrazine or health advisory levels for the herbicide cyanazine. Currently, there is just one reservoir considered impaired for atrazine – Lewistown Lake in Lewis County, although this is no longer used as a drinking water supply. Local watershed management programs aimed at reducing herbicide runoff have been relatively effective. Several

other herbicides are occasionally found in drinking water reservoirs, but at concentrations below health advisory levels.

The quality of groundwater in northern and western Missouri is also influenced by the geology of the area. Public water supply sources include reservoirs and wells. The wells obtain water primarily from glacial drift deposits in portions of north-central and western Missouri. Wells in western Missouri, south of Kansas City, obtain water from limestone aquifers, except for the extreme western limits of Missouri near the state border with Kansas. Private water supplies are obtained from glacial drift deposits and from underlying limestone bedrock in portions of northwestern, central, eastern, and northeastern Missouri. However, deep bedrock wells in many north-central and northwestern Missouri locations tap water supplies that are too mineralized for drinking water purposes. It is believed that some private wells in this part of Missouri may exceed the drinking water standard for nitrate, and a very small number may exceed the standard for pesticides. This trend is most frequently caused by localized surface contamination of the wellhead and does not represent widespread contamination of the aquifer. Deeper aquifers are generally protected from surface contamination by impermeable strata.

The Ozarks

The hilly topography of the Ozarks region contains areas with the greatest relief in the state. Pre-settlement vegetation was dominated by forests to the east, woodlands in the central and western Ozarks, and prairies along the outer boundary of the subregion. Currently, the eastern Ozarks is dominated by forest cover, whereas the western Ozarks have considerably more land in crops and pasture, with woods concentrated on steeper terrain. The bedrock – consisting of limestone, dolomite, and sandstone – yields groundwater of excellent quality and of a volume generally adequate to supply urban, industrial, and other needs. The soil or subsoil has developed from weathering of bedrock formations and is typically 20 to 80 feet thick. Some areas have extremely thin soils, but in locations where weathering has been extensive, soils may be 100 feet thick or more. The subsoil has moderate to high infiltration rates, which contribute to the recharge of groundwater supplies. Streams are typically entrenched into bedrock and influenced to some degree by groundwater flow from large springs (Nigh and Schroeder 2002). Losing streams, which lose flow through underground infiltration, occur in karst regions of the Ozarks.

Ozark streams are generally clear, with base flows well sustained by many seeps and springs. Some streams and reservoirs in the Ozarks are becoming nutrient and algae enriched as a result of increasing human population and domestic animal production in their watersheds.

Groundwater contamination risks are moderate to high due to the permeability of the soil and bedrock. A variety of surface activities, including agricultural and suburban-urban stormwater and wastewater disposal, mining, stormwater runoff, lawn care, improper well construction or closure, and individual onsite wastewater disposal practices, pose threats to surface water and groundwater quality. However, overall water quality remains good as a result of efforts to protect vulnerable aquifers in the Ozarks.

Groundwater is a heavily relied upon source of drinking water in this part of Missouri. Most municipalities in the southern half of the state exclusively use groundwater as their drinking water supply. The number of private drinking water wells statewide is not known, but is likely

between 100,000 and 250,000, mostly south of the Missouri River. One major groundwater concern is the potentially rapid and unfiltered transmission of contaminated surface runoff or leachate (e.g., septic tanks, underground storage tanks, landfills, animal production or processing waste) through fractures or sinkholes directly into potable aquifers. Properly cased wells in deep aquifers rarely encounter water quality problems, but shallow or improperly cased wells are at risk.

Mississippi Alluvial Basin

The Mississippi Alluvial Basin consists of flat terrain that at one time was largely covered by seasonal or perennial wetlands called “swamp forests.” Nearly all historic land cover in this region has been converted to crop production. Many streams have been channelized, and hundreds of man-made ditches drain the land. The natural hydrographies of perennial and seasonal wetlands have been modified here more than anywhere else in Missouri, and aquatic habitat degradation is widespread.

Groundwater is abundant due to high infiltration rates on these flat fields. Public water supplies that tap deeper aquifers provide good quality water, but shallow private wells may have nitrates and low levels of pesticides at times. The exceedance frequency of drinking water standards for nitrates and pesticides in private wells would be roughly similar to that of northern Missouri.

Great Rivers

The Great Rivers, the Missouri and Mississippi Rivers, are not classified as a subregion of their own, but are unique aquatic ecosystems that represent a significant water resource of Missouri. Approximately 1,053 miles of Great River habitat fall under Missouri’s jurisdiction. Great Rivers support a wide array of industrial and commercial needs, numerous recreational opportunities, and are utilized as primary sources of drinking water for many communities. Fish fauna of Great Rivers is comprised of a distinct assemblage of species, some of which occur nowhere else in Missouri (Pflieger 1997).

In northern Missouri, where surface and deep aquifer supplies are unreliable, many towns depend on the alluvial aquifers of nearby rivers. Landfills and industrial land use in Kansas City and St. Louis have historically been located on river floodplains and have caused local contamination of the Mississippi and Missouri River aquifers near St. Louis and the Missouri River aquifer in Kansas City. While alluvial aquifers of the Great Rivers may yield large quantities of groundwater, pumping induces recharge from the rivers which is a potential source of contamination. Some municipal water supplies have been impacted by groundwater contamination in the past, therefore, groundwater from these aquifers requires treatment.

B.3. Water Pollution Control Program

Missouri Surface Water Quality Standards

Authority for enforcing Missouri Clean Water Law and state regulations concerning water pollution resides with the Department’s WPP. Missouri’s approach to water quality management is primarily based on its WQS provided in 10 CSR 20-7.031. Under this rule, waters of the state are protected for specific designated uses. WQS are the basis for protecting designated uses, which in Missouri include: (1) drinking water supply; (2) human health protection - fish

consumption; (3) whole body contact recreation (e.g., swimming); (4) secondary contact recreation (e.g., fishing and wading); (5,6) aquatic life protection for general warm water and limited warm water habitat (7,8) aquatic life protection for cold water and cool water habitat; (9,10) aquatic life protection for ephemeral and modified aquatic habitats, (11) irrigation; (12) livestock and wildlife watering; and (13) industrial water supply. The Department is responsible for developing scientifically based WQS and proposing them to the Missouri CWC for adoption into state regulations. In accordance with the federal CWA, Missouri is required to review and update WQS at least once every three years.

To determine if designated uses are being protected, two general modes of WQS are used, narrative and numeric criteria. Narrative criteria are essentially protective descriptions that may be measured using numeric values. For example, 10 CSR 20-7.031(4)(D) states that waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal, or aquatic life. Quantitative methodologies then utilize numeric values to determine if a narrative criterion is exceeded and if substance(s) is/are having a toxic effect on human, animal, or aquatic life. In some cases, narrative criteria alone may be used to assess attainment of designated uses. For example, under 10 CSR 20-7.031(4)(A), waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly, or harmful bottom deposits that prevent full maintenance of designated uses. Streams with dense mats of floating sewage scum are in violation of this narrative standard. Numeric criteria are essentially water quality limits used to determine if designated uses are attained or not. Quantitative methods always use measured numeric values to examine if the numeric criterion is being upheld.

Additional protection to state waters is provided in the antidegradation component of WQS as contained in 10 CSR 20-7.031(3). Missouri's antidegradation policy consists of a three-tiered system. In the first tier, a level of water quality necessary to protect public health and in-stream. In the second tier, in cases where water quality is better than applicable water quality criteria, the existing quality shall be protected and maintained. Lowering of in-stream water quality is only allowed in such cases when it is determined to be a necessity for important economic and social development. This second tier also contains a set of strict provisions that must be followed for any permitted degradation of state waters. In the third tier, there shall be no degradation of water quality in outstanding national resource waters or outstanding state resource waters as listed in Tables D and E of 10 CSR 20-7.031.

Point Source Pollution Control

The Department, under the State of Missouri's authorization, administers a program equivalent to the National Pollution Discharge Elimination System (NPDES). Under Missouri Clean Water Law, the Department issues permits for discrete wastewater discharges (e.g., human wastewater, industrial wastewater, stormwater, confined animal operations) that flow directly into surface waters. Industrial, municipal, and other facilities are regulated in order to ensure that surface waters receiving effluent from these sources meet WQS. Permits include requirements for limitations on specific pollutants (e.g., biochemical oxygen demand, ammonia as nitrogen, chloride), monitoring and reporting, and the implementation of best management practices (BMPs) as needed. The Department requires wastewater facilities to meet certain design specifications, while plant supervisors and other operators are required to be certified at a level that corresponds to the plant's size and complexity. Approximately 756 miles of waters assigned

specific designated uses are on the 2020 303(d) List as a result of discharges from wastewater treatment facilities (WWTFs) or wastewater treatment plants (WWTPs). For additional information on the types of regulated discharges and available permits, please see the Department's website at <http://www.dnr.mo.gov/env/wpp/permits/index.html>.

Concentrated animal feeding operations (CAFOs) in Missouri are required to be designed, constructed, operated and maintained as "no discharge" facilities. Manure and wastewater produced by CAFOs is land-applied rather than discharged to streams. Permit requirements include development and implementation of a nutrient management plan which contains a strategy for the onsite utilization of BMPs. There are approximately 500 permitted CAFOs in Missouri, the majority of which are for swine and poultry production. For more information on CAFOs, please see the Department's website at <http://www.dnr.mo.gov/env/wpp/cafo/>.

The Department issues land disturbance permits to control stormwater runoff from disturbed sites that comprise of an area of one acre or more. Land disturbance permits require the use of BMPs to prevent the migration of silt and sediment into surface waters. A stormwater pollution prevention plan must also be prepared prior to issuance of any permit. Some activities that commonly require land disturbance permits include housing or building construction, road and dam construction, and utility pipelines. For more information on land disturbance permits, please see the Department's website at <http://www.dnr.mo.gov/env/wpp/stormwater/sw-land-disturb-permits.htm>.

The discharge of stormwater runoff transported through Municipal Separate Storm Sewer Systems (MS4s) is another regulated activity. Separate storm sewer systems include any method of conveying stormwater including streets, ditches, swales, or any man-made structure that directs flow. There are 164 identified MS4s in Missouri, and each one is required to develop and implement a stormwater management program to prevent and reduce any contamination of stormwater runoff and prevent illegal discharges. The stormwater management program includes six minimum control measures: (1) public education and outreach; (2) a process for public involvement and participation; (3) illicit discharge detection and elimination; (4) construction site stormwater runoff control; (5) post-construction stormwater management; and, (6) pollution prevention/good housekeeping for municipal operations. For additional information regarding stormwater regulations, please see the Department's website at <http://www.dnr.mo.gov/env/wpp/stormwater/index.html>.

Nonpoint Source Pollution Control

Nonpoint source (NPS) pollution comes from many diffuse sources and is defined as the transport of natural and man-made pollutants by rainfall or snowmelt, moving over and through the land surface and entering lakes, rivers, streams, wetlands or groundwater. Some common sources of NPS pollution include row crops and agricultural fields, road surfaces and parking lots, septic systems and underground storage tanks. In Missouri, significant contributors of NPS pollution include agricultural lands, urban areas, and abandoned mines. The Department takes two general approaches in managing NPS pollution: one that is volunteer-based and offers monetary incentives and grants, and another that is regulation-focused.

Many NPSs may be addressed by the Department's NPS Management Program. This program engages concerned citizen organizations, landowners, federal, state and local governments, as well as universities and other stakeholders to implement NPS control practices and monitor improvements to water quality and habitat. One priority of the Department's 2020-2025 draft NPS Management Plan is to restore impaired waters and to protect unimpaired high-quality waters. Grant funds provide local citizens the knowledge and ability to improve their common land use practices and to protect and improve water quality. The NPS Management Program's mission is to "protect and improve the quality of the state's water resources using locally led approaches to address nonpoint source impairments." NPS projects target numerous types of runoff pollutants (e.g., sediment, fertilizers, pesticides, bacteria, animal waste) through the implementation of land management measures (e.g., stream bank stabilization, riparian and wetland improvements) and cost-share programs. With the exception of special projects, funded activities are carried out as part of a larger watershed plan to improve specific stream and lake resources. Project funding is provided by the EPA through Section 319(h) of the federal CWA and supports 60 percent of total project costs. The NPS Program is a key partner of the Natural Resources Conservation Service's (NRCS) Mississippi River Basin Initiative (MRBI) and the recent NRCS-EPA collaborative National Water Quality Initiative. For more information regarding the Department's NPS Management Program, please visit the program's website at <https://dnr.mo.gov/env/swcp/nps/index.html>.

The Department's Soil and Water Conservation Program (SWCP) provides financial incentives to landowners for implementing conservation practices that help prevent soil erosion and protect water resources. Under this program, 114 district offices serve residents in each county of the state. The SWCP's Agricultural Nonpoint Source Special Area Land Treatment Program allows district staff to direct technical and financial assistance to property owners of agricultural lands identified as contributing sources of water quality impairments. SWCP also administers a cost-share program to help fund up to 75 percent of the estimated cost for certified conservation practices. In addition, SWCP is a contributing partner of the Mississippi River Basin Healthy Watersheds Initiative (MRBI), a 12-state effort addressing nutrient loading in the Mississippi River Basin. SWCP's primary funding source comes from a one-tenth-of-one-percent parks, soils, and water sales tax that is shared with the Division of State Parks. Please visit the SWCP website for more information at <http://www.dnr.mo.gov/env/swcp/index.html>.

While general NPS pollution is not formally regulated, there are instances of several different types of NPSs falling under a form of water pollution control. As noted earlier, permits are issued to control stormwater runoff from land disturbance activities of an acre or more, as well as for certain industries like biodiesel manufacturers and agrichemical producers. Some additional activities permitted by the state include clay, rock, and mineral mining; abandoned mine land reclamation; land application of human and animal wastewater; and underground petroleum storage. Construction, placement, dredging and filling, or general earth moving activities within a wetland or water body requires a 401 certification from the Department and 404 permit from the United States Army Corps of Engineers (USACE²). Single family residential wastewater systems, or septic systems, which are known nonpoint sources of pollution fall under the jurisdiction and responsibility of the Missouri Department of Health and Senior Services (DHSS).

² <http://www.dnr.mo.gov/env/wpp/401/>

TMDL Program

TMDLs are tools to inform watershed planning. A TMDL calculates the maximum amount of a pollutant that a water body can receive and still meet WQS. This calculated pollutant load is then allocated to the various sources in the watershed and becomes the goal to restore water quality. A portion of the pollutant load is also often allocated to an explicit margin of safety to account for any uncertainties in scientific and technical understandings of water quality in natural systems. The margin of safety provides additional assurance that WQS will be attained after allocations to point and nonpoint sources have been achieved. In addition to TMDLs, the Department has begun developing supplemental implementation plans to provide guidance to watershed managers, facility operators, landowners, and other stakeholders on approaches to meet the goals of the TMDL. In Missouri, all draft TMDLs and implementation plans are made available for public review and comment through a 45-day public notice period. All approved and draft TMDLs are available on the Department's TMDL webpage at dnr.mo.gov/env/wpp/tmdl/index.html. At the time of this report, the Department has 244 approved or EPA established TMDL actions. These actions address approximately 3,704 miles of streams in Missouri and approximately 3,612 surface acres of lakes.

TMDLs are required for all waters on the 303(d) List of impaired waters. Individual water body impairments included on the 303(d) List are ranked as High, Medium, or Low priority for TMDL development. For impairments ranked as High priority, a specific year is given for when a TMDL may be developed. All priority rankings and development schedules are reevaluated with each new 303(d) List. The Department maintains its most current TMDL development prioritization and schedule, as well as its framework for making prioritization decisions, on the TMDL webpage linked above. Questions or requests for information regarding TMDLs can be submitted by email to tmdl@dnr.mo.gov.

B.4. Cost/Benefit Assessment

Section 305(b) requires the state to report an estimate of economic and social costs and benefits required to realize objectives of the CWA. Cost information pertaining to water quality improvement and protection efforts is difficult to calculate exactly but can be estimated to some degree. While the Department tracks its own programmatic costs, those representatives of municipal, private, and industrial treatment facility operations, and in some cases, the implementation of BMPs, are typically not readily available. Economic benefits, in monetary terms, resulting from water protection efforts are even more difficult to calculate. An overview of the amount of funding the Department spends on various aspects of water pollution control and prevention is provided in the following paragraphs.

The Department spends an average of \$1.3 million on the United States Geological Survey (USGS) ambient water quality monitoring network each year. Annual costs for permit issuance averaged approximately \$3.2 million for fiscal years 2017 and 2018 (this only includes personal service (PS), fringe, and indirect on PS and fringe as expense and equipment is not coded to the activity level). On average, approximately \$12 million is spent each year for other facets of water pollution control and administrative support.

Another significant expense includes grants aimed at improving water quality. The Department awards funding provided by the EPA under Section 319 of the CWA for projects that address NPS pollution, and approximately \$3.6–\$3.7 million was available annually for NPS projects in federal fiscal years (FFYs) 2016 to 2018. Approximately \$200,000–\$300,000 is awarded annually for planning and implementation projects.

Through the Department's SWCP, an annual average of \$24.1 million is distributed directly to landowners to address agricultural NPS pollution and to conserve and protect the quality of water resources in agricultural landscapes. Over FFYs 2014 to 2015, a total of \$48.3 million was spent on SWCP conservation practices aimed at reducing soil runoff from farmland. Conservation practices have focused on managing animal waste, livestock grazing, irrigation, nutrients and pests, protecting sensitive areas and reducing erosion. Over the life of these conservation practices (i.e., generally 10 years), it is estimated that 4.3 million tons of soil will be protected.

Missouri's Clean Water State Revolving Fund (CWSRF) loan program provides low-interest financing to construct wastewater and stormwater projects that improve water quality. Other eligible projects include, but are not limited to, NPS projects and water conservation or reuse. During the 2019 reporting period, the Department entered into nine direct loans and four grants for a total of \$80,979,585 in CWSRF binding commitments. Funding for the CWSRF is provided by the EPA with matching funds from the State of Missouri. As of September 30, 2019, the CWSRF's cumulative binding commitments have totaled \$3,005,880,025, resulting in estimated interest savings for Missouri communities of \$1,001,973,263 as compared to conventional loans.

The Department's Public Drinking Water Branch operates a Source Water Protection Program (SWPP) that is designed to keep drinking water safe for Missouri's residents. The SWPP operates under a voluntary basis to provide public water suppliers with opportunities to protect drinking water that may be threatened by potential contaminants such as pesticides, other hazardous chemicals, stormwater runoff, and waste disposal sites as well as septic tanks. Funding activities primarily include wellhead protection and capacity development. Costs associated with implementing SWPP activities are generally funded by drinking water State Revolving Fund (SRF) set aside monies, approximately \$145,000 per year.

Looking ahead, the Natural Resource Damages (NRD) Trustees, based primarily upon authority vested in the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA a.k.a Superfund) law, is responsible for assessing injuries to and restoring natural resources that have been impacted by environmental hazards. The Department's NRD staff, together with federal trustees such as the USFWS and United States Forest Service (USFS), have reached settlements totaling approximately \$70 million to restore impacted natural resources and the services they provide. Natural resource damage assessment and restoration settlements were largely the result of impacts from heavy metal mining in southeast and southwest Missouri. Two regional restoration plans, which guide restoration activities, have been developed to date, including one for the Southeast Missouri Ozarks Lead Mining District and another for the Missouri portion of the Tri-State Mining District located on the Springfield Plateau. The trustees are actively funding restoration projects in these regions to ameliorate the negative impacts of heavy metals on natural resources.

To maximize efficiency, the Department routinely coordinates its monitoring activities to avoid overlap with other agencies and to provide and receive interagency input on monitoring study design. Examples of this coordination include:

- Collaboration with MDC on fish tissue monitoring, macroinvertebrate collection, and reference stream identification.
- A memorandum of understanding with the Upper Mississippi River Basin Association (UMRBA) for conducting a pilot study on the Mississippi River. The Department also participates in meetings and other activities that UMRBA coordinates.

Missouri is strongly committed to protecting water quality in our over 115,000 miles of stream and 3,000 lakes and reservoirs. Missouri's waters are highly valued public resources, where good water quality promotes a healthy economy which in turn provides support for better water quality. Sixty-one percent of Missouri residents participate in water based recreational activities, much of that is fishing, swimming, and boating on our lakes and reservoirs. Visitors for water-based activities in Missouri are increasing by about 2.7 percent per year, and total visitor expenditures increasing by 5.4 percent per year. These recreational activities generate \$14.9 billion in consumer spending and support 33,000 direct jobs. Purchases generate \$889 million in state and local taxes.

B.5. Special State Concerns and Recommendations

Missouri has accomplished significant advances in environmental quality due to its water protection programs. Municipal and industrial wastewater discharged to state waters is not permitted without consideration given to the potential impacts to receiving waters. Improved forestry and agriculture practices have reduced polluted runoff. The same conservation practices have helped preserve farmland and enhance wildlife habitat. While Missouri waters are certainly cleaner today than 40 or 50 years ago, substantial threats remain. Current major environmental concerns may be divided into categories as described in the following paragraphs.

Agricultural and Urban Land Use as Nonpoint Sources of Pollution

Managing agricultural and urban runoff is an ongoing challenge in Missouri; both sources have substantial influence on the condition of water quality. Cropland runoff may contain large amounts of sediment, nutrients, and pesticides. Pollutant loads from urban runoff include sediment from new development and construction; oil, grease, and other chemicals from automobiles; nutrients and pesticides from commercial and residential lawn management; grass clippings and brush disposal into streams; road salts, and heavy metals. Impervious surfaces, such as roadways and rooftops increase water volumes in streams during storm events and lower base flows during dry periods. This hydrological pattern frequently results in eroded stream banks, widened channels, and impaired habitat. Moreover, impervious surfaces are easily heated by the sun which in turn warms surface runoff and ultimately causes stream temperatures to increase. Changes in water quality and habitat conditions that generally accompany urban and agricultural runoff impair aquatic life and diminish the value of other designated uses.

Department programs that are both regulatory and voluntary have proven effective for managing runoff, but such programs are not available to cover all runoff problems occurring across the

state. Additional monitoring, resources, and external support are needed to eliminate the threat of NPS runoff.

Municipal and Industrial Sources

WWTFs and other point source dischargers have a significant impact on water quality. Point sources are subject to NPDES permit requirements; however, pollution incidents still happen occasionally. Failing treatment systems, bypasses, accidental spills, or illicit waste disposal are some types of violations that can occur. Discharges of inorganic nutrients may promote blooms of algal growth in receiving waters. Raw or partially treated sludge releases will degrade aquatic communities as organic matter decomposes and dissolved oxygen is removed from the water. Other toxic substances can have more direct effects on aquatic life.

Pharmaceutical and Personal Care Products (PPCPs) include any product used by individuals for personal health or cosmetic reasons, or those used by agribusiness to enhance the growth or health of livestock. Some examples of PPCPs include endocrine disrupting sex hormones, antibiotics, steroids, antidepressants, and various prescription and over-the-counter drugs. Treatment facilities are not equipped to eliminate PPCPs from wastewater as these substances pass through on their way to receiving streams and lakes. While little is known about the impacts of PPCPs on human health, aquatic organisms at any stage in development may be affected. An example of the effect of PPCPs on aquatic biota is the feminization (disruption of normal gonad development and function) of male fish as a result of estrogens being released into the water.

The Department has worked with numerous entities to upgrade WWTFs in order to meet WQS. While most treatment facilities are in compliance, additional facility upgrades are anticipated. The objective of these upgrades is to further alleviate water quality degradation.

Abandoned Mines

Current mining operations have caused significant changes to water quality. Heavy metals, such as lead and zinc, may enter streams from smelters, mills, mine water, and tailings ponds. However, abandoned lead-zinc mines and their tailings continue to impact waters for decades after mining activity has ceased. Mines that have been left exposed to the elements may pollute waters via stormwater, erosion, and fugitive dust. Through these same pathways, mines that were properly shutdown after operations, but then reclaimed for another land use, have also polluted the environment.

Missouri's Superfund Program is addressing some of these concerns, but despite such efforts, long-term impacts are expected to remain until additional resources are made available. Monitoring will need to target abandoned mines that are suspected of contributing heavy metals to streams. Similarly, reclaimed mines may need to be inspected from time to time to ensure post closure actions have been maintained. Although new mineral extraction operations would be managed under state permits, areas of the state that are sensitive to disruption are being investigated for mining potential.

Concentrated Animal Feeding Operations

As of February 2020, there were about 500 actively permitted Class I CAFOs in Missouri. These include operations containing at least 1,000 beef cattle, 700 dairy cows, 2,500 swine weighing

over 55 pounds, or 125,000 broiler chickens. Facilities that generate large amounts of animal waste and manure have the potential to cause serious water pollution problems. Land application of manure on agricultural fields is the preferred method of manure management. Class II and smaller animal feeding operations (AFO) are not required to be permitted.

Missouri's CAFO laws and regulations are designed to minimize any threats of water pollution and ensure long-term protection for the environment. Multiple permits may be required for the construction and operation of a CAFO, including a construction permit for earthen basins, a land disturbance permit, and an operating permit. Additionally, operating permits require a nutrient management plan to be developed and the implementation of certain BMPs for the land application of animal manure.

Mercury in Fish Tissue

Mercury levels in fish continue to threaten fish consumption in Missouri waters. For 2020, totals of 844 stream miles and 27,134 lake acres were listed as impaired for mercury in fish tissue. Waters that have been monitored for long periods have shown that mercury levels in fish tissue have remained relatively stable over the years. Without adequate air pollution control, it is anticipated that future monitoring will detect additional water bodies with elevated levels of mercury in fish tissue.

DHSS issues an annual health advisory and guide for safely eating fish. Due to mercury contamination, DHSS has issued a statewide consumption advisory for sensitive populations, which include children younger than 13, pregnant women, women of childbearing age, and nursing mothers. This group has been advised to limit consumption of walleye, largemouth bass, spotted bass, and smallmouth bass greater than 12 inches in length to one meal per month, and all other sport fish to one meal per week. The advisory also includes a limit of one meal per month for white bass greater than 15 inches from Clearwater Lake only. Additional advisories for all consumers due to other contaminants may be found at <http://health.mo.gov/living/environment/fishadvisory/>. In most instances and for most people, the health benefits of eating fish outweigh the potential risks from contaminants. The Department plans to continue monitoring for mercury levels in fish.

Eutrophication

Nutrient enrichment, or eutrophication, of state waters, particularly the recreationally important large reservoirs, is an ongoing concern. Heavy residential development around portions of these reservoirs can threaten water quality in coves and shoreline areas. The large size of these reservoirs and rugged local topography make the construction of centralized collection and treatment systems for wastewater difficult. Without proper maintenance of lakeside septic systems, nutrient-enriched water can find its way into the lake.

Missouri's WQS do not include statewide nutrient criteria, but site-specific criteria have been assigned to a limited set of lakes. Moreover, the imposition of limits on most wastewater discharges to Table Rock Lake has reduced phosphorus levels in the James River arm of that lake. The Department continues to track lake nutrient conditions and offers various programs and grants to help address any issues and concerns. For example, the Department awarded \$1,000,000 to the Upper White River Basin Foundation for the purpose of assisting homeowners

with the cost of replacing failing septic systems through a combination of grants and loans through the WPP's Financial Assistance Center.

Groundwater Protection

Additional groundwater protection measures are needed. Missouri has programs in place to register and inspect underground storage tanks and oversee the cleanup of leaking underground storage tank sites. Additional programs address wellhead protection, the sealing of abandoned wells, and the closing of hazardous waste sites. A complete groundwater protection program would also include a groundwater monitoring network accompanied by educational programs for those involved in the application of farm chemicals, transport of hazardous materials, and the general public. Additional information may be found at <http://dnr.mo.gov/env/hwp/>.

Additional Concerns

Beyond the threats and concerns mentioned above, others remain. Fish and macroinvertebrate data from across the state indicate biological communities are impacted by degraded aquatic habitat. Physical alterations of the channel, alterations in stream flow patterns, removal of much or all of the riparian zone, and upland land use changes in the watershed are all significant contributors to this problem. Stream channelization is prevalent in the northern and western Central Plains as well as the Mississippi Alluvial Basin in the southeastern corner of the state. Large-scale channelization projects no longer occur, but smaller projects are still carried out to facilitate urban and residential development. Stream road crossings are an additional source of habitat degradation. Low-water crossings and improperly placed and/or sized culverts, which are frequently encountered across Missouri, create upstream barriers to fish passage and are primary points of habitat fragmentation.

Aquatic nuisance species pose a significant threat to the aquatic resources and economy of Missouri. Several invasive species are already present in some waters of Missouri including the zebra mussel (*Dreissena polymorpha*), Eurasian water milfoil (*Myriophyllum spicatum*), and silver carp (*Hypophthalmichthys molitrix*). Algae commonly known as "rock snot" (*Didymosphenia geminata*) and hydrilla (*Hydrilla verticillata*) have been found in neighboring states and are continuing threats due to human dispersal. MDC developed an Aquatic Nuisance Species Management Plan in February 2007.

Long term climatic variability presents additional challenges to the state's aquatic resources. In the Midwest, cold water fish species are projected to be replaced by cool water species (Karl *et al.* 2009). While precipitation is projected to increase in winter and spring with intense events occurring more frequently throughout the year, warmer temperatures during summer may increase the likelihood of drought (Karl *et al.* 2009). Resulting changes in stream flow would be more likely to have a negative impact on aquatic habitats and residing organisms. According to Missouri's Forest Resource Assessment and Strategy (Raeker *et al.* 2010), riparian forests could become more important than ever for protecting stream banks and providing filtering functions under a significantly wetter climate. Previously mentioned aquatic invasive species are projected to benefit under a changing climate as they tend to thrive under a wide range of environmental conditions compared to a narrower range tolerated by native species (Karl *et al.* 2009).

PART C: SURFACE WATER MONITORING AND ASSESSMENT

C.1. Monitoring Program

The overall goal of Missouri's water quality monitoring program is to provide sufficient data to allow for a water quality assessment of all waters of the state. This goal is achieved by meeting six specific objectives: (1) characterizing background or reference water quality conditions; (2) better understanding daily flow events, seasonal water quality variations, and their underlying processes; (3) characterizing aquatic biological communities and habitats and distinguishing differences between the impacts of water chemistry and habitat quality; (4) assessing time trends in water quality; (5) characterizing local and regional impacts of point and NPS pollution on water quality, which includes compliance monitoring and development of water quality based permits and TMDL studies; and, (6) supporting development of strategies to return impaired waters to compliance with WQS.

Monitoring includes four strategic approaches to meet the six specific objectives mentioned above: (1) fixed station monitoring; (2) intensive and special surveys; (3) screening level monitoring; and (4) probability-based surveys. Missouri's "Surface Water Monitoring Strategy" (MDNR 2013) provides an in-depth discussion of the entire water quality monitoring program and strategy. All monitoring is conducted under approved Quality Assurance Project Plans (QAPPs) with the Department's Environmental Services Program (ESP) laboratory. The Department's Quality Assurance Management Program was previously approved by EPA.

Fixed Station Monitoring

The fixed station monitoring network is designed to obtain water chemistry, sediment, fish tissue, and biological monitoring sites equitably among major physiographic and land use divisions in the state. Selected sites must meet one of the following two criteria: (1) the site is believed to have water quality that represents many similarly sized streams in the region due to likeness in watershed geology, hydrology, and land use, as well as an absence of impact from local point or discrete nonpoint source pollution, or (2) the site is downstream of a significant point source or localized nonpoint source pollution area. There are five subprogram areas that make up the fixed station network:

1. The Department provides funding for an ambient stream network that includes nearly 70 sites monitored between 4 to 12 times per year by the USGS for a wide variety of physical, chemical and bacteriological constituents, and six of these sites are also sampled at less frequent intervals for a range of pesticides. Two sites on the Missouri River use sondes to collect continuous nitrate data from spring through fall.
2. Chemical monitoring is conducted by the Department at approximately 58 sites four to six times per year for nutrients, major ions, flow, temperature, pH, dissolved oxygen, and specific conductance.
3. Lake monitoring consists of two programs, the SLAP and the LMVP. SLAP samples an average of 76 lakes four times each summer for nutrients, chlorophyll, volatile and nonvolatile solids, Secchi disc depth, four algal toxins, and a depth profile. LMVP

volunteers sample approximately 65–70 lakes six to eight times per year for total nitrogen, total phosphorus, chlorophyll-a, Secchi disc depth, and two algal toxins. Multiple sites are sampled on some larger reservoirs. For additional information regarding LMVP, please see the program’s website at <http://www.lmvp.org/>.

4. Fish tissue monitoring is conducted to assess the health of aquatic biota as well as the human health risks associated with consuming fish. Thirteen fixed sites are monitored once every two years and samples are analyzed for mercury, chlordane, and Polychlorinated Biphenyls (PCBs). Whole fish composite samples of either common carp or redhorse sucker are analyzed for metals, mercury, cadmium, selenium, several pesticides, and PCBs.

Additional samples are collected from approximately 30 discretionary sites annually. Piscivorous fish sampled are preferably black bass species, but alternatively include walleye, sauger, northern pike, trout, flathead catfish, and/or blue catfish. Tissue plug samples are collected from bass species and analyzed for mercury only. Fillet samples (skin off) may be collected from the remainder of bottom and non-bottom feeding species. Fillet samples are analyzed for metals, including mercury, cadmium, and selenium; additionally, fillet samples from bottom feeding species are analyzed for a suite of organic compounds, including several pesticides and PCBs.

Outside of Department-based sampling, MDC monitors another 20–40 sites each year that are considered popular sport fisheries. Fish tissue is analyzed for pesticides, PCBs, mercury and other metals. This data is submitted to the Department and is used to assess the human health/fish consumption beneficial use for the water body.

5. Routine monitoring is conducted at approximately 20–30 discretionary sites annually to test for sediment contamination. Sediment samples are analyzed for a suite of heavy metals that individually or synergistically are known to be lethal or detrimental to fish, mussels, and other macroinvertebrates.

In addition to sampling activities noted above, the Department’s Division of State Parks conducts routine bacterial monitoring of swimming beaches during the recreational season.

Intensive and Special Studies

Intensive and special studies typically involve frequent monitoring of several sites in a small geographic area. These studies are driven by the need for site-specific water quality information. Findings resulting from intensive and special studies may be used to develop water quality based NPDES permit limits, assist with compliance and enforcement activities, or guide resource management. The Department currently conducts several types of intensive and special studies:

- Wasteload Allocation Studies – Assess receiving waters of wastewater treatment facilities to judge compliance with in-stream WQS and/or be used to develop water quality-based permit limits. Up to ten wasteload allocation studies are completed annually.

- **Toxics Monitoring** – Assess receiving waters of coal mining and processing stations, metal mining operations, various industrial and municipal facilities and CAFOs. The need for this type of monitoring varies greatly from year to year, from zero to 30 sites. Sampling frequency depends on the intended use of data.
- **Aquatic Invertebrate Biomonitoring** – Macroinvertebrate communities are surveyed to evaluate concerns with either point source discharges, discrete NPS areas such as active or abandoned mining sites, or watershed wide NPS problems. Reference sites are sampled periodically as controls to which targeted sites may be compared. Approximately 45–50 sites are sampled each year. Additionally, the Department contracted with the USGS in 2001 to conduct a study of aquatic invertebrate communities on the Missouri River. The study, *Validation of Aquatic Macroinvertebrate Community Endpoints for Assessment of Biological Condition in the Lower Missouri River*, was published in 2005. The Department sees this work as the first of several steps by which it will promote a better understanding of fish and invertebrate communities of large rivers, and ultimately the development of biological criteria for the Missouri and Mississippi Rivers.
- **Dissolved Oxygen Studies** – Continuous monitors (data sondes) are deployed where low dissolved oxygen levels are suspected. Sampling is carried out below selected hydropower dams with past low dissolved oxygen problems and in other areas where noncompliant discharges are suspected.
- **Contract Studies** – The Department typically has several active contracts for water quality monitoring at any given time. Most contracts support CWA Section 319 funded watershed projects, but past contractors have also completed Use Attainability Analyses (UAAs) as well as simple monitoring projects, specifically in cases where work entailed highly specialized skills and equipment, or when costs or manpower limitations made it practical.

Screening Level Monitoring

Screening level monitoring involves two separate strategies, low flow surveys and volunteer-based water quality monitoring. Both strategies integrate rapid stream assessment protocols that rely on qualitative sampling of stream biota and visual evidence. Additional water chemistry sampling may occur as a result of inspections and complaint investigations.

Low flow surveys are conducted to assess stream conditions potentially influenced by wastewater treatment facilities, mining activities, or landfills. These surveys are a rapid and inexpensive method of screening large numbers of streams for obvious water quality problems and determining where more intensive monitoring is needed. Generally, up to 100 sites are screened each year.

The Volunteer Water Quality Monitoring (VWQM) Program is a cooperative project between the Department, MDC, and the Conservation Federation of Missouri. This program is a subset of the Missouri Stream Team Program. Since its inception in 1993, 11,030 citizens have attended 810 water quality monitoring workshops held by program staff across the state. This has resulted in the submission of more than 45,342 separate data sheets for 3,336 Missouri stream sites. In FFY 2018, volunteers spent approximately 10,498 hours in this endeavor and in 2019, volunteers

spent 10,090 hours collecting water quality data. The value to the state in time spent by volunteers engaged in water quality monitoring was \$215,198.04 in 2018, and \$175,288.99 in 2019.

In both FFY 2018 and 2019, approximately 200 new stream teams were formed. The total number of stream teams has now reached 6,088, and the total number of active teams is 4,773. In 2018, a total of 197 citizens attended the Introductory Level class, while 215 attended the same workshop in 2019. After the Introductory workshop, many volunteers proceeded on to at least one workshop for higher level training. In FFY 2018, 112 citizens attended a Level 1 workshop, and in FFY 2019 there were another 58 attendees for Level 1. The number of volunteers that attended Level 2 workshops in FFY 2018 and 2019 were both around 30. In both 2018 and 2019, one Level 3 audit was held. There were 4 Cooperative Stream Investigation (CSI) advanced monitoring projects initiated involving and training 4 volunteers in 2018; and 2019 saw 4 CSI projects initiated that involved 6 specially trained volunteers who committed to data collection for each of the 2-year long projects.

Each level of training is a prerequisite for the next higher level, as is acceptable data submission. Levels 2, 3, and CSI are accompanied by increasingly higher quality assurance and quality control stringency. Data submitted by volunteers of Level 2 or above may be used by the Department to establish baselines of water quality condition for particular streams, or to point out potential problems that are in need of further investigation. Level 2 and higher volunteer monitors are required to return for a validation workshop at least every three years in order to ensure their equipment and methods are up to date, and the data they are gathering has a high level of quality assurance. Volunteers may opt to either attend a Level 2 workshop again or attend a special Validation workshop in order to meet validation requirements. In FFY 2018, a total of 53 volunteers updated their validation status: 27 volunteers attended a Validation workshop and an additional 26 attended a Level 2 workshop; in FFY 2019, a total of 58 volunteers updated their validation status: 26 attended a Validation workshop and another 32 attended a Level 2 workshop. In FFY 2018 and 2019, volunteers submitted 578 sets of macroinvertebrate data; 1,135 sets of water chemistry data; 527 sets of visual survey data; 755 sets of stream discharge data; and 125 site selection data sheets. Wastewater, CAFO and drinking water operators have also attended workshops in order to receive operator certification credits. In FFY 2018-19, a total of 35 operators attended stream team VWQM training.

Level 2 volunteer data, or higher, is screened annually for physical, chemical, and biological parameters. If adequate data indicate water quality concern or a potential issue, then follow up monitoring by the Department is scheduled. CSI level volunteers may be directly utilized for assisting in Departmental studies (e.g., watershed planning, TMDL implementation plans). For higher-level data to be utilized by the Department for 303(d) and 305(b) screening purposes, there must have been at least five chemical monitoring visits and/or three biological monitoring visits within a four-year period. For additional information regarding the Department's VWQM program, please visit the following websites <http://www.dnr.mo.gov/env/wpp/VWQM.htm> and <http://www.mostreamteam.org/water-quality-monitoring.html>.

Probability-based Sampling

The Department's probability-based sampling is derived from a partnership with MDC that is formalized in a signed Memorandum of Understanding (MOU). Under this MOU, the Department and MDC share various resource management responsibilities via specific programs, such as MDC's RAM program. It is through this program that the Department's probabilistic-based sampling is implemented (Combes [MDC], pers. comm.). The sampling effort supports MDC and Department trend monitoring, as well as CWA Section 305(b) and 303(d) reporting requirements.

Annually, MDC's RAM program monitors approximately 70 sites from third to fifth order streams. From 2004 to 2008, up to 40 sites were randomly sampled from ecological drainage units on a rotating basis. In 2010, sampling shifted to focus on aquatic subregions rather than ecological drainage units. To ensure all regions of the state are monitored effectively, sub-regional sampling is conducted on a five-year cycle, with two years spent monitoring streams in the Central Plains subregion, two years in the Ozark subregion, and one year in the Mississippi Alluvial Basin subregion (see Figure 1).

At each sampling site, the RAM program assesses stream water quality and stream habitat, as well as aquatic macroinvertebrate and fish communities. Metrics for assessing the biological integrity of macroinvertebrate communities are implemented statewide; however, fish community metrics have thus far only been validated for Ozark and Ozark border streams (Doisy et al. 2008). Using their RAM assessments, MDC may report potentially impaired sites to the Department for additional monitoring.

Monitoring Program Evaluation

The above components to the Department's water quality monitoring program describe the approach for a comprehensive assessment of state waters. Additional elements of the program, such as core and supplemental indicators, quality assurance, data management, data analysis and assessment, reporting, and general support and infrastructure, are discussed in "A Proposal For A Water Quality Monitoring Strategy For Missouri" (MDNR 2013).

Monitoring has generally addressed critical point source assessments as needed and has adequately characterized regional water quality unimpaired by point source discharges. However, the state's information needs have considerably increased. Of the 115,701 total assessed classified stream miles, 9.1 percent of stream miles were considered monitored (i.e., recent [2012-2019] data were available), whereas 90.9 percent were evaluated despite the lack of recent data. Information gaps and data needs are highlighted in "[A Proposal For A Water Quality Monitoring Strategy for Missouri.](#)" Among the major monitoring needs identified in this strategy are: (1) the ecological characterization of the Mississippi, Missouri, and other large rivers; (2) the inventory, monitoring, and assessment of the state's wetlands; (3) bacterial monitoring of large reservoirs and biological criteria development for small reservoirs and lakes; (4) screening level surveys for intermittent streams; and (5) additional chemical monitoring of small wadeable streams.

Data Acquisition and Information Sharing

The Department retrieves a large amount of raw data from the USGS and other state, federal, and municipal sources. These data, along with those of the Department, are imported to and maintained in the Department's Water Quality Assessment (WQA) database. Data include information pertaining to water chemistry, bacterial concentrations, sediment toxicity, fish tissue contaminants, and fish and invertebrate communities. The WQA database is available to the public online at https://apps5.mo.gov/mocwis_public/wqa/waterbodySearch.do.

Missouri uses the internet-based WQA system for tracking and reporting water body use attainment information. The stream and lake network of the state, WQS information, and locations of permitted wastewater discharges and other potential pollutant sources can all be viewed within a Geographic Information System (GIS) environment.

ESP has developed a bioassessment database that provides access to raw data and summarized statistics for all macroinvertebrate sampling it has completed. This database is typically updated following each season of sampling and the most recent version is available to the public online at <http://dnr.mo.gov/env/esp/Bioassessment/index.html>.

The Department has a variety of additional information regarding water quality and conservation programs in the state on its website at www.dnr.mo.gov/water.htm. Some available information includes current and proposed NPDES permits, Missouri's WQS, the latest LMD, the 303(d) list of impaired waters and TMDLs, as well as opportunities for water resource conservation and grant funding.

Access to the Department's water quality data is relatively straightforward using online tools. Should additional assistance be needed, general requests for water quality information may be made by calling 1-800-361-4827. Official requests for specific information can be made by submitting an online request form found at <http://www.dnr.mo.gov/sunshinerequests.htm>. Specific requests that cannot be easily accommodated by the online public database may require the Department to search published reports or water quality data files. If the report or data was generated by the Department, it can be sent to the requestor through electronic mail or regular mail (a hard copy for small reports and data files, or compact disks for larger data files). If the report or data file did not originate with the Department, the request may be passed on to the organization that published the report or data. The requestor is welcome to visit the Department office and view files directly. To do so please contact Robert Voss below to schedule an appointment.

Requests to view water quality data files, should be sent to:

Missouri Department of Natural Resources
Water Protection Program
ATTN: Mr. Robert Voss
P.O. Box 176
Jefferson City, MO 65102-0176
Phone: 573-522-4505 | E-mail: robert.voss@dnr.mo.gov

C.2. Assessment Methodology

Water quality is judged by its conformance with Missouri's WQS. This section describes procedures used by the Department to rate the quality of Missouri's waters under this approach, which includes an explanation of the types of data used to determine designated use attainment, how that data is used, and how findings are reported. The assessment methodology is the process the Department uses for meeting requirements of CWA Sections 305(b) and 303(d), and is the basis for summary tables and appendices provided later in this document.

Information Used to Determine Designated Use Attainment

To determine whether or not each designated use is supported, water body-specific monitoring data and other relevant information are reviewed against applicable criteria. Monitoring data generated under the four strategic monitoring approaches mentioned in Section C.1. are key elements analyzed in the assessment process. The Department also utilizes data from many external sources that monitor for similar purposes and produce data of acceptable quality. Federal agencies collecting such data include USGS, EPA, USFS, USFWS, USACE, and the National Park Service. Other contributors of data include resource agencies from the neighboring states of Illinois, Iowa, Kansas, Arkansas, and Oklahoma; several municipal entities; selected projects from graduate level researchers; MDC fish kill and pollution investigation reports; county public health departments; and data collected by wastewater dischargers as a condition of their discharge permits (although this data is not used in 303(d) listing purposes). For a complete list of data types and sources, please see Missouri's 2020 LMD, *Methodology for the Development of the 2020 Section 303(d) List in Missouri* (Appendix A).

Water Body Segments

Tables G and H of Missouri's WQS published in 10 CSR 20-7.031 contain classifications and use designations for all classified lakes and streams. Each individual water body listing in Tables G and H is considered an assessment unit. For each lake in Table G, there is only one listing unit. For streams however, single systems may receive multiple classifications according to the character of their natural flow regime (e.g., permanent flow vs. intermittent flow); thus, there may be multiple listings or assessment units in Table H for any given stream or river. For the Mississippi River, water body segments reflect an interstate MOU between five states (Missouri, Illinois, Iowa, Wisconsin, Minnesota) signed in September 2003 (UMRBA 2003). The purpose of the MOU is to enhance coordination of water quality assessments and management decisions on the Upper Mississippi River. Segmentation points are as follows: Des Moines River, Lock and Dam 21, Cuivre River, Missouri River, Kaskaskia River, and Ohio River. Results of UAAs and CWC rulings have affected the designation of recreational uses on the Mississippi River, from the Ohio River to the Missouri River, resulting in further sub-segmentation. Both specific and general criteria may be applied to classified waters of the state. Unclassified waters are usually assessed against general (narrative) criteria and a subset of specific criteria commonly associated with acute toxicity to aquatic life. There are less available data on unclassified waters, and except for a few streams and lakes, these waters are normally not reported for 305(b) and 303(d) purposes.

Water bodies are generally assessed individually. For each water body, all available data of acceptable quality is reviewed and assessed. That assessment may then be extrapolated to the entire spatial extent of that classified segment. However, the final extent of the assessment may be adjusted to account for significant influences of point source discharges, substantial changes in land use and stream characteristics, and significant hydrologic and channel modifications. In order to adjust the final extent of an assessment, multiple sample points are needed. Occasionally, this method results in assessments that are shorter than the full spatial extent of the classified water body.

C.2.1. Determining Designated Use Attainments

Unique sets of criteria are used to protect specific designated uses assigned to individual waters. Protective criteria include a range of physical, chemical and biological parameters. This means that in order to determine a level of attainment for a designated use, certain types of data must be collected to compare to those protective criteria. Assessing most designated uses involves analyzing multiple parameters, but in some cases, exceeding a single criterion is enough evidence to assess a use as impaired. All classified waters of the state, including large public lakes, are designated to be protected for whole body and/or secondary contact recreation, protection of aquatic life, fish consumption by humans, and livestock and wildlife watering. A subset of these waters is protected for drinking water supply, irrigation and industrial processes, and use as cooling water for industrial processes. This section describes how data and information are used by the Department to assess each of these designated uses. For each classified water body, and for each applicable designated use to that water body, Department assessments will be in one of four categories: (1) *designated use is fully attained*; (2) *designated use is not attained*; (3) *designated use not assessed due to an insufficient data*; or (4) *designated use not assessed*.

Generally, a water body use assessment of “fully attained” suggests water quality is fair to excellent, whereas an assessment of “not attained” indicates poor water quality. To what extent resource quality is impacted depends on the degree to which the use is not attained. Waters with at least one designated use assessed as “not attained” are considered impaired. When possible, potential or known causes and sources of the impairment are described.

To make a determination of “fully attained” or “not attained,” data from the previous seven years are generally used. In some cases, however, older data may be used if the data remains reflective of present conditions.

For complete assessment methodology details please see Missouri’s 2020 LMD (Appendix A). The 2020 LMD lists all data that may be used for performing water quality-based assessments and the applicable statistical methods for interpreting Missouri’s WQS. Prior to each listing cycle, the LMD goes through a stakeholder input and review process where it can be revised. Development of the 2020 Section 303(d) List and Section 305(b) report was based exclusively on the 2020 LMD.

Statistical Considerations

For designated use assessment methods, a specific set of statistical procedures are used to determine if exceedances resulting in non-attainment warrant a 303(d) listing. Appendices B and C in the 2020 LMD lists all statistical considerations and analytical tools the Department uses for listing waters as impaired. For each analytical tool, a specific decision rule and test procedure is provided. Procedures outlined in the LMD are based on data that meet quality assurance and control standards.

Additional Approaches for Determining Designated Use Attainment

While specific designated use assessment procedures are contained in the LMD, there are several approaches that may be applied to all designated uses. Designated use protection may be accomplished in the absence of data, if the stream being assessed has similar land use and geology to a stream that has already received a water quality assessment. In such cases, the same rating must be applied to the stream being assessed, and this information may only be used for 305(b) reporting, not for 303(d) listing. Additionally, where models or other dilution calculations indicate noncompliance with allowable pollutant levels, waters may be added to Category 3B (see section C.2.2. *Water Body Assignment Categories*) and considered a high priority for additional water quality monitoring. For assessing narrative criteria for all designated uses, data types that are quantifiable can be used. Full attainment with WQS is achieved when the stream appearance is typical of reference or control streams in that region of the state. For example, if water color measured using the platinum-cobalt method is significantly higher than an applicable reference stream, the water body would be judged to be in non-attainment of WQS.

The Department uses its best professional judgment for interpreting data that has been influenced by abnormal weather patterns and/or situations that complicate appropriate interpretation of the data. In some cases, this means data that would normally be adequate to assess a use is actually determined to be inadequate, and additional sampling is required to ensure a confident assessment.

C.2.2. Water Body Assignment Categories

Once all attainment decisions have been made for a given water body, it is categorized according to a degree of compliance with WQS. The Department utilizes a five-part category system which is helpful for reporting attainment of applicable WQS, and in the development of monitoring strategies that respond to resource issues identified in the assessment. The five-part categorization process is summarized below:

Category 1: All designated uses are fully attained.

Category 2: Available data indicate that some, but not all, designated uses are fully attained.

Subcategory 2A: Available data suggest compliance with WQS. No impairment suspected.

Subcategory 2B: Available data suggest noncompliance with WQS. Impairment suspected.

Category 3: There are insufficient data and/or information to assess any designated uses.

Subcategory 3A: Available data suggest compliance with WQS. No impairment suspected.

Subcategory 3B: Available data suggest noncompliance with WQS. Impairment suspected.

Category 4: Available data indicate that at least one designated use is not attained, but a TMDL study is not needed.

Subcategory 4A: Any portion of the water is in non-attainment with WQS due to one or more discrete pollutants, and EPA has approved a TMDL.

Subcategory 4B: Any portion of the water is in non-attainment with WQS due to one or more discrete pollutants, and pollution control requirements (i.e., water quality based permits and/or voluntary watershed control plans) have been issued that are expected to adequately address the pollutant(s) causing the impairment.

Subcategory 4C: Any portion of the water is in non-attainment with WQS and a discrete pollutant(s) or other property of the water does not cause the impairment.

Category 5: At least one discrete pollutant has caused nonattainment with WQS, and the water does not meet the qualifications for listing as either Category 4A, 4B, or 4C. Category 5 waters are those that are placed on the state's 303(d) list.

For 303(d) assessment purposes, each data type (e.g., bacterial, toxic chemical, bioassessment) undergoes a particular statistical treatment to determine compliance with WQS.

The Department uses a weight of evidence approach for assessing narrative criteria with numeric thresholds to determine the existence or likelihood of an impairment and the appropriateness of proposing a listing based on narrative criteria. For Tier Three waters, which includes outstanding state and national waters, no level of water quality degradation is allowed; therefore, assessment of these waters will generally compare current data to either historical data or data from segments that support water quality conditions that existed at the time the state's antidegradation rule was promulgated (April 20, 2007). Based upon earlier guidance from EPA, the Department uses a burden-of-proof approach in its hypothesis testing that places emphasis on the null hypothesis. In other words, there must be very convincing data to accept the alternative hypothesis (that the water body is impaired).

C.2.3. De-listing Impaired Waters

Several factors may lead to removing a water body from the Section 303(d) list. Removal may occur when a TMDL study addressing all pollutant pairs for a given water body has been completed and approved. In situations where an impairment is due solely to a permitted facility, it may be possible to revise the facility's permit to meet the targeted water quality criteria, this is known as a Permit in Lieu of TMDL. Waters that recover from pollution may be delisted once water quality is assessed as meeting water quality criteria. Analytical tools used for de-listing purposes are described in Missouri's 2020 LMD (see Appendix A). Waters can also be removed as a result of finding errors in the original assessment or listing.

C.2.4. Changes to the Listing Methodology Document

Noted earlier, the LMD may be revised every even numbered year, undergoing the same review and approval schedule as required for the Section 303(d) list. There were several updates made to the previous LMD. The present LMD incorporates revisions related to reformatting and consolidation of information, along with clarifying statements or information relating to biological assessments, and minor corrections to tables. Additional updates were made as a result of discussions from the Biological Assessment Workgroup meeting and public comments. Those revisions are summarized below, please see the 2020 LMD for further details.

- Corrections for general formatting, grammar, and spelling errors or to improve clarity
- Fish tissue toxic concentrations were clarified to be assessed using wet weight concentrations
- Correction to species name for Sauger *Sander canadensis*
- Clarification of data solicitation and a specific cutoff date for data to be assessed in order for it to be taken into account for the 303(d) list of impaired waters
- Data Qualifiers- a section was added on the treatment of less than, greater than, non-detect, and estimated values
- Data age- a section was added to specify the use of data of greater than seven years old
- Clarification that DO criteria are assessed during flowing conditions
- Further considerations for chronic pH assessment were added pending WQS Approval
- An example of calculating the binomial probability formula was added
- Three references were updated to the most recent versions and three references were added; two for sediment toxicity and one for macroinvertebrate communities.
- Added background and clarification of information for assessing biological communities in smaller streams
- Greater description and explanation were added to the 13-step process for selecting small candidate reference streams
- Added toxicity test requirements and preferences to include acute and chronic tests and analysis of media for suspected toxicants
- Updates to sediment toxicity:
 - Sediment must be sieved to <2mm
 - Assessment of total PAHs rather than individual PAHs
 - Addition of a list of 34 most common PAH compounds that are considered for the calculation of total PAHs in Table 3
 - How Equilibrium Sediment Benchmark (ESB) data can be used for assessment
 - Flow Charts for the Biological Weight of Evidence Decision for Sediment Toxicity in Appendix E
- Clarification that the length of stream when listing as impaired is currently the length of the water body identification (WBID), but the Department is working toward impairments as smaller segments.

- Updates to reflect Lake Numeric Nutrient Criteria with Appendix F containing the Nutrient Criteria Implementation Plan

C.3. Assessment Results

This section is a summary of the Department’s surface water assessments for the 2020 assessment cycle. Included in this section is the allocation of designated uses among classified waters, assessment results per monitored and evaluated waters, summary of lake trophic conditions and water quality trends, results of the five-part categorization of surface waters and probability-based surveys, the Section 303(d) list, and designated use support summaries.

In Tables G and H of Missouri’s WQS, all classified lakes and stream segments are identified. Classified waters are designated for recreation, aquatic life, fish consumption, as well as livestock and wildlife watering, with some waters receiving additional designations as described earlier. Table 2 summarizes designated uses allocated among classified waters in the state.

Table 2. Allocation of designated uses among Missouri’s classified waters.

Designated Use	Stream miles	Percent of Total	Lake acres	Percent of Total
Protection of Aquatic Life	115,701	100	321,736	100
Warm-Water Fishery	115,701	100	316,427	98
Cool-Water Fishery	3,262	3	0	0
Cold-Water Fishery	298	<1	11,232	3
Human Health Protection – Fish Consumption	115,701	100	321,736	100
Whole Body Contact Recreation – A	6,284	5	261,417	81
Whole Body Contact Recreation – B	108,773	94	60,319	19
Secondary Contact Recreation	115,701	100	321,736	100
Livestock and Wildlife Watering	115,701	100	321,736	100
Drinking Water Supply	3,546	3	125,684	39
Industrial	1,643	1	6,959	2
Irrigation	115,701	100	321,736	100
Antidegradation				
Outstanding National Resource Waters	202	<1	0	0
Outstanding State Resource Waters	217	<1	270*	<1
Total Classified Waters	115,701		321,736	

*Represents acreage for three marsh wetlands.

Surface Water Monitoring and Assessment Summary

Designated use assessments were developed using Departmental monitoring efforts as described in Section C.1., and using data from numerous federal, state, and municipal programs. Due to the state’s extensive stream and lake network, it is not feasible to collect adequate data on every classified water body in Missouri. Consequently, only a portion of all classified waters are

monitored each assessment cycle. An overview of stream and lake data used for assessment decisions is provided in Tables 3 and 4.

Table 3. Classified stream miles having been monitored, evaluated, and assessed, 2012-2018

Assessment Result	Monitored (miles)	Evaluated (miles)	Total Miles Assessed
Full Support of Assessed Uses (1, 2A, 2B)	4,898	1,201	6,099
Impaired for One or More Uses (4A, 4B, 4C, 5)	5,090	483	5,574
Inadequate Data for Use Assessment (3A, 3B)	494	102,983	--
Total Considered (all categories)	--	--	115,150

Table 4. Classified lake acreage having been monitored, evaluated, and assessed, 2012-2018

Assessment Result	Monitored (acres)	Evaluated (acres)	Total Acres Assessed
Full Support of Assessed Uses (1, 2A, 2B)	171,797	3,142	174,940
Impaired for One or More Uses (4A, 4B, 4C, 5)	90,941	1,504	92,446
Inadequate Data for Use Assessment (3A, 3B)	4,102	48,063	--
Total Considered (all categories)	--	--	319,550

Monitored waters include streams and lakes where sufficient water quality data for an assessment have been collected in the past seven years. Approximately 9.1 percent of all classified stream miles and 83 percent of all classified lake acres are considered monitored. Evaluated waters are those waters for which no data are available from the past five years. In these cases, either older data are available, and are considered representative of current conditions; or they have geology and land use similar to nearby monitored waters and their water quality condition is assumed to be similar as well. Totals of 90.4 percent of all classified stream miles and 16.4 percent of all classified lake acres are considered evaluated. Unassessed waters are those waters that are not monitored directly and do not have nearby waters with similar geology and land use that are monitored. These represent the classified waters in the state for which an accurate assessment of water quality condition is not possible. Thus, 79.8 percent of classified stream miles and 16.9 percent of classified lake acres remain unassessed.

Probability Summary

The Department's probability-based summary was primarily informed by data generated by MDC's RAM program. Specifically, index of biological integrity (IBI) scores from fish surveys were used to inform the percentage of streams fully supporting aquatic life use. For this summary, data was restricted to surveys of randomly selected sites on third, fourth, and fifth order streams in the Ozark subregion collected between 2002-2010 and 2011-2018 (Figure 1). Only fish IBI scores with accompanying habitat assessments were used. Habitat scores were based on six metrics: (1) substrate quality, (2) channel disturbance, (3) channel volume, (4) channel spatial complexity, (5) fish cover, and (6) tractive force and velocity. Together these six metrics make up the QCPH1 score, which to date, is the best overall indicator of habitat

condition as assessed using MDC’s RAM protocol. Data was excluded from analysis when stream habitat quality was too poor to fully support the fish community (QCPH1 score <0.39). Included fish IBI scores are, therefore, assumed to reflect stream water quality. Fish IBI scores greater than 36 indicate aquatic life use is fully attained; scores of 29-36 indicate a community is suspected to be impaired but is at least partially in attainment; and scores less than 29 suggest the community is impaired and aquatic life use is not attained. Final inclusion of fish IBI scores incorporated MDC staff’s best professional judgment to ensure survey consistency and reliability.

Fish IBI scores from 362 surveys, which represent approximately 3,235 miles of Ozark streams, were used in the probability-based summary. Classified streams, third to fifth order in size, contribute to approximately 9,843 total stream miles in the Ozark subregion. The Department utilized fish IBI scores to determine the percentages of stream surveys in which aquatic life use was fully attained (not impaired), partially attained (impairment suspected), or not attained (impaired). Extrapolated from these percentages were the estimated total miles of attaining, non-attaining, and suspect streams in the Ozark subregion. Complete results are provided in Table 5.

Table 5. Probability-based summary of aquatic life use attainment in Ozark Streams.

Project Name	MDC RAM Program	
Type of Water Body	Stream	
Target Population	3 rd to 5 th Order, Ozark subregion	
Unit of Measurement	Classified stream miles	
Designated Use	Aquatic Life	
Indicator	Biological – Fish IBI	
Assessment Date	3/31/2020	
Survey Years	2002-2010	2011-2018
Size of Target Population # of surveys / represented miles	181 assessments / 2,341.2 miles	181 assessments / 1,424.9 miles
Attaining - percent, estimated miles	71.3%, 7,018 miles	61.9%, 6,093 miles
Non-attaining - percent, estimate miles	14.4%, 1,417 miles	11.0%, 1,083 miles
Suspect - percent, estimated miles	14.4%, 1,417 miles	27.1%, 2,667 miles

Lake Trophic Status

Trophic status is used to characterize a lake’s water quality condition in response to nutrient concentrations. In Missouri, lake trophic status is classified based on thresholds of total chlorophyll (ChlT), total nitrogen (TN), total phosphorus (TP), and Secchi transparency (Secchi). Chlorophyll is the green, photosynthetic pigment present in plants and plant-like organisms, such as algae. The amount of chlorophyll in a lake is dependent on the amount of algae in it, making chlorophyll a good measure of water quality conditions. Algae require nutrients, such as nitrogen and phosphorus, in order to grow. TN is the sum of nitrate, nitrite, ammonia, and organically bound nitrogen. TP is composed of soluble phosphorus and the phosphorus bound to organic and inorganic suspended sediments in the water. In most Missouri reservoirs, phosphorus is the primary limiting nutrient for algal growth.

Following this classification method, originally presented in Jones et al. (2008), the Department may classify each Missouri lake as one of the following four trophic classes: oligotrophic, mesotrophic, eutrophic, or hypereutrophic (see Table 6). Oligotrophic lakes tend to be low in nutrients and low in chlorophyll with high water clarity, whereas hypereutrophic lakes have the highest levels of nutrients and chlorophyll with low water clarity. Nutrient levels in lakes result from both natural processes and anthropogenic influences; however, eutrophication of lakes is generally accelerated by human activities, particularly in agricultural and urban areas.

Table 6. Classification thresholds for lake trophic status using total chlorophyll (ChlT), total nitrogen (TN), total phosphorus (TP), and Secchi depth from criteria proposed by Jones et al. 2008

Trophic Class	ChlT (µg/L)	TN (µg/L)	TP (µg/L)	Secchi (meters)
Oligotrophic	< 3	< 350	<10	≥ 2.6
Mesotrophic	3 - 9	≥ 350 - 550	≥ 10 - 25	≥1.3 - < 2.6
Eutrophic	> 9 - 40	≥ 550 - 1200	≥ 25 - 100	≥ 0.45 - < 1.3
Hypereutrophic	> 40	> 1200	>100	< 0.45

In this report, the trophic status summary was updated to account for data collected through 2019. Trophic status was determined by averaging seasonal values of ChlT and TP. Samples were collected near the surface, at the deepest part of the lake or just upstream of a reservoir dam, typically three to four times between May and August. Summarized results are presented in Table 7. For lake-specific trophic status, please see Appendix D.

There are 319,550 classified lakes included in Missouri’s WQS. This number excludes 15 water bodies that are classified as major reservoirs (L2). Approximately ten classified lakes are natural lakes occurring within the floodplains of either the Missouri River or the Mississippi River, the others are man-made reservoirs. Approximately 75 lakes are monitored four or more times during the summer. Monitoring includes analysis of nutrients, suspended solids, and chlorophyll, and measurement of water clarity.

Table 7. Ecoregional summary of trophic status for Missouri lakes*

Trophic Status	<u>Plains</u>		<u>Ozark Border</u>		<u>Ozark Highlands</u>		<u>Statewide Total</u>	
	#	acres	#	acres	#	acres	#	acres
Oligotrophic	1	18	3	343	7	695	11	1,056
Mesotrophic	18	2,038	10	806	19	80,834	63	83,678
Eutrophic	114	104,662	17	1,027	14	76,734	145	182,423
Hypereutrophic	12	2,183	3	109	--	--	15	2,292
Total	145	108,901	33	2,285	40	158,263	234	269,449

*Excludes Big River ecoregion lakes: Creve Coeur Lake and Mallard Lake

Trophic status was summarized for 222 lakes, of which 196 were classified and 26 were unclassified. Only lakes with at least three years of data, with each year consisting of at least 3 samples between May 1 and August 31, were included in the examination. Trophic classes were grouped by natural divisions with distinct combinations of soils, bedrock geology, topography, plant and animal distribution and pre-settlement vegetation (Thom and Wilson 1980). Natural region divisions are very similar to the primary ecological sections of the classification system developed by Nigh and Schroeder (2002).



Figure 2. Missouri Lake Ecoregions

Trophic status varies considerably between the physiographic regions of the state (Figure 2). Oligotrophic lakes are found predominantly in the Ozark Highlands (Ozarks) where the mostly forested landscape contributes few nutrients through NPS. Within the Glaciated and Osage Plains regions, where agriculture is widespread, the majority of lakes are in the eutrophic category.

Lake Nutrient Impairment and Trends [10 CSR 20-7.031(5)(N)]

In an effort to reduce eutrophication due to human activities, the Department has implemented nutrient criteria for all lakes that are waters of the state with at least 10 acres, with the exception of natural lakes (oxbows) in the Big River Floodplain ecoregion. These numeric criteria include chlorophyll-a (Chl-a) response impairment thresholds, as well as nutrient screening thresholds for Chl-a, TN, and TP by ecoregion. At least three years of data is required for assessment to account for natural variations in nutrient levels due to climatic variability (Jones and Knowlton, 2005). The geometric mean is calculated for samples taken between May and September for each calendar year. If the yearly geometric mean of Chl-a exceeds the Chl-a response impairment threshold more than once in the last three years of available data, the lake is determined to be impaired. If a lake exceeds a nutrient screening threshold, it is deemed to be impaired only if one

of five assessment endpoints are also exceeded in the same calendar year. The five assessment endpoints are:

- Occurrence of eutrophication-related mortality or morbidity events in fish and other aquatic organisms
- Epilimnetic excursions from dissolved oxygen or pH criteria
- Cyanobacteria counts in excess of 100,000 cells/mL
- Observed shifts in aquatic diversity attributed to eutrophication
- Excessive levels of mineral turbidity that consistently limit algal productivity between May 1 and September 30.

Lakes included in Table N (Site-Specific Nutrient Criteria) of 10 CSR 20-7.031 have site-specific criteria to account for the unique characteristics of each water body; therefore, the ecoregional criteria do not apply.

The Department evaluates individual lake trends for TP, TN, and Chl-a. Due to seasonal variability, a minimum of ten years of data is necessary for the Department to have confidence in the trend and any resulting 303(d) listings. Additionally, the trend must be statistically significant according to a standard statistical modeling technique, such as least squares regression or Locally Weighted Scatterplot Smoothing (LOWESS) analysis. To be statistically significant, the associated p-value must be less than 0.05. Listing decisions require that the slope of the trend line indicate a potential exceedance of the Chl-a criterion within 5 years of the last monitoring date. This decision also considers confounding or exogenous variables, such as natural phenomena (e.g., rainfall or temperature) as well as other evidence of anthropogenic nutrient enrichment.

During the 2020 cycle, trend analyses were performed on 31 lakes (see Appendix C). Of these, 19 are considered impaired due to mercury in fish tissue, Chl-a, or nutrients. TMDL studies have been developed to address the impairments in 2 of the 19 lakes. One lake in this subset, Hunnewell Lake, is listed due to trend analysis indicating the lake will exceed the Chl-a response impairment threshold within 5 years of the last date of data collection. Data collected in 2018 for Hunnewell Lake, as well as for several other lakes, was demonstrably different than data collected in other years. The Department excluded 2018 data from the trend analysis on Hunnewell Lake until further information and additional data is collected. Without the 2018 data, the trend on Hunnewell Lake was statistically significant. Both parametric and non-parametric trend analyses were performed. With the 2018 data included, only two lakes had statistically significant trends for the parametric analysis: Hazel Hill Lake ($p=0.020$) and DiSalvo Lake ($p=0.002$). Both lakes are listed as impaired for Chl-a due to exceedance of the response impairment threshold. None of the non-parametric trend analyses were statistically significant with 2018 data included. In Appendix C, p-values that are close to being statistically significant are lightly shaded, while those that are statistically significant are distinctly shaded with bolded values. Additionally, several lakes were noted to have a negative trend suggesting a reduction in nutrients over time.

While Appendix C provides a year of potential Chl-a exceedance, these are only estimates based on current trends. These can be greatly impacted by natural phenomena, such as climatic extremes or changes in land use. They are subject to change with the addition of more data. Years of exceedance accompanied by p-values greater than 0.05 in Appendix C are not statistically significant and should not be considered reliable. Lakes with p-values greater than 0.05 will need additional data collection.

Controlling Pollution in Lakes

In Missouri, the three primary sources of NPS pollution include agriculture lands, urban areas, and to a lesser extent, abandoned mine lands. The Department operates several programs that address water quality and habitat issues facing lakes and reservoirs in the state. While lake pollution may be addressed through regulatory controls, most activities are voluntary. As previously discussed, volunteer activities are typically addressed by the Department's NPS program and SWCP. For more information regarding these programs, please see *Water Pollution Control Activities*, Section B.3. of this report.

In-lake management techniques that were previously funded under CWA Section 314 can now be funded under CWA Section 319 in the context of an appropriate NPS project. Several in-lake management techniques are eligible for CWA Section 319 funding, including water level drawdown, shading, biological controls (e.g., fish or insects), and planting or harvesting of aquatic plants. The Department also works with several watershed groups on a regular basis. At least 77 watershed groups have been formed in Missouri. These groups work to educate and inform landowners of threats to water resources in their area and promote land management practices that minimize NPS pollution.

The Department samples lake water quality as needed, but general monitoring is primarily conducted under two specific programs, SLAP and LMVP. Together, these programs monitor well over 100 lakes each year. Funding for both SLAP and LMVP is provided under CWA Section 319. Outreach activities are a major component of LMVP.

TMDLs also help reduce pollution in Missouri lakes and reservoirs. The TMDL program began in 1999 and, as of December 2014, eight studies have been completed for lakes to address reducing NPS pollution contributions. Appendix B shows the proposed schedule of future TMDL studies within the 303(d) list.

Five-Part Categorization of Surface Waters

Results of the five-part categorization of classified surface waters in Missouri are shown in Table 8. Please see Section C.2.2 for category definitions.

Table 8. Surface waters (stream mileage and lake acreage) assigned to reporting categories

Water Body Type	Category									Total Classified	Total Assessed
	1	2A	2B	3A	3B	4A	4B	4C	5		
Streams (mi.)	116	5,171	812	101,893	1,584	703	40	436	4,395	115,150	11,673
Lakes (ac.)	0	101,943	72,997	49,566	2,599	2,672	0	0	89,774	319,550	266,936

Note: Waters in categories 3A and 3B are considered unassessed. Discrepancies between Tables 3 and 9 are due to rounding in stream segment lengths and lake acreages.

Designated Use Support Summary

Designated uses assigned to classified lakes and streams were individually assessed using site specific information, and summarized results are shown in Tables 9 and 10. Each designated use (aquatic life; fish consumption; whole body contact recreation A and B; secondary contact recreation; drinking water supply; industrial process and cooling water; irrigation; livestock and wildlife watering) was assessed as either supporting or not supporting. Designated uses were not assessed for waters without existing data, or for waters where existing data were insufficient to accurately conclude a support level. Totals of 11,673 stream miles and 266,936 lake acres were assessed for at least one designated use.

Table 8. Designated use support summary for classified streams, 2020.

Designated Use	Miles Fully Supporting	Miles Non Supporting	Miles Not Assessed	Total Miles in the state
Protection of Aquatic Life	8,555 (7.4%)	2,440 (2.1%)	104,132 (90.5%)	115,126
Drinking Water Supply	1,818 (51.5%)	0	1,715 (48.6%)	3,533
General Criteria	2,619 (2.3%)	109 (0.1%)	112,413 (97.6%)	115,141
Human Health Protection-Fish Consumption	2,119 (1.8%)	945 (0.8%)	112,057 (97.3%)	115,120
Industrial	169 (10.3%)	0	1,474 (89.7%)	1,643
Irrigation	1,635 (1.4%)	0	113,485 (98.6%)	115,120
Livestock and Wildlife Watering	2,831 (2.5%)	0	112,286 (97.5%)	115,117
Secondary Contact Recreation	4,804 (4.2%)	227 (0.2%)	110,090 (95.6%)	115,120
Whole Body Contact Recreation (A)	1,831 (29.2%)	951 (15.2%)	3,494 (55.7%)	6,276

Whole Body Contact Recreation (B)	729 (0.7%)	1,732 (1.6%)	105,747 (97.3%)	108,208
Cool-Water Habitat	2,126 (65.5%)	89 (2.8%)	1,032 (31.8%)	3,248
Cold-water Habitat	101 (33.8%)	0	197 (66.2%)	298
Grand Total	29,336.4	8,169.7	778,120.45	815,626.55

Table 9. Designated use support summary for classified lakes, 2020.

Designated Use	Acres Fully Supporting	Acres Non Supporting	Acres Not Assessed	Total Acres in State
Protection of Aquatic Life	163,523 (51.2%)	67,047 (21.0%)	88,878 (27.8%)	531,192
Drinking Water Supply	24,895 (19.8%)	262 (0.2%)	100,527 (80.0%)	125,684
General Criteria	5,772 (1.8%)	97 (0.0%)	313,661 (98.2%)	319,530
Human Health Protection-Fish Consumption	168,518 (52.8%)	27,072 (8.5%)	123,858 (38.8%)	319,448
Industrial	0	0	6,959 (100.0%)	6,959
Irrigation	0	0	319,448 (100%)	319,448
Livestock and Wildlife Watering	0	0	319,448 (100%)	319,448
Secondary Contact Recreation	200,068 (62.6%)	0	119,380 (37.4%)	319,448
Whole Body Contact Recreation (A)	223,546 (85.8%)	0	37,141 (14.2%)	260,686
Whole Body Contact Recreation (B)	115 (0.2%)	0	58,647 (99.8%)	58,762
Cold-Water Habitat	0	2,119 (18.9%)	9,113 (81.1%)	11,232

For each designated use identified as non-supporting, there may be one to several potential contaminants causing the impairment(s) (Tables 11 and 12). The list of potential contaminants in Tables 11 and 12 is based on waters categorized as 4A, 4B, 4C, and 5. Summarized data are based on site-specific information. When a classified stream segment is identified as impaired, the contaminant(s) is usually considered to impair the entire segment length. However, if available data suggests only a portion of the classified segment is impaired, it is this shorter length which is included in the total impaired stream mileage listed per contaminant, rather than the entire classified segment. When a lake's designated use is impaired, the entire surface area of

the lake is considered impaired per contaminant, rather than a smaller portion in closer proximity to the dam outlet where data are collected.

Table 10. Causes of designated use impairments assigned to classified streams.

Cause/Impairment Type	Impaired Stream Miles	Percent of Total Miles
Bacteria (Fecal Coliform and <i>E. coli</i>)	3,455	42.4
Low Dissolved Oxygen	1,328	16.3
Mercury in Fish Tissue	849	10.4
Lead	539	6.6
Fish Bioassessment	369	4.5
Macroinvertebrate Bioassessment	278	3.4
Cadmium	265	3.3
Zinc	263	2.1
Sediment/Siltation	167	1.4
Water Temperature	116	1.3
Chloride	105	1.1
Habitat Assessment	92	0.7
Unknown Cause(s)	53	0.6
pH	50	0.5
Ammonia, Total	44	0.5
Sulfates	37	0.4
Physical substrate habitat alterations	32	0.4
Total Dissolved Solids	28	0.2
Solids, Suspended Bedload	18	0.2
Ammonia, Un-ionized	13	0.1
Copper	9	0.1
Dissolved Oxygen Saturation	9	<0.1
Nickel	8	<0.1
Total Suspended Solids	5	<0.1
Chlordane in Fish Tissue	4	<0.1
Polycyclic Aromatic Hydrocarbons	4	<0.1
Biological Indicators of Eutrophication	4	<0.1
Total Nitrogen	4	<0.1

Table 11. Causes of designated use impairment assigned to classified lakes.

Cause/Impairment Type	Impaired Lake Acres	Percent of Total Acres
Chlorophyll (Total and Chlorophyll-a)	108,682	35
Total Nitrogen	84,503	27
Biological Indicators of Eutrophication	83,642	27
Mercury in Fish Tissue	27,169	8.8

Total Phosphorus	2,182	0.7
Dissolved Oxygen Saturation	2,119	0.7
Pesticides (Atrazine)	44	0.01

Contaminants that cause designated use impairments originate from numerous sources. In some cases, a single source is responsible for providing multiple contaminants to the same water body. Impaired stream miles and lake acreages for each contaminant source are listed in Tables 13 and 14. Summarized information is based on site-specific surveys. While contaminants can usually be identified, monitoring limitations can make it difficult to pinpoint exact sources. Despite these limitations, various pollutant sources have been recognized as causing impairments in Missouri's streams and lakes.

Table 12. Contaminant sources for designated use impairments assigned to classified streams

Source Category	Impaired Stream Miles	Percent of Total Miles
Unspecified Nonpoint Source	2,375	29.1
Source Unknown	1,310	16.1
Municipal Point Source	957	11.7
Mill Tailings	926	11.4
Atmospheric Deposition (Mercury)	849	10.4
Urban Runoff/Storm Sewers	464	5.7
Channelization	461	5.7
Agriculture	148	1.8
Mine Tailings	144	1.7
Dam or Impoundment	102	1.3
Industrial Point Source Discharges	89	1.1
Habitat Modification other than Hydromodification	89	1.1
Other Recreational Pollution Sources	62	0.7
Coal Mining	50	0.6
Industrial Point Source Discharge	48	0.6
Impacts of Flow Modification	29	0.4
Natural Conditions	14	0.2
Subsurface Coal Mining	7	<0.1
Coal Mining, Subsurface	7	<0.1
Natural Sources	6	<0.1
Road/Bridge Runoff, Non-Construction	5	<0.1
Rural, Residential Areas	4	<0.1
Municipal Urbanized High-Density Area	2	<0.1

Table 13. Contaminant sources for designated use impairments assigned to classified lakes

Source Category	Impaired Lake Acres	Percent of Total Acres
Unspecified Nonpoint Source	152,721	49
Municipal Point Source	125,241	41
Atmospheric Deposition (Mercury)	27,169	8.8
Dam or Impoundment	2,119	0.7
Urban Runoff or Storm Sewers	555	0.2
Source Unknown	421	0.1
Rural or Residential Areas	106	<0.1
Crop Production, Crop Land, or Dry Land	9	<0.1

Section 303(d) Assessment Results – List of Impaired Waters

Under Section 303(d) of the CWA, states are required to develop lists of impaired or threatened waters every two years. An impaired water body is defined as having chronic or recurring violations of numeric and/or narrative water quality criteria. Development of the list is based on assessment methods described in section C.2.1. *Determining Designated Use Attainments* and detailed in the 2020 LMD. Missouri’s proposed Section 303(d) list is included in Appendix B.

The proposed 2020 Section 303(d) List of impaired water bodies (approved by the Missouri CWC) includes specific water body pollutants, their sources, and estimated impairment size. This proposed list reflects any deletions and additions of water body-pollutant pairs since the previous Integrated Report. Water body-pollutant pairs proposed to be removed from Missouri’s previous Section 303(d) Missouri’s are also provided in Appendix B. Waters are typically de-listed when new data shows water quality criteria are no longer exceeded, an assessment method changes, an initial listing error is identified, the EPA established or approved a TMDL, or a permit in lieu of a TMDL was approved by EPA.

In summary, the proposed 2020 Section 303(d) List of impaired waters includes 481 water body-pollutant pairs for both classified and unclassified waters. Approximately 5,215.4 stream miles and 180,402 acres of lakes are categorized as impaired by a specific pollutant. Pollutants most commonly identified include bacteria (142 listings), heavy metals in water or sediment (878), dissolved oxygen (71), and mercury in fish tissue (63). Most common pollutant sources include nonpoint source runoff (urban, rural, or unspecified nonpoint sources), mining related impacts, atmospheric deposition, municipal WWTPs and other point sources.

Forty-four pollutant pairs from the 2018 Section 303(d) List were proposed to be removed from the 2020 list. Often, de-listing was due to compliance with WQS, sometimes due to a change in the standard. In a few cases, the return to compliance was attributable to new assessment methods, erroneous listings, or restoration actions. In most cases, however, the recovery reason was unknown. Please see Appendix B for additional details on de-listed waters.

Water bodies that have been removed from this and previous Section 303(d) lists as a result of an approved TMDL or permit in lieu of a TMDL are listed in Appendix E. These waters were categorized as 4A, 4B, or 4C, and are still considered impaired due to noncompliance with WQS.

Appendix F lists the waterbodies that are considered potentially impaired, but do not have sufficient data to make that assessment conclusive.

TMDL Schedule

Under 40 CFR Part 130.7(b), states are required to submit a priority ranking schedule that identifies all waters targeted for TMDL development in the next two years. Each water body-pollutant combination listed in the Section 303(d) list must receive a clear priority ranking. EPA guidance also encourages states to develop TMDLs for each water body-pollutant combination in a time frame that is no longer than eight to 13 years from the time the water body-pollutant pair was first listed.

For Missouri's 303(d) list, the Department ranks water body impairments as "High," "Medium," or "Low" for TMDL development. Specific schedules for TMDL development are provided for water body impairments prioritized as High. Water body impairments ranked as Medium or Low priority are given a general range of years for which TMDL development may occur. When determining priority rankings, the Department considers a wide variety of factors, including, the severity of the pollution, designated uses, type of pollutant, data availability, existing work plans, suitability for a watershed approach, and age of listing. The prioritization and proposed schedule for TMDL development is included in the 303(d) list. The public is encouraged to provide feedback on the proposed schedule during the public comment period and public availability sessions offered during development of the 303(d) list. Missouri's TMDL Prioritization Framework is available online at <https://dnr.mo.gov/env/wpp/tmdl/index.html>.

C.4. Wetlands Programs

Waters of the state identified as wetlands are those that meet criteria in the *United States Army Corps of Engineers Wetlands Delineation Manual 1987*. Missouri's current WQS lack designated uses specific to wetlands that are supported by numeric water quality criteria; however, as waters of the state, narrative criteria do apply to wetlands. Additional information about wetlands in Missouri may be found at <http://dnr.mo.gov/env/wrc/wetlands.htm>.

Wetlands meeting criteria in the *United States Army Corps of Engineers Wetlands Delineation Manual 1987* and considered jurisdictional are protected under CWA Sections 404 and 401. Persons seeking to alter wetlands through the discharge of "dredge or fill" materials and related impacts (e.g., installing culverts or rip-rap, rerouting streams, filling wetland for development purposes) must apply for a Section 404 permit with USACE; in conjunction, the applicant must also obtain a Section 401 Water Quality Certification from the Department ensuring WQS will not be violated and/or appropriate mitigation steps will be taken when impacts are unavoidable.

The Department's WPP, under direction by the Missouri CWC and EPA, is working to establish WQS for wetlands. In 2013, the WPP was awarded a Wetland Program Development Grant by EPA, which helped establish a set of reference wetlands in Missouri that were subject to onsite water chemistry and biological sampling. Sampling on these reference wetlands has continued through the Wetland Water Quality Monitoring QAPP. Ultimately, it is intended that reference wetland information may be used as the basis for developing wetland WQS and for establishing an IBI for wetlands.

The Department's Water Resources Center administers the State Wetlands Conservation Plan, which encourages the protection and restoration of wetlands and provides technical assistance to other agencies involved in wetland issues. With the assistance of other state and federal agencies, and a partnership with the University of Central Missouri (UCM), the Department has completed several projects. These include studies assessing urban wetlands, identifying types of wetlands through image analysis, wetland nutrient monitoring, determining the hydrology of Missouri riparian wetlands, and an assessment of specific wetland mitigation sites. Continuous monitoring of wetland hydrology is conducted at six sites in the state.

Numerous state and federal wetland projects have been undertaken to protect and enhance Missouri's wetland resources. Together, MDC, USFWS and NRCS have protected more than 260,000 acres of wetlands through easements or purchases, restored more than 43,000 acres, and enhanced more than 41,000 acres in Missouri.

C.5. Public Health Issues

EPA asks states to provide information on public health issues, including information on drinking water supply, whole body contact recreation, and fish consumption advisories. The procedures for determining attainment of each use are provided in section C.2.1, *Determination of Designated Use Attainments*. Please see Tables 9 and 10 for designated use support summaries related to drinking water supply, whole body contact recreation, and fish consumption uses.

Drinking water supply usage is designated for 3,533 stream miles and 125,684 lake acres. This use is not supported in two lakes, Lewistown Lake (Lewis Co., 35 ac.) and Wyaconda Lake (Clark Co., 9 ac.). In both cases, the contaminant is atrazine due to local herbicide applications.

All classified lakes and streams are designated for fish consumption use. For streams, 844 miles are impaired due to contaminants in fish tissue. In all of the 15 impaired streams, the contaminant is mercury. Forty-four classified lakes covering a total of 27,134 acres are also impaired by mercury in fish tissue. Mercury is known to make its way to surface waters through atmospheric deposition.

DHSS publishes an annual fish advisory and guide for eating fish in state waters. DHSS's advisory offers guidelines for two populations, all consumers and a sensitive population, which is defined as pregnant women, women of childbearing age, nursing mothers, and children younger than 13. In Missouri, guidelines vary according to water body, fish species and length. Contaminants of concern include mercury, chlordane, lead, and PCBs. For all consumers, recommendations vary from one meal per week to "Do Not Eat" for specific species from certain rivers. The statewide recommendation for the sensitive population is to eat no more than one meal of fish per month. The complete fish advisory guide for 2020 is available in portable document format at <http://health.mo.gov/living/environment/fishadvisory/pdf/fishadvisory.pdf>.

E. coli is sampled at a select set of designated swimming beaches in the state park system on a regular basis during the recreational season. Swimming is discouraged when the geometric mean of weekly sample results exceeds 190 *E. coli* colonies per 100 mL of water. Sampling results and beach notifications can be viewed online at <http://www.dnr.mo.gov/asp/beaches/index.html>.

PART D. GROUNDWATER MONITORING AND ASSESSMENT

Groundwater resources vary considerably in quantity and quality across Missouri. It is estimated that during normal weather cycles, 500 trillion gallons of drinkable groundwater is stored in Missouri's aquifers (Miller and Vandike 1997). Certain aquifers yield high volumes of quality water, whereas in some areas groundwater yields are low and/or contain water that is too mineralized for consumption. This section provides an overview of significant groundwater resources in the state, groundwater interactions with surface waters, groundwater quality, sources of groundwater contamination, and current monitoring efforts and protection programs.

D.1. Groundwater in Missouri

Approximately 40 percent of Missourians rely on groundwater for drinking water. Groundwater is the primary source of private and public drinking water in the Ozarks and the Southeastern Lowlands. The cities of St. Joseph, Independence, Columbia, and St. Charles use groundwater from the alluvial aquifer of the Missouri River. In the Plains region, many small communities are able to obtain adequate water from shallow alluvial wells near rivers or large creeks, and many individual households still rely on shallow upland aquifers despite small yields.

In the Ozarks, groundwater yields are usually large and of excellent quality, as witnessed by the fact that many municipalities pump groundwater directly into their water supplies without treatment, unlike cities in other areas of the state. However, the geologic character of the Ozarks that supplies it with such an abundance of groundwater, namely its ability to funnel large amounts of rainfall and surface runoff to the groundwater system, can present problems for groundwater quality. This is because much surface water flows directly to groundwater through cracks, fractures or solution cavities in the bedrock, with little or no filtration. Contaminants from leaking septic tanks or storage tanks, or surface waters affected by domestic wastewater, animal feedlots, and other pollution sources can move directly into groundwater through these cavities in the bedrock.

As in the Ozarks, groundwater in the Southeast Lowlands is abundant and of good quality, although public water supply wells in the southeast lowlands typically are high in minerals and water systems using this source have iron removal plants to improve the aesthetic quality of the water. Unlike the Ozarks, contaminants are filtered by thick deposits of sand, silt, and clay as they move through the groundwater system. Shallow groundwater wells, however, are subject to the same problems of elevated levels of nitrate or bacteria experienced in the Ozark aquifer and can also have low levels of pesticides. Deep wells are generally unaffected by contaminants.

Shallow groundwater in the Plains of northern and western Missouri tends to be somewhat more mineralized and have taste and odor problems due to high levels of iron and manganese. Like shallow private wells in the Southeast Lowlands, wells in this part of the state can be affected by nitrates, bacteria, or pesticides.

In urban areas, alluvial aquifers of large rivers, such as the Missouri and the Meramec, which serve water supplies have occasionally been locally contaminated by spills or improper disposal of industrial or commercial chemicals.

D.2. Well Construction and Groundwater Quality

Well construction greatly influences the quality of well water and therefore, state regulations include construction standards for both public and private wells. Public drinking water wells and many private wells are deep, and properly cased and grouted. These wells rarely become contaminated. However, many private wells established prior to the development of construction standards are shallow or not properly cased. These wells can be easily contaminated by septic tanks, feedlots or chemical mixing sites near the well. Studies in Missouri have shown that two-thirds of wells contaminated by pesticides are less than 35 feet deep. The three most common problems in private wells are bacteria, nitrate, and pesticides. Water quality criteria for each of these pollutants can occasionally be exceeded in private wells.

D.3. Major Potable Aquifers in Missouri

Locations of major aquifers providing drinkable water in Missouri are described below. Unconfined aquifers are those influenced by water table conditions (the pressure at the water table is the atmospheric pressure), and tend to yield greater amounts of water, but are also more easily contaminated by activities occurring at the land's surface. In confined aquifers, groundwater is overlain by a low permeable geologic material, and groundwater below is under pressure greater than atmospheric pressure alone. Confined aquifers generally recharge more slowly than unconfined aquifers but are better protected from surface contaminants.

Glacial Till Aquifer

This aquifer covers most of Missouri north of the Missouri River. Glacial till is an unsorted mixture of clay, sand, and gravel, with occasional boulders and lenses of sand or gravel. Loess, fine wind-blown silt deposits four to eight feet in depth, covers the till on the uplands. In some places, the till is underlain by sorted deposits of sand or gravel. Although this aquifer is unconfined, surface water infiltrates very slowly and groundwater yields are very small. In scattered areas, the till has buried old river channels that remain as large sand or gravel deposits that contain much more groundwater than the till. Some households rely on these areas for drinking water, but it is generally inadequate as a source for municipal water supply.

Alluvial Aquifer

Alluvial aquifers are the unconfined aquifers on the floodplains of rivers and are of Quaternary age. In Missouri, the largest of these aquifers lie along the Missouri and Mississippi Rivers, reaching their widest extent in the Southeast Lowlands, where they extend as far as 50 miles west of the Mississippi River. Many small communities north of the Missouri River use alluvial aquifers of nearby streams as their drinking water supply, and the Missouri River alluvium supplies the cities of St. Joseph, Independence, and Columbia and sections of St. Charles County. In the Southeast Lowlands, most private water supplies and about 45 percent of people served by public water supplies use water from the alluvial aquifer. Agricultural irrigation

consumes much more water in this area of Missouri than does domestic water use. All agricultural irrigation water is drawn from the alluvial aquifer.

Wilcox-McNairy Aquifers

These two aquifers lie beneath much of the alluvial aquifer of the Southeast Lowlands. They are in unconsolidated or loosely consolidated deposits of marine sands and clays of Tertiary and Cretaceous age. Except where the McNairy aquifer outcrops in the Benton Hills and along Crowley's Ridge, these aquifers are confined. They yield abundant amounts of good quality water, and they provide water for 55 percent of people served by public supplies. In the southeastern part of this region, the deeper of these aquifers, the McNairy, becomes too mineralized to be used for drinking water supply. These two aquifers appear to be unaffected by contaminants of human origin.

Ozark-St. Francois Aquifer

This aquifer covers most of the southern and central two-thirds of Missouri. It is composed of dolomites and sandstones of Ordovician and Cambrian age. Most of the aquifer is unconfined. This aquifer is used for almost all public and private drinking water supplies in this area of Missouri. Exceptions would include supplies in the St. Francois Mountains, such as Fredericktown and Ironton, where the aquifer has been lost due to geologic uplift and erosion, and near Springfield, where demand is so heavy that groundwaters are supplemented with water from three large reservoirs and the James River.

Yields and water quality are typically very good, but in many areas, the bedrock is highly weathered, contains many solution cavities, and can transmit contaminated surface waters into the groundwater rapidly with little or no filtration. Where the confined portion of the aquifer is overlain only by the Mississippian limestones of the Springfield aquifer, the confined Ozark aquifer continues westward for 80 miles or more as a potable water supply, serving the communities of Pittsburg, Kansas, and Miami, Oklahoma. However, where it is also overlain by less permeable Pennsylvanian bedrock, the confined Ozark becomes too mineralized for drinking water within 20 to 40 miles.

The unconfined Ozark-St. Francois aquifer is susceptible to contamination from surface sources. Increasing urbanization and increasing numbers of livestock are threats to the integrity of portions of this valuable aquifer.

Springfield Aquifer

This aquifer covers a large portion of southwestern Missouri. It is composed of Mississippian limestones that are highly weathered, particularly in its eastern extent. The aquifer is unconfined and surface water in many areas is readily transmitted to groundwater. Urbanization and livestock production also affect this aquifer. Elevated nitrates and bacterial contamination are common problems in groundwater here.

D.4. Groundwater Contamination, Monitoring, and Protection

Contamination

Major sources of groundwater contamination in Missouri are generally associated with agricultural activities, chemical and waste storage and treatment facilities, industrial and mining processes, and accidental spills. Each contaminant source may lead to one or more contaminants and is typically associated with one or more significant risk factors. Contamination sources can be prioritized by their contaminants and risk factors. The Department has identified 10 priority sources of groundwater contamination in the state. See Table 15 for a list of major groundwater contamination sources in Missouri, their related contaminants, and associated risk factors.

Table 14. Major sources of Missouri groundwater contamination

Contaminant Source	10 Highest Priority Sources (X) ¹	Significant Risk Factors ²	Contaminants ³
Agricultural Activities			
Agricultural chemical facilities			
Animal feedlots			
Drainage wells			
Fertilizer applications	X	A,C,D,E	a
Irrigation practices			
Pesticide applications	X	A,B,C,D,E	b
Storage and Treatment Activities			
Land application	X	A,D,E	a,c
Material stockpiles			
Storage tanks (above ground)			
Storage tanks (underground)	X	A,B,C,D,E	d
Surface impoundments			
Waste piles			
Waste tailings			
Disposal Activities			
Deep injection wells			
Landfills			
Septic systems	X	A,D,E	a,c
Shallow injection wells			
Other			
Hazardous waste generators			
Hazardous waste sites	X	A,B,C,D	b,e,f,g
Industrial facilities	X	A,B,C,E	a,h,i,j
Material transfer operations			
Mining and mine drainage	X	A,E	f
Pipelines and sewer lines			
Salt storage and road salting			

pesticides entered groundwater as a result of normal field application. The survey focused on four primary pesticides: atrazine, simazine, alachlor, and metolachlor. Samples were collected from 190 wells, of which 186 showed no measurable levels of specific pesticides. Of the four wells that showed some level of pesticide contamination in groundwater, no samples contained concentrations above maximum contaminant levels listed under EPA guidelines at that time.

PART E. PUBLIC PARTICIPATION

In accordance with federal CWA regulation and Missouri Revised Statute 644.036.5, the Department provides several opportunities for the public to participate in the development of the Section 303(d) list. The LMD also receives public review and is approved pursuant to 10 CSR 20-7.050.

The public comment period for the proposed 2020 Section 303(d) List opened on November 15, 2019, and closed February 20, 2020. The public notice was posted in eight major newspapers circulated primarily in and around the cities of St. Louis, Kansas City, St. Joseph, Springfield, Kirksville, Columbia, Jefferson City and Cape Girardeau. Documents were posted on the Department's Section 303(d) website at <https://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm> throughout the comment period. Assessment worksheets for proposed water body listings were also included on the webpage. During the comment period, two public availability meetings were held at the Lewis and Clark State Office Building in Jefferson City, one on December 10, 2019, and another on January 14, 2020. Additionally, a hearing on the proposed 2020 Section 303(d) List was held on February 13, 2020.

Summaries of each public availability meeting were posted on the Department's Section 303(d) website following each meeting and have been included with all administrative records submitted with the 2020 Section 303(d) list package to EPA. During each meeting, impaired water body listing decisions were discussed with members of the 303(d) stakeholder group and others in attendance. The Department responded to all questions and comments received during the public notice period. Responses to public comments regarding the Section 303(d) List are included in Appendix G. Missouri's Section 303(d) List was approved by the CWC during a public meeting held on April 2, 2020.

The present LMD went through two public notice processes and was approved by the Missouri CWC on July 18, 2019. The 2022 LMD has not yet gone out for public notice.

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**APPENDIX A - METHODOLOGY FOR THE DEVELOPMENT OF THE 2020
SECTION 303(D) LIST**

**Methodology for the Development
of the
2020 Section 303(d) List in Missouri**

Final

Clean Water Commission Approved

July 22, 2019

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program



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I. Citation and Requirements

A. Citation of Section of Clean Water Act

The Missouri Department of Natural Resources (MDNR) is responsible for the implementation and administration of the Federal Clean Water Act in Missouri. Pursuant to Section 40 CFR 130.7, States, Territories or authorized Tribes must submit biennially to the United States Environmental Protection Agency (EPA) a list of water quality limited (impaired) segments, pollutants causing impairment, and the priority ranking of waters targeted for Total Maximum Daily Load (TMDL) development. Federal regulation at 40 CFR 130.7 also requires States, Territories, and authorized Tribes to submit to EPA a written methodology document describing the State's approach in considering, and evaluating existing readily available data used to develop their 303(d) list of impaired water bodies. The listing methodology must be submitted to the EPA each year the Section 303(d) list is due. While EPA does not approve or disapprove the listing methodology, the agency considers the methodology during its review of the states 303(d) impaired waters list and the determination to list or not to list waters.

Following the Missouri Clean Water Commission approval, Section 303(d) is submitted to EPA. This fulfills Missouri's biennial submission requirements of an integrated report required under Sections 303(d), 305(b) and 314 of the Clean Water Act. In years when no integrated report is submitted, the department submits a copy of its statewide water quality assessment database to EPA.

B. U.S. EPA Guidance

In 2001 the Office of General Counsel and the Office of Wetlands, Oceans, and Watersheds developed a recommended framework to assist EPA regions in the preparation of their approval letters for the States' 2002 Section 303(d) list submissions. This was to provide consistency in making approval decisions along with guidance for integrating the development and submission of the 2002 Section 305(b) water quality reports and Section 303(d) list of impaired waters¹.

The following sections provide an overview of EPA Integrated Report guidance documents from calendar year 2002 through 2015.

The 2002 Integrated Water Quality Monitoring and Assessment Report Guidance was the first document EPA provided to the States, Territories, and authorized Tribes with directions on how to integrate the development and submission of the 2002 305(b) water quality reports and Section 303(d) list of impaired waters.

The guidance recommended that States, Territories and authorized Tribes submit a combined integrated report that would satisfy the Clean Water Act requirements for both Section 305(b) water quality reports and Section 303(d) list. The 2002 Integrated Report was to include:

¹ Additional information can be obtained from EPA's website:
<http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/guidance.cfm>.

- Delineation of water quality assessment units based on the National Hydrography Dataset (NHD);
- Status of and progress toward achieving comprehensive assessments of all waters;
- Water quality standard attainment status for every assessment unit;
- Basis for the water quality standard attainment determinations for every assessment unit;
- Additional monitoring that may be needed to determine water quality standard attainment status and, if necessary, to support development of total maximum daily loads (TMDLs) for each pollutant/assessment unit combination;
- Schedules for additional monitoring planned for assessment units;
- Pollutant/assessment unit combinations still requiring TMDLs; and
- TMDL development schedules reflecting the priority ranking of each pollutant/assessment unit combination.

The 2002 EPA guidance described the requirements under Section 303(d) of the Clean Water Act where states were required to describe the methodology used to develop their 303(d) list. EPA's guidance recommended the states provide: (1) a description of the methodology used to develop Section 303(d) list; (2) a description of the data and information used to identify impaired and threatened waters; (3) a rationale for not using any readily available data and information; and (4) information on how interstate or international disagreements concerning the list are resolved. Lastly (5), it is recommended that "prior to submission of its Integrated Report, each state should provide the public the opportunity to review and comment on the methodology." In accordance with EPA guidance, the department reviews and updates the Listing Methodology Document (LMD) every two years. The LMD is made available to the public for review and comment at the same time the state's 303(d) impaired waters list is published for public comment. Following the public comment period, the department responds to public comments and provides EPA with a document summarizing all comments received.

In July 2003, EPA issued new guidance entitled "Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act." This guidance gave further recommendations about listing of 303(d) and other waters.

In July 2005, EPA published an amended version entitled "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act" (see Appendix A for Excerpt).

In October 2006, EPA issued a memorandum entitled "Information Concerning 2008 Clean Water Act Sections 303(d), 305(b) and 314 Integrated Reporting and Listing Decisions." This memorandum serves as EPA's guidance for the 2008 reporting cycle and beyond. This guidance recommended the use of a five-part categorization scheme and that each state provides a comprehensive description of the water quality standards attainment status of all segments within a state (reference Table 1 below). The guidance also defined a "segment" as being used synonymous with the term "assessment unit" used in previous Integrated Report Guidance. Overall, the selected segmentation approach should be consistent with the state's water quality standards and be capable of providing a spatial scale that is adequate to characterize the water quality standards attainment status for the segment.

It was in the 2006 guidance that EPA recommended all waters of the state be placed in one of five categories described below.

Table 1. Placement of Waters within the Five Categories in the 2006² EPA Assessment, Listing and Reporting Guidance

<p><u>Category 1</u></p>	<p>All designated uses are fully maintained. Data or other information supporting full use attainment for all designated uses must be consistent with the state’s Listing Methodology Document (LMD). The department will place a water in Category 1 if the following conditions are met:</p> <ul style="list-style-type: none"> • The water has physical and chemical data (at a minimum, water temperature, pH, dissolved oxygen, ammonia, total cobalt, and total copper for streams, and total nitrogen, total phosphorus and secchi depth for lakes) and biological water quality data (at a minimum, <i>E. coli</i> or fecal coliform bacteria) that indicates attainment with water quality standards. • The level of mercury in fish filets or plugs used for human consumption is 0.3 mg/kg (wet weight) or less. Only samples of higher trophic level species (largemouth, smallmouth and spotted bass, sauger, walleye, northern pike, trout (rainbow and trout), striped bass, white bass, flathead catfish and blue catfish) will be used. • The water is not rated as “threatened.”
<p><u>Category 2</u></p>	<p>One or more designated uses are fully attained but at least one designated use has inadequate data or information to make a use attainment decision consistent with the state’s LMD. The department will place a water in Category 2 if at least one of the following conditions are met:</p> <ul style="list-style-type: none"> • There is inadequate data for water temperature, pH, dissolved oxygen, ammonia, total cobalt or total copper in streams to assess attainment with water quality standards or inadequate data for total nitrogen, total phosphorus or secchi depth in lakes. • There is inadequate <i>E. coli</i> or fecal coliform bacteria data to assess attainment of the whole body contact recreational use. • There are insufficient fish fillet, tissue, or plug data available for mercury to assess attainment of the fish consumption use. <p>Category 2 waters will be placed in one of two sub-categories.</p> <p>Category 2A: Waters will be placed in this category if available data, using best professional judgement, suggests compliance with numerical water quality criteria of Tables A or B in Missouri’s Water Quality Standards (10 CSR 20-7.031) or other quantitative thresholds for determining use attainment.</p>

² <http://www.epa.gov/sites/production/files/2015-10/documents/2006irg-report.pdf>

	<p>Category 2B: Waters will be placed in this category if the available data, using best professional judgment, suggests noncompliance with numeric water quality criteria of Tables A or B in Missouri's Water Quality Standards, or other quantitative thresholds for determining use attainment, and these data are insufficient to support a statistical test or to qualify as representative data. Category 2B waters will be given high priority for additional water quality monitoring.</p>
<u>Category 3</u>	<p>Water quality data are not adequate to assess any of the designated beneficial uses consistent with the LMD. The department will place a water in Category 3 if data are insufficient to support a statistical test or to qualify as representative data to assess any of the designated uses. Category 3 waters will be placed in one of two sub-categories.</p> <p>Category 3A. Waters will be placed in this category if available data, using best professional judgment, suggests compliance with numerical water quality criteria of Tables A or B in Missouri's Water Quality Standards (10 CSR 20-7.031) or other quantitative thresholds for determining use attainment. Category 3A waters will be tagged for additional water quality monitoring, but will be given lower priority than Category 3B waters.</p> <p>Category 3B. Waters will be placed in this category if the available data, using best professional judgment, suggest noncompliance with numerical water quality criteria of Tables A or B in Missouri's Water Quality Standards or other quantitative thresholds for determining use attainment. Category 3B waters will be given high priority for additional water quality monitoring.</p>
<u>Category 4</u>	<p>State water quality standards or other criteria, as per the requirements of Appendix B & C of this document, are not attained, but a Total Maximum Daily Load (TMDL) study is not required. Category 4 waters will be placed in one of three sub-categories.</p> <p>Category 4A. EPA has approved a TMDL study that addresses the impairment. The department will place a water in Category 4A if both the following conditions are met:</p> <ul style="list-style-type: none">• Any portion of the water is rated as being in non-attainment with state water quality standards or other criteria as explained in

	<p>Appendix B & C of this document due to one or more discrete pollutants or discrete properties of the water³, and</p> <ul style="list-style-type: none"> • EPA has approved a TMDL for all pollutants that are causing non-attainment. <p>Category 4B. Water pollution controls required by a local, state or federal authority, are expected to correct the impairment in a reasonable period of time. The department will place a water in Category 4B if both of the following conditions are met:</p> <ul style="list-style-type: none"> • Any portion of the water is rated as being in non-attainment with state water quality standards or other criteria as explained in Appendix B & C of this document due to one or more discrete pollutants or discrete properties of water³, and • A water quality based permit that addresses the pollutant(s) causing the designated use, impairment has been issued, and compliance with the permit limits will eliminate the impairment; or other pollution control requirements have been made that are expected to adequately address the pollutant(s) causing the impairment. This may include implemented voluntary watershed control plans as noted in EPA’s guidance document. <p>Category 4C. Any portion of the water is rated as being in non-attainment with state water quality standards or other criteria as explained in Appendix B & C of this document, and a discrete pollutant(s) or other discrete property of the water³ does not cause the impairment. Discrete pollutants may include specific chemical elements (e.g., lead, zinc), chemical compounds (e.g., ammonia, dieldrin, atrazine) or one of the following quantifiable physical, biological or bacteriological conditions: water temperature, percent of gas saturation, amount of dissolved oxygen, pH, deposited sediment, toxicity or counts of fecal coliform or <i>E. coli</i> bacteria.</p>
<p><u>Category 5</u></p>	<p>At least one discrete pollutant has caused non-attainment with state water quality standards or other criteria as explained in Appendix B & C of this document, and the water does not meet the qualifications for listing as either Categories 4A or 4B. Category 5 waters are those that are candidates for the state’s 303(d) List⁴.</p>

³ A discrete pollutant or a discrete property of water is defined here as a specific chemical or other attribute of the water (such as temperature, dissolved oxygen or pH) that causes beneficial use impairment and that can be measured quantitatively.

⁴ The proposed state 303(d) List is determined by the Missouri Clean Water Commission and the final list is determined by the U.S. Environmental Protection Agency.

	<p>If a designated use is not supported and the segment is impaired or threatened, the fact that a specific pollutant is not known does not provide a basis for excluding a segment from Category 5.</p> <p>Category 5. These segments must be listed as Category 5 unless the state can demonstrate that no discrete pollutant(s) causes or contributes to the impairment. Pollutants causing the impairment will be identified through the 303(d) assessment and listing process before a TMDL study is written. The TMDL should be written within the time frame preferred in EPA guidance for TMDL development, when it fits within the state’s TMDL prioritization scheme.</p> <p>Category 5-alt. A water body assigned to 5-alt is an impaired water without a completed TMDL but assigned a low priority for TMDL development because an alternative restoration approach is being pursued. This also provides transparency to the public that a state is pursuing restoration activities in those waters to achieve water quality standards. The addition of this sub-category will facilitate tracking alternative restoration approaches in 303(d) listed waters in priority areas.</p>
<u>Threatened Waters</u>	<p>When a water is currently attaining all designated uses, but the data shows an inverse (time) trend in quality for one or more discrete water quality pollutants indicating the water will not continue to meet these uses before the next listing cycle. Such water will be considered “threatened.” A threatened water will be treated as an impaired water and placed in the appropriate Category (4A, 4B, or 5).</p>

In subsequent years, EPA has provided additional guidance, but only limited new supplemental information has been provided since the 2008 cycle.

In August 2015, the EPA provided draft guidance that would include a Category 5-alternative (5-alt) (reference Table 1 above). Additional information can be found at EPA’s website:

<http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/guidance.cfm>.

II. The Methodology Document

A. Procedures and Methods Used to Collect Water Quality Data

- Department Monitoring

The major purposes of the department's water quality monitoring program are to:

- characterize background or reference water quality conditions;
- better understand daily, flow event and seasonal water quality variations and their underlying processes;
- characterize aquatic biological communities;
- assess trends in water quality;
- characterize local and regional effects of point and nonpoint sources pollutants on water quality;
- check for compliance with water quality standards and/or wastewater permit limits;
- support development of strategies, including Total Maximum Daily Loads, to return impaired waters to compliance with Water Quality Standards. All of these objectives are statewide in scope.

- Coordination with Other Monitoring Efforts in Missouri

To maximize efficiency, the department routinely coordinates its monitoring activities with other agencies to avoid overlap, and to give and receive feedback on monitoring design. Data from other sources are used for meeting the same objectives as department-sponsored monitoring. The data must fit the criteria described in the data quality considerations section of this document. The agencies most often involved are the U.S. Geological Survey, the U.S. Army Corps of Engineers, EPA, the Missouri Department of Conservation (MDC), and the Missouri Department of Health and Senior Services. The Department of Natural Resources also tracks the monitoring efforts of the National Park Service; the U.S. Forest Service; several of the state's larger cities; the states of Oklahoma, Arkansas, Kansas, Iowa, and Illinois; and graduate level research conducted at universities within Missouri. For those wastewater discharges where the department has required instream water quality monitoring, the department may also use monitoring data acquired by wastewater dischargers as a condition of discharge permits issued by the department. In 1995, the department also began using data collected by volunteers that have passed Volunteer Water Quality Monitoring Program Quality Assurance/Quality Control tests.

- Existing Monitoring Networks and Programs

The following is a list and a brief description of the kinds of water quality monitoring activities presently occurring in Missouri.

1. Fixed Station Network

- a) Objective: To better characterize background or reference water quality conditions, to better understand daily, flow events, and seasonal water quality variations and their underlying processes, to assess trends and to check for compliance with water quality standards.
- b) Design Methodology: Sites are chosen based on one of the following criteria:
 - Site is believed to have water quality representative of many neighboring streams of similar size due to similarity in watershed geology, hydrology and land use, and the absence of any impact from a significant point or discrete nonpoint water pollution source.
 - Site is downstream of a significant point source or discrete nonpoint source area.
- c) Number of Sites, Sampling Methods, Sampling Frequency, and Parameters:
 - MDNR/U.S. Geological Survey cooperative network: approximately 70 sites statewide, horizontally and vertically integrated grab samples, four to twelve times per year. Samples are analyzed for major ions (e.g. calcium, magnesium, sulfate, and chloride), nutrients (e.g. phosphorus and nitrogen), temperature, pH, dissolved oxygen, specific conductance, bacteria (e.g. *Escherichia coli* (*E. coli*) and fecal coliform) and flow on all visits, two to four times annually for suspended solids and heavy metals, and for pesticides six times annually at four sites.
 - MDNR/University of Missouri-Columbia's lake monitoring network. This program has monitored about 249 lakes since 1989. About 75 lakes are monitored each year. Each lake is usually sampled four times during the summer and about 12 are monitored spring through fall for nutrients, chlorophyll, turbidity and suspended solids.
 - Department routine monitoring of finished public drinking water supplies for bacteria and trace contaminants.
 - Routine bacterial monitoring for *E. coli* of swimming beaches at Missouri's state parks during the recreational season by the department's Missouri State Parks.
 - Monitoring of sediment quality by the department at approximately 10-12 discretionary sites annually. Sites are monitored for several heavy metals (e.g. arsenic, cadmium, copper, lead, mercury, nickel, zinc, etc.) and/or organic contaminants (e.g. polycyclic aromatic hydrocarbons, etc.).

2. Special Water Quality Studies

- a) Objective: Special water quality studies are used to characterize water quality effects from a specific pollutant source area.

- b) **Design Methodology:** These studies are designed to verify and measure the contaminants of concern based on previous water quality studies, effluent sampling and/or Missouri State Operating Permit applications. These studies employ multiple sampling stations downstream and upstream (if appropriate). If contaminants of concern have significant seasonal or daily variation, the sampling design must account for such variation.
- c) **Number of Sites, Sampling Methods, Sampling Frequency and Parameters:** The department conducts or contracts up to 10 to 15 special studies annually, as funding allows. Each study has multiple sampling sites. The number of sites, sampling frequency and parameters all vary greatly depending on the study. Intensive studies would also require multiple samples per site over a relatively short time frame.

3. Toxics Monitoring Program

The fixed station network and many of the department's intensive studies monitor for acute and chronic toxic chemicals⁵. In addition, major municipal and industrial dischargers must monitor for acute and chronic toxicity in their effluents as a condition of their Missouri State Operating Permit.

4. Biological Monitoring Program

- a) **Objectives:** The objectives of the Biological Monitoring programs are to develop numeric criteria describing "reference" aquatic macroinvertebrate and fish communities in Missouri's streams, to implement these criteria within state water quality standards and to maintain a statewide fish and aquatic macroinvertebrate monitoring program.
- b) **Design Methodology:** Development of biocriteria for fish and aquatic macroinvertebrates⁶ involves identification of reference streams in each of Missouri's aquatic ecoregions and 17 ecological drainage units, respectively. It also includes intensive sampling of invertebrate and fish communities to quantify temporal and spatial variation in reference streams within ecoregions and variation among ecoregions, and the sampling of chemically and physically impaired streams to assess the aquatic community.
- c) **Number of Sites, Sampling Methods, Sampling Frequency and Parameters:** The department has conducted biological sampling of aquatic macroinvertebrates for many years. Since 1991, the department's aquatic macroinvertebrate monitoring program has consisted of standardized monitoring of approximately 45 to 55 sites twice annually. In addition, the MDC presently has a statewide fish and aquatic macroinvertebrate monitoring program, the Resource Assessment and Monitoring (RAM) Program, designed monitor and assess the health of Missouri's stream resources on a rotating basis. This program samples a minimum of 450 random and 30 reference sites every five years.

⁵ As defined in 10 CSR 20-7.031(1)

⁶ For additional information visit: <http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm>

5. Fish Tissue Monitoring Program

- a) Objective: Fish tissue monitoring addresses two objectives: (1) the assessment of ecological health or the health of aquatic biota (usually accomplished by monitoring whole fish samples); and (2) the assessment of human health risk based on the level of contamination of fish tissue plugs, or fillets.
- b) Design Methodology: Fish tissue monitoring sites are chosen based on one of the following criteria:
 - Site is believed to have water and sediment quality representative of many neighboring streams or lakes of similar size due to similarity in geology, hydrology and land use, and the absence of any known impact from a significant point source or discrete nonpoint water pollution source.
 - Site is downstream of a significant point source or discrete nonpoint source area.
 - Site has shown fish tissue contamination in the past.
- c) Number of Sites, Sampling Methods, Sampling Frequency and Parameters:

The department plans to maintain a fish tissue monitoring program to collect whole fish composite samples⁷ at approximately 13 fixed sites. In previous years, this was a cooperative effort between EPA and the department through EPA's Regional Ambient Fish Tissue (RAFT) Monitoring Program. Each site will be sampled once every two years. The preferred species for these sites are either Common Carp (*Cyprinus carpio*) or one of the Redhorse (a.k.a. sucker) species (*Moxostoma* sp.).

The department, EPA, and MDC also sample 40 to 50 discretionary sites annually for two fish fillet composite samples or fish tissue plug samples (mercury only) from fish of similar size and species. One sample is of a top carnivore such as Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieu*), Walleye (*Sander vitreus*), or Sauger (*Sander canadensis*). The other sample is for a species of a lower trophic level such as catfish, Common Carp or sucker species (Catostomidae). This program occasionally samples fish eggs for certain fish species at selected locations. Both of these monitoring programs analyze for several chlorinated hydrocarbon insecticides, PCBs, lead, cadmium, mercury, and fat content.

6. Volunteer Monitoring Program

Two major volunteer monitoring programs generate water quality data in Missouri. The data generated from these programs are used for statewide 305(b) reporting on general water quality health, used as a screening level tool to determine where additional monitoring is needed, or used to supplement other water quality data for watershed planning purposes.

- Lakes of Missouri Volunteer Program⁸. This cooperative program consists of persons from the department, the University of Missouri-Columbia, and volunteers who monitor

⁷ A composite sample is one in which several individual fish are combined to produce one sample.

⁸ For additional program information visit: <http://www.lmvp.org/>

approximately 137 sites on 66 lakes, including Lake Taneycomo, Table Rock Lake and several lakes in the Kansas City area. Lake volunteers are trained to collect samples for total phosphorus, total nitrogen, chlorophyll and inorganic suspended sediments. Data from this program is used by the university as part of a long-term study on the limnology of mid-western reservoirs.

- **Volunteer Water Quality Monitoring Program.** The Volunteer Water Quality Monitoring Program⁹ is an activity of the Missouri Stream Team Program, which is a cooperative project sponsored by the department, the Missouri Department of Conservation, and the Conservation Federation of Missouri. The program involves volunteers who monitor water quality of streams throughout Missouri. There are currently over 5,000 Stream Teams and more than 3,600 trained water quality monitors. Approximately 80,000 citizens are served each year through the program. Since the beginning of the Stream Team program, 494,232 volunteers have donated about 2 million hours valued at more than \$38 million to the State of Missouri.

After the Introductory class, many attend at least one more class of higher level training: Levels 1, 2, 3 and 4. Each level of training is a prerequisite for the next higher level, as is appropriate data submission. Data generated by Levels 2, 3, and 4 and the Cooperative Stream Investigation (CSI) Program volunteers represent increasingly higher quality assurance. For CSI projects, the volunteers have completed a quality assurance/quality control workshop, completed field evaluation, and/or have been trained to collect samples following department protocols. Upon completing Introductory and Level 1 and 2 training, volunteers will have received the basic level training to conduct visual stream surveys, stream discharge measurements, biological monitoring, and collect physical and chemical measurements for pH, conductivity, dissolved oxygen, nitrate, and turbidity.

Of those completing an Introductory course, about 35 percent proceed to Levels 1 and 2. The CSI Program uses trained volunteers to collect samples and transport them to laboratories approved by the department. Volunteers and department staff work together to develop a monitoring plan. All Level 2, 3, and 4 volunteers, as well as all CSI trained volunteers, are required to attend a validation session every 3 years to ensure equipment, reagents and methods meet program standards.

- Identification of All Existing and Readily Available Water Quality Data Sources

Data Solicitation Request

In the calendar year 2 years prior to the current listing cycle, the department sends out a request for all available water quality data (chemical and biological). The data solicitation requests water quality data for approximately a two year timeframe prior to and including the current calendar year (up to October 31st of the current year). The data solicitation request is sent to multiple agencies, neighboring states, and organizations. In addition, and

⁹ For additional program information visit: <http://dnr.mo.gov/env/wpp/VWQM.htm>

as part of the data solicitation process, the department queries available water quality data from national databases such as EPA's Storage and Retrieval (STORET)/Water Quality Exchange (WQX) data warehouse¹⁰, and the USGS Water Quality Portal¹¹.

The data must be spatially and temporally representative of the actual annual ambient conditions of the water body. Sample locations should be characteristic and representative of the main water mass or distinct hydrologic areas. With the exception of the data collected for those designated uses that require seasonally based data (e.g., whole body contact recreation, biological community data, and critical season dissolved oxygen), data should be distributed over at least three seasons, over two years, and should not be biased toward specific conditions (such as runoff, season, or hydrologic conditions).

Data meeting the following criteria will be accepted.

- Samples must be collected and analyzed under a Quality Assurance/Quality Control (QA/QC) protocol that follows the EPA requirements for quality assurance project plans.
- Samples must be analyzed following protocols that are consistent with the EPA or Standard Method procedures.
- All data submitted must be accompanied by a copy of the organization's QA/QC protocol and standard operating procedures.
- All data must be reported in standard units as recommended in the relevant approved methods.
- All data must be accompanied by precise sample location(s), preferably in either decimal degrees or Universal Transverse Mercator (UTM).
- All data must be received in a Microsoft Excel or compatible format.
- All data must have been collected within the requested period of record.

All readily available and acceptable data are uploaded into the department's Water Quality Assessment Database¹², where the data undergoes quality control checks prior to 303(d) or 305(b) assessment processes.

- Laboratory Analytical Support

Laboratories used:

- Department/U.S. Geological Survey Cooperative Fixed Station Network: U.S. Geological Survey Lab, Denver, Colorado
- Intensive Surveys: Varies, many are done by the department's Environmental Services Program
- Toxicity Testing of Effluents: Many commercial laboratories

¹⁰ http://www.epa.gov/storet/dw_home.html

¹¹ <http://www.waterqualitydata.us/>

¹² http://dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

- Biological Criteria for Aquatic Macroinvertebrates: department's Environmental Services Program and Missouri Department of Conservation
- Fish Tissue: EPA Region VII Laboratory, Kansas City, Kansas, and miscellaneous contract laboratories (Missouri Department of Conservation or U.S. Geological Survey's Columbia Environmental Research Center)
- Missouri State Operating Permit: Self-monitoring or commercial laboratories
- Department's Public Drinking Water Monitoring: department's Environmental Services Program and commercial laboratories¹³
- Other water quality studies: Many commercial laboratories

B. Sources of Water Quality Data

The following data sources are used by the department to aid in the compilation of the state's integrated report (previously the 305(b) report). Where quality assurance programs are deemed acceptable, additional sources would also be used to develop the state's Section 303(d) list.

These sources presently include, but are not limited to:

1. Fixed station water quality and sediment data collected and analyzed by the department's Environmental Services Program personnel.
2. Fixed station water quality data collected by the U.S. Geological Survey under contractual agreements with the department.
3. Fixed station water quality data collected by the U.S. Geological Survey under contractual agreements to agencies or organizations other than the department.
4. Fixed station water quality, sediment quality, and aquatic biological information collected by the U.S. Geological Survey under their National Stream Quality Accounting Network and the National Water Quality Assessment Monitoring Programs.
5. Fixed station raw water quality data collected by the Kansas City Water Services Department, the St. Louis City Water Company, the Missouri American Water Company (formerly St. Louis County Water Company), Springfield City Utilities, and Springfield's Department of Public Works.
6. Fixed station water quality data collected by the U.S. Army Corps of Engineers. The Kansas City, St. Louis, and Little Rock Corps Districts have monitoring programs for Corps-operated reservoirs in Missouri.
7. Fixed station water quality data collected by the Arkansas Department of Environmental Quality, the Kansas Department of Health and Environment, the Iowa Department of Natural Resources, and the Illinois Environmental Protection Agency.
8. Fixed station water quality monitoring by corporations.
9. Annual fish tissue monitoring programs by EPA/Department RAFT Monitoring Program and MDC.
10. Special water quality surveys conducted by the department. Most of these surveys are

¹³ For additional information visit: <http://dnr.mo.gov/env/wpp/labs/>

focused on the water quality impacts of specific point source wastewater discharges. Some surveys are of well-delimited nonpoint sources such as abandoned mined lands. These surveys often include physical habitat evaluation and monitoring of aquatic macroinvertebrates as well as water chemistry monitoring.

11. Special water quality surveys conducted by U.S. Geological Survey, including but not limited to:
 - a) Geology, hydrology and water quality of various hazardous waste sites,
 - b) Geology, hydrology and water quality of various abandoned mining areas,
 - c) Hydrology and water quality of urban nonpoint source runoff in metropolitan areas of Missouri (e.g. St. Louis, Kansas City, and Springfield), and
 - d) Bacterial and nutrient contamination of streams in southern Missouri.
12. Special water quality studies by other agencies such as MDC, the U.S. Public Health Service, and the Missouri Department of Health and Senior Services.
13. Monitoring of fish occurrence and distribution by MDC.
14. Fish Kill and Water Pollution Investigations Reports published by MDC.
15. Selected graduate research projects pertaining to water quality and/or aquatic biology.
16. Water quality, sediment, and aquatic biological data collected by the department, EPA or their contractors at hazardous waste sites in Missouri.
17. Self-monitoring of receiving streams by cities, sewer districts and industries, or contractors on their behalf, for those discharges that require this kind of monitoring. This monitoring includes chemical and sometimes toxicity monitoring of some of the larger wastewater discharges, particularly those that discharge to smaller streams and have the greatest potential to affect instream water quality.
18. Compliance monitoring of receiving waters by the department and EPA. This can include chemical and toxicity monitoring.
19. Bacterial monitoring of streams and lakes by county health departments, community lake associations, and other organizations using acceptable analytical methods.
20. Other monitoring activities done under a quality assurance project plan approved by the department.
21. Fixed station water quality and aquatic macroinvertebrate monitoring by volunteers who have successfully completed the Volunteer Water Quality Monitoring Program Level 2 workshop. Data collected by volunteers who have successfully completed a training Level 2 workshop is considered to be Data Code One. Data generated from Volunteer Training Levels 2, 3 and 4 are considered "screening" level data and can be useful in providing an indication of a water quality problem. For this reason, the data are eligible for use in distinguishing between waters in Categories 2A and 2B or Categories 3A and 3B. Most of this data are not used to place waters in main Categories (1, 2, 3, 4, and 5) because analytical procedures do not use EPA or Standard Methods or other department approved methods. Data from volunteers who have not yet completed a Level 2 training

workshop do not have sufficient quality assurance to be used for assessment. Data generated by volunteers while participating in the department's Cooperative Site Investigation Program (Section II C1) or other volunteer data that otherwise meets the quality assurance outlined in Section II C2 may be used in Section 303(d) assessment.

The following data sources (22-23) **cannot** be used to rate a water as impaired (Categories 4A, 4B, 4C or 5); however, these data sources may be used to direct additional monitoring that would allow a water quality assessment for Section 303(d) listing.

22. Fish Management Basin Plans published by MDC.
23. Fish Consumption Advisories published annually by the Missouri Department of Health and Senior Services. Note: the department may use data from data source listed as Number 9 above, to list individual waters as impaired due to contaminated fish tissue.

As previously stated, the department will review all data of acceptable quality that are submitted to the department prior to the first public notice of the draft 303(d) list. However, the department will reserve the right to review and use data of acceptable quality submitted after this date if the data results in a change to the assessment outcome of the water.

C. Data Quality Considerations

- DNR Quality Assurance/Quality Control Program

The department and EPA Region VII have completed a Quality Management Plan. All environmental data generated directly by the department, or through contracts funded by the department, or EPA require a Quality Assurance Project Plan¹⁴. The agency or organization responsible for collecting and/or analyzing environmental data must write and adhere to a Quality Assurance Project Plan approved through the department's Quality Management Plan. Any environmental data generated via a monitoring plan with a department approved Quality Assurance Project Plan are considered suitable for use in water quality assessment and the 303(d) listing. This includes data generated by volunteers participating in the department's CSI Program. Under this program, the department's Environmental Services Program will audit select laboratories. Laboratories that pass this audit will be approved for the CSI Program. Individual volunteers who collect field samples and deliver them to an approved laboratory must first successfully complete department training on how to properly collect and handle environmental samples. The types of information that will allow the department to make a judgment on the acceptability of a quality assurance program are: (1) a description of the training, and work experience of the persons involved in the program, (2) a description of the field meters and maintenance and calibration procedures, (3) a description of sample collection and handling procedures, and (4) a description of all analytical methods used in the laboratory for analysis.

¹⁴ For additional information visit: <http://www.epa.gov/quality/qapps.html>

- Other Quality Assurance/Quality Control Programs

Data generated in the absence of a department-approved Quality Assurance Project Plan may be used to assess a water body if the department determines that the data are adequate after reviewing and accepting the quality assurance procedures plan used by the data generator. This review would include: (1) names of all persons involved in the monitoring program, their duties, and a description of their training and work related experience, (2) all written procedures, Standard Operating Procedures, or Quality Assurance Project Plans pertaining to this monitoring effort, (3) a description of all field methods used, brand names and model numbers of any equipment, and a description of calibration and maintenance procedures, and (4) a description of laboratory analytical methods. This review may also include an audit by the department's Environmental Services Program.

- Data Qualifiers

Data qualifiers will be handled in different ways depending upon the qualifier, the analytical detection limit, and the numeric WQS.

- Less Than Qualifier "<" – For this qualifier the department will use half of the reported less than value. Unless circumstances cause issues with assessment. Examples of this include but are not limited to:
 - Less than values for bacteria. Since we calculate a geometric mean any value less than 1.0 could cause the data to be skewed if using the geometric mean calculation method of multiplying the values then dividing by the nth root.
 - Less than values below the criterion but still close to the criterion, less than values that are above the criterion. In these cases the department will not use the data for assessments.
- Non-detection Qualifier "ND" – The department treats these same as less than ("<") qualifiers, with the exception that a value is not reported. For these cases the department will use the method detection limit as the reported less than value.
- Greater Than Qualifier ">" – The department will only consider data with these qualifiers for assessments when it pertains to bacteria. In the cases of bacteria data the reported greater than (">") value is doubled then used in the assessment calculation. In circumstances where this practice is the sole reason for impairment then the greater than value(s) will be used at the reported value (i.e. not doubled) in the assessment calculation.
- Estimated Values "E" – These values are usually characterized as being above the laboratory quantification limit but below the laboratory reporting limit and are thus reported as estimated ("E"). Sometimes bacteria values are reported as estimated ("E") at the high end and due to the particular method used for analysis this usually means a dilution of the sample was used because the true bacteria count is higher than the method reporting maximum. The department will not use estimated ("E") values if the value reported is near the criterion. If the value is well above or well below the criterion then it will be used in assessments.

- Data Age

For assessing present conditions, more recent data are preferable; however, older data may be used to assess present conditions if the data remains representative of present conditions.

- If the department uses data older than seven years to make a Section 303(d) list decision a written justification for the use of such data will be provided.
- If a water body has not been listed previously and all data indicating an impairment is older than 7 years, then the water body shall be placed into Category 2B or 3B and prioritized for future sampling.
- A second consideration is the age of the data relative to significant events that may have an effect on water quality. Data collected prior to the initiation, closure, or significant change in a wastewater discharge, or prior to a large spill event or the reclamation of a mining or hazardous waste site, for example, may not be representative of present conditions. Such data would not be used to assess present conditions even if it was less than seven years old. Such “pre-event” data can be used to determine changes in water quality before and after the event or to show water quality trends.

- Data Type, Amount and Information Content

EPA recommends establishing a series of data codes, and rating data quality by the kind and amount of data present at a particular location ([EPA 1997¹⁵](#)). The codes are single-digit numbers from one to four, indicating the relative degree of assurance the user has in the value of a particular environmental data set. Data Code One indicates the least assurance or the least number of samples or analytes and Data Code Four the greatest. Based on EPA’s guidance, the department uses the following rules to assign code numbers to data.

- Data Code¹⁶ One: All data not meeting the requirements of the other data codes.
- Data Code Two: Chemical data collected quarterly to bimonthly for at least three years, or intensive studies that monitor several nearby sites repeatedly over short periods of time, or at least three composite or plug fish tissue samples per water body, or at least five bacterial samples collected during the recreational season of one calendar year.

¹⁵ *Guidelines for the Preparation of the Comprehensive State Water Quality Assessments (305b) and Electronic Updates*, 1997. (<http://water.epa.gov/type/watersheds/monitoring/repguid.cfm>)

¹⁶ Data Code One is equivalent to data water quality assurance Level One in 10 CSR 20-7.050 General Methodology for Development of Impaired Waters List, subsection (2)(C), Data Code Two is equivalent to Level 2, etc.

- Data Code Three: Chemical data collected at least monthly for more than three years on a variety of water quality constituents including heavy metals and pesticides; or a minimum of one quantitative biological monitoring study of at least one aquatic assemblage (fish, macroinvertebrates, or algae) at multiple sites, multiple seasons (spring and fall), or multiple samples at a single site when data from that site is supported by biological monitoring at an appropriate control site.
- Data Code Four: Chemical data collected at least monthly for more than three years that provides data on a variety of water quality constituents including heavy metals and pesticides, and including chemical sampling of sediments and fish tissue; or a minimum of one quantitative biological monitoring study of at least two aquatic assemblages (fish, macroinvertebrates, or algae) at multiple sites.

In Missouri, the primary purpose of Data Code One data is to provide a rapid and inexpensive method of screening large numbers of waters for obvious water quality problems and to determine where more intensive monitoring is needed. In the preparation of the state's Integrated Report, data from all four data quality levels are used. Most of the data is of Data Code One quality, and without Data Code One data, the department would not be able to assess a majority of the state's waters.

In general, when selecting water bodies for the Missouri 303(d) List, only Data Code Two or higher are used, unless the problem can be accurately characterized by Data Code One data.¹⁷ The reason is that Data Code Two data provides a higher level of assurance that a Water Quality Standard is not actually being attained and that a TMDL study is necessary. All water bodies placed in Categories 2 or 3 receive high priority for additional monitoring so that data quality is upgraded to at least Data Code Two. Category 2B and 3B waters will be given higher priority than Categories 2A and 3A.

EPA suggests that states use these codes as a way of describing the type of information collected, the frequency of collection, spatial/temporal coverage, and quality. Missouri has followed this guidance for the most part, but where Missouri differs is that we use the data codes to explain the type of information collected, the frequency it is collected, and the spatial/temporal coverage. For data quality the department reviews the data on a project specific basis and looks at the laboratory analysis and collection methods used to generate the data. If the data is of acceptable quality we mark the project and all of its underlying data as QA acceptable. We should only be using QA acceptable data for assessments, unless that data provides additional corroboration of impairment or attainment status.

¹⁷ When a listing, amendment or delisting of a 303(d) water is made with only Data Code One data, a document will be prepared that includes a display of all data and a presentation of all statistical tests or other evaluative techniques that documents the scientific defensibility of the data. This requirement applies to all Data Code One data identified in Appendix B of this document.

- Dissolved Oxygen and Flow

Dissolved oxygen in streams is highly dependent on flow. For the assessment of streams dissolved oxygen measurements must be accompanied by a flow measurement taken on the same day as the dissolved oxygen measurement. The dissolved oxygen measurements must also be collected from the flowing portion of the stream and must not be influenced by flooding or backwater conditions.

- pH Data Considerations

The criterion for pH will be clarified at some point in the Missouri WQS as a chronic criterion. Assessment will be handled in the following ways:

- Continuous Sampling (i.e. time series or sonde data collection)
 - Data collected in a time series fashion will be looked at on a 4 day period. If an entire 4 day period is outside of the 6.5 – 9.0 criterion range that will count as a chronic toxicity event. More than one of these events will constitute an impairment listing of the stream.
- Grab Samples
 - Data collected as grab samples will be treated as is and the binomial probability calculation will be used for assessment. See Appendix D for further information.

D. How Water Quality Data is Evaluated to Determine Whether or Not Waters are Impaired for 303(d) Listing Purposes

I. Physical, Chemical, Biological and Toxicity Data

During each reporting cycle, the department and stakeholders review and revise the guidelines for determining water quality impairment. The guidelines shown in Appendix B & C provide the general rules of data use and assessment and Appendix D provides details about the specific analytical procedure used. In addition, if trend analysis indicates that presently unimpaired waters will become impaired prior to the next listing cycle, these “threatened waters” will be judged as impaired. Where antidegradation provisions in Missouri’s Water Quality Standards apply, those provisions shall be upheld. The numerical criteria included in Appendix B have been adopted into the state water quality standards, 10 CSR 20-7.031, and are used, as described in Appendix B to make use attainment decisions.

II. Weight of Evidence Approach

When evaluating narrative criteria described in the state water quality standards, 10 CSR 20-7.031, the department will use a weight of evidence analysis for assessing numerical translators that have not been adopted into state water quality standards (see Appendix C). Under the weight of evidence approach, all available information is examined and the greatest weight is given to data providing the “best supporting evidence” for an attainment decision. Determination of “best supporting evidence” will be made using best professional judgment, considering factors such as data quality, and site-specific

environmental conditions. For those analytes with numeric thresholds, the threshold values given in Appendix C will trigger a weight of evidence analysis to determine the existence or likelihood of a use impairment and the appropriateness of proposing a 303(d) listing based on narrative criteria. This weight of evidence analysis will include the use of other types of environmental data when it is available or collection of additional data to make the most informed use attainment decision. Examples of other relevant environmental data might include physical or chemical data, biological data on fish [Fish Index of Biotic Integrity (fIBI)] or aquatic macroinvertebrate [Macroinvertebrate Stream Condition Index (MSCI)] scores, fish tissue, or toxicity testing of water or sediments.

Biological data will be given greater weight in a weight of evidence analysis for making attainment decisions for aquatic life use and subsequent Section 303(d) listings. Whether or not numeric translators of biological criteria are met is a strong indicator for the attainment of aquatic life use. Moreover, the department retains a high degree of confidence in an attainment decision based on biological data that is representative of water quality condition.

When the weight of evidence analysis suggests, but does not provide strong scientifically valid evidence of impairment, the department will place the water body in question in Categories 2B or 3B. The department will produce a document showing all relevant data and the rationale for the attainment decision. All such documents will be available to the public at the time of the first public notice of the proposed 303(d) list. A final recommendation on the listing of a water body based on narrative criteria will only be made after full consideration of all comments on the proposed list.

III. Biological Data

Methods for assessing biological data typically receive considerable attention during the public comment period of development of the Listing Methodology Document. Currently, a defined set of biocriteria¹⁸ are used to evaluate biological data for assessing compliance with water quality standards. These biological criteria contain numeric thresholds, that when exceeded relative to prescribed assessment methods, serve as a basis for identifying candidate waters for Section 303(d) listing. Biocriteria are based on three types of biological data, including: (1) aquatic macroinvertebrate community data; (2) fish community data; and, (3) a catch-all class referred to as “other biological data.”

In general, for interpretation of macroinvertebrate data where Stream Habitat Assessment Project Procedure (SHAPP) (MDNR 2016b) assessment scores indicate habitat is less than 75 percent of reference or appropriate control stream scores, and in the absence of other data indicating impairment by a discrete pollutant, a water body judged to be impaired will be placed in Category 4C. When interpreting fish community data, a

¹⁸ This refers to Missouri’s Water Quality Standards (10 CSR 20-7.031) Section 5 (Specific Criteria) (R) (Biocriteria). Although the Department uses the term “criteria” in association with biological metrics and indices throughout this document, numeric biological criteria have not been promulgated in the rule. This document uses the developed numerical biological metrics and indices as translators for the Biocriteria portion of 10 CSR 20-7.031(5)(R) [3/31/2018].

provisional multi-metric habitat index called the QCPH1 index is used to identify stream habitat in poor condition. The QCPH1 index separates adequate habitat from poor habitat using a 0.39 threshold value; whereby, QCPH1 scores < 0.39 indicate stream habitat is of poor quality, and scores greater than 0.39 indicate available stream habitat is adequate. In the absence of other data indicating impairment by a discrete pollutant, impaired fish communities with poor habitat will be placed in Category 4C. Additional information about QCPH1 is provided in the *Considerations for the Influence of Habitat Quality and Sample Representativeness* section.

The sections below describe the methods used to evaluate the three types of biological data (macroinvertebrate community, fish community, and other biological data), along with background information on the development and scoring of biological criteria, procedures for assessing biological data, methods used to ensure sample representativeness, and additional information used to aid in assessing biological data such as the weight of evidence approach.

Aquatic Macroinvertebrate Community Data

The department conducts aquatic macroinvertebrate assessments to determine macroinvertebrate community health as a function of water quality and habitat. The health of a macroinvertebrate community is directly related to water quality and habitat. Almost all macroinvertebrate evaluation consists of comparing the health of the community of the “target” to healthy macroinvertebrate communities from reference streams of the same general size and usually in the same Ecological Drainage Unit (EDU).

The department’s approach to monitoring and evaluating aquatic macroinvertebrates is largely based on *Biological Criteria for Wadeable/Perennial Streams of Missouri* (MDNR 2002). This document provides the framework for numerical biological criteria (biocriteria) relevant to the protection of aquatic life use for wadeable streams in the state. Biocriteria were developed using wadeable reference streams that occur in specific EDUs as mapped by the Missouri Resource Assessment Partnership (reference Figure 1 below). For macroinvertebrates, the numerical biocriterion translator is expressed as a multiple metric index referred to as the MSCI. The MSCI includes four metrics: Taxa Richness (TR); Ephemeroptera, Plecoptera, and Trichoptera Taxa (EPTT); Biotic Index (BI); and the Shannon Diversity Index (SDI). These metrics are considered indicators of stream health, and change predictably in response to the environmental condition of a stream.

Metric values are determined directly from macroinvertebrate sampling. To calculate the MSCI, each metric is normalized to unitless values of 5, 3, or 1, which are then added together for a total possible score of 20. MSCI scores are divided into three levels of stream condition:

Unitless metric values (5, 3, or 1) were developed from the lower quartile of the distribution of each metric as calculated from reference streams for each EDU. The lower quartile (25th percentile) of each metric equates to the minimum value still representative of unimpaired conditions. In operational assessments, metric values below the lower quartile of reference conditions are typically judged as impaired (United States Environmental Protection Agency 1996, Ohio Environmental Protection Agency 1990, Barbour *et al.* 1996). Moreover, using the 25th percentile of reference conditions for each metric as a standard for impairment allows natural variability to be filtered out. For metrics with values that decrease with increasing impairment (TR, EPTT, SDI), any value above the lower quartile of the reference distribution receives a score of five. For the BI, whose value increases with increasing impairment, any value below the upper quartile (75th percentile) of the reference distribution receives a score of five. The remainder of each metric's potential quartile range below the lower quartile is bisected, and scored either a three or a one. If the metric value is less than or equal to the quartile value and greater than the bisection value it is scored a three. If the metric value is less than or equal to the bisection value it is scored a one.

MSCI scores meeting data quality considerations may be assessed for the protection of aquatic life using the following procedures.

Determining Full Attainment of Aquatic Life Use:

- For seven or fewer samples, 75% of the MSCI scores must be 16 or greater. Fauna achieving these scores are considered to be very similar to biocriteria reference streams.
- For eight or more samples, results must be statistically similar to representative reference or control streams.

Determining Non-Attainment of Aquatic Life Use:

- For seven or fewer samples, 75% of the MSCI scores must be 14 or lower. Fauna achieving these scores are considered to be substantially different from biocriteria reference streams.
- For eight or more samples, results must be statistically dissimilar to representative reference or control streams.

Data will be judged inconclusive when outcomes do not meet requirements for decisions of full or non-attainment.

As noted, when eight or more samples are available, results must be statistically similar or dissimilar to reference or control conditions in order to make an attainment decision. To accomplish this, a binomial probability with an appropriate level of significance (α =alpha), is calculated based on the null hypothesis that the test stream would have a similar percentage of MSCI scores that are 16 or greater as reference streams. The significance level is set at $\alpha=0.1$, meaning if the p-value of the hypothesis test is less than α , the hypothesis is considered statistically significant. The significance level of α is in fact the probability of making a wrong

decision and committing a Type I error (rejecting a true null hypothesis). When the Type I error rate is less than $\alpha=0.1$, the null hypothesis is rejected. Inversely, when the Type I error rate is greater than $\alpha=0.1$, the null hypothesis is accepted. For comparing samples from a test stream to samples collected from reference streams in the same EDU, the percentage of samples from reference streams scoring 16 or greater is used to determine the probability of “success” and “failure” in the binomial probability equation. For example, if 84% of the reference stream MSCI scores in a particular EDU are 16 or greater, then 0.84 would be used as the probability of success and 0.16 would be used as the probability of failure. Note that Appendix D states to “rate a stream as impaired if biological criteria reference stream frequency of fully biologically supporting scores is greater than five percent more than the test stream,” thus, a value of 0.79 (0.84 - 0.05) would actually be used as the probability of success in the binomial distribution equation.

Binomial Probability Example:

Reference streams from the Ozark/Gasconade EDU classified as riffle/pool stream types with warm water temperature regimes produce fully biologically supporting streams 85.7% of the time. In the test stream of interest, six out of ten samples resulted in MSCI scores of 16 or more. Calculate the Type I error rate for the probability of getting six or fewer fully biologically supporting scores in ten samples.

The binomial probability formula may be summarized as:

$$p^n + (n! / X!(n-X)! * p^X q^{n-X}) = 1$$

Where,

Sample Size (n) = 10

Number of Successes (X) = 6

Probability of Success (p) = 0.857 - 0.05 = 0.807

Probability of Failure (q) = 0.193

Excel has the BINOM.DIST function that will perform this calculation.

=BINOM.DIST(number_s, trials, probability_s, cumulative)

=BINOM.DIST(6, 10, 0.807, TRUE)

Using Excel's Binomial Function	
Probability of Success	0.807
Sample Size	10
# of Successes	6
Type 1 Error Rate	0.109

Since 0.109 is greater than the test significance level (minimum allowable Type I error rate) of $\alpha=0.1$, we accept the null hypothesis that the test stream has the same percent of fully biologically supporting scores as the same type of reference streams from the Ozark/Gasconade EDU. Thus, this test stream would be judged as unimpaired.

If under the same scenario, there were only 5 samples from the test stream with MSCI scores of 16 or greater, the Type I error rate would change to 0.028, and since this value is less than the significance level of $\alpha=0.1$, the stream would be judged as impaired.

Within each EDU, MSCI scores are categorized by sampling regime (Glide/Pool vs. Riffle/Pool) and temperature regime (warm water vs. cold water). The percentage of fully biologically supporting scores for the Mississippi River Alluvial Basin/Black/Cache EDU is not available due to the lack of reference sites in this region. Percentages of fully biologically supporting samples per EDU is not included here, but can be made available upon request. The percentage of reference streams per EDU that are fully biologically supporting may change periodically as additional macroinvertebrate samples are collected and processed from reference samples within an EDU.

Sample Representativeness

The departments field and laboratory methods used to collect and process macroinvertebrate samples are contained in the document *Semi-Quantitative Macroinvertebrate Stream Bioassessment* (MDNR 2015). Macroinvertebrates are identified to levels following standard operating procedures contained in *Taxonomic Levels for Macroinvertebrate Identifications* (MDNR 2016b). Macroinvertebrate monitoring is accompanied by physical habitat evaluations as described in the document *Stream Habitat Assessment* (MDNR 2016a). For the assessment of macroinvertebrate samples, available information must meet data code levels three and four as described in Section II.C of this LMD. Data coded as levels three and four represent environmental data providing the greatest degree of assurance. Thus, at a minimum, macroinvertebrate assessments include multiple samples from a single site, or samples from multiple sites within a single reach.

It is important to avoid situations where poor or inadequate habitat prohibits macroinvertebrate communities from being assessed as fully biologically supporting. Therefore, when assessing macroinvertebrate samples, the quality of available habitat must be similar to that of reference streams within the appropriate EDU. The department's policy for addressing this concern has been to exclude MSCI scores from an assessment when accompanying habitat scores are less than 75 percent of the mean habitat scores from reference streams of the appropriate EDU. The following procedures outline the department's method for assessing macroinvertebrate communities from sites with poor or inadequate habitat.

Assessing Macroinvertebrate Communities from Poor/Inadequate Habitat:

- If less than half the macroinvertebrate samples in an assessed stream segment have habitat scores less than 75 percent of the mean score for reference streams in that EDU, any sample that scores less than 16 and has a habitat score less than 75 percent of the mean reference stream score for that EDU, is excluded from the assessment process.
- If at least half the macroinvertebrate samples in an assessed stream segment have habitat scores less than 75 percent of the mean score for reference streams in that EDU and the assessment results in a judgment that the macroinvertebrate community is impaired, the assessed segment will be placed in Category 4C impairment due to poor aquatic habitat.
 - If one portion of the assessment reach contains two or more samples with habitat scores less than 75 percent of reference streams from that EDU while the remaining portion does not, the portion of the stream with poor habitat scores could be separately assessed as a category 4C stream permitting low MSCI scores.

Macroinvertebrate sampling methods vary by stream type. One method is used in riffle/pool predominant streams, and the other method is for glide/pool predominant streams. For each stream type, macroinvertebrate sampling targets three habitats.

- For riffle/pool streams, the three habitats sampled are flowing water over coarse substrate, non-flowing water over depositional substrate, and rootmat substrate.
- For glide/pool streams, the three habitats sampled are non-flowing water over depositional substrate, large woody debris substrate, and rootmat substrate.

In some instances, one or more of the habitats sampled can be limited or missing from a stream reach, which may affect an MSCI score. Macroinvertebrate samples based on only two habitats may have an MSCI score equal to or greater than 16, but it is also possible that a missing habitat may lead to a decreased MSCI score. Although MDNR stream habitat assessment procedures take into account a number of physical habitat parameters from the sample reach (for example, riparian vegetation width, channel alteration, bank stability, bank vegetation protection, etc.), they do not exclusively measure the quality or quantity of the three predominant habitats from each stream. When evaluating potentially impaired macroinvertebrate communities, the number of habitats sampled, in addition to the stream habitat assessment score, will be considered to ensure MSCI scores less than 16 are properly attributed to poor water quality or poor/inadequate habitat condition.

Biologists responsible for conducting biological assessments will determine the extent to which habitat availability is responsible for a non-supporting (<16) MSCI score. If it is apparent that a non-supporting MSCI score was due to limited habitat, these effects will be stated in the biological assessment report. This limitation will then be considered when deciding which Listing Methodology category is most appropriate for an individual stream. This procedure, as part of an MDNR biological assessment, will aid in determining whether

impaired macroinvertebrate samples have MSCI scores based on poor water quality conditions versus habitat limitations.

To ensure assessments are based on representative macroinvertebrate samples, samples collected during or shortly after prolonged drought, shortly after major flood events, or any other conditions that fall outside the range of environmental conditions under which reference streams in the EDU were sampled, will not be used to make an attainment decision for a Section 303(d) listing or any other water quality assessment purposes. Sample “representativeness” is judged by Water Protection Program (WPP) staff after reading the biomonitoring report for that stream, and if needed, consultation with biologists from the department’s Environmental Services Program. Regarding smaller deviations from “normal” conditions, roughly 20 percent of reference samples failing to meet a fully biologically supporting MSCI score were collected following weather/climate extremes; as a result, biological criteria for a given EDU are inclusive of samples collected during not only ideal macroinvertebrate-rearing conditions, but also during the weather extremes that Missouri experiences.

Assessing Small Streams

Occasionally, macroinvertebrate monitoring is needed to assess streams smaller than the typical wadeable/perennial reference streams listed in Table I of Missouri’s Water Quality Standards. Smaller streams may include Class C streams (streams that may cease flow in dry periods but maintain permanent pools which support aquatic life) or those that are unclassified. Assessing small streams involves comparing test stream and candidate reference stream MSCI scores first, to Wadeable/Perennial Reference Stream (WPRS) criteria, and second to each other.

In MDNR’s Biological Criteria Database, there are 16 candidate reference streams labeled as Class P, 23 labeled as Class C, and 24 labeled as Class U. In previous work by MDNR, when the MSCI was calculated according to WPRS criteria, the failure rate for such candidate reference streams was 31% for Class P, 39% for Class C, and 70% for Class U. The data trend showed a higher failure rate for increasingly smaller high quality streams when scored using WPRS biological criteria. This trend demonstrates the need to include the utilization of candidate reference streams in biological stream assessments.

Prior to the 2014 revision of the Missouri Water Quality Standards there was no size classification for streams. The 2014 revision codified size classification for rivers and streams based on five size categories for Warm Water, Cool Water and Cold Water Habitats. The size classifications are defined as Headwater, Creek, Small River, Large River and Great River. Water permanence continues to be classified as Class P (streams that maintain permanent flow even in drought periods); Class C (streams that cease flow in dry periods but maintain permanent pools which support aquatic life); and the newly adopted Class E (streams that do not maintain permanent surface flow or pools, but have surface flow or pools in response to precipitation events).

Table I of Missouri's Water Quality Standards lists 62 wadeable/perennial reference streams that provide the current basis for numeric biological criteria. Wadeable/perennial reference streams are a composite of Creek and Small River size classes. Interpretation of Creek (Size Code 2) and Small River (Size Code 3) is based on the Missouri Resource Assessment Partnership Shreve Link number found in Table 2. These wadeable/perennial reference streams were selected previous to the 2014 revision of the Missouri Water Quality Standards and were based on the former Table H (Stream Classifications and Use Designations). All, or a portion, of seven wadeable/perennial reference streams are Class C; and all, or a portion, of 57 wadeable/perennial reference streams are Class P.

As part of the 2014 revision of the Missouri Water Quality Standards, classified streams were changed from Table H to a modified version of the 1:100,000 National Hydrography Dataset. This dataset provides a geospatial framework for classified streams and is referred to as the Missouri Use Designation Dataset (MUDD). The streams and rivers now listed in MUDD contain approximately 100,000 miles of newly classified streams, many of which are the Headwater size class. Interpretation of Headwater size (Size Code 1) is based on the Missouri Resource Assessment Partnership Shreve Link number found in Table 2

Table 2.
Missouri Resource Assessment Partnership Shreve Link Number for Stream Size Code

Stream Size	Size Code	Plains Shreve Link Number	Ozark Shreve Link Number
Headwater	1	1-2	1-4
Creek	2	3-30	5-50
Small River	3	31-700	51-450
Large River	4	701-maximum	451- maximum
Great River	5	Missouri & Mississippi	Missouri & Mississippi
Unknown	0		

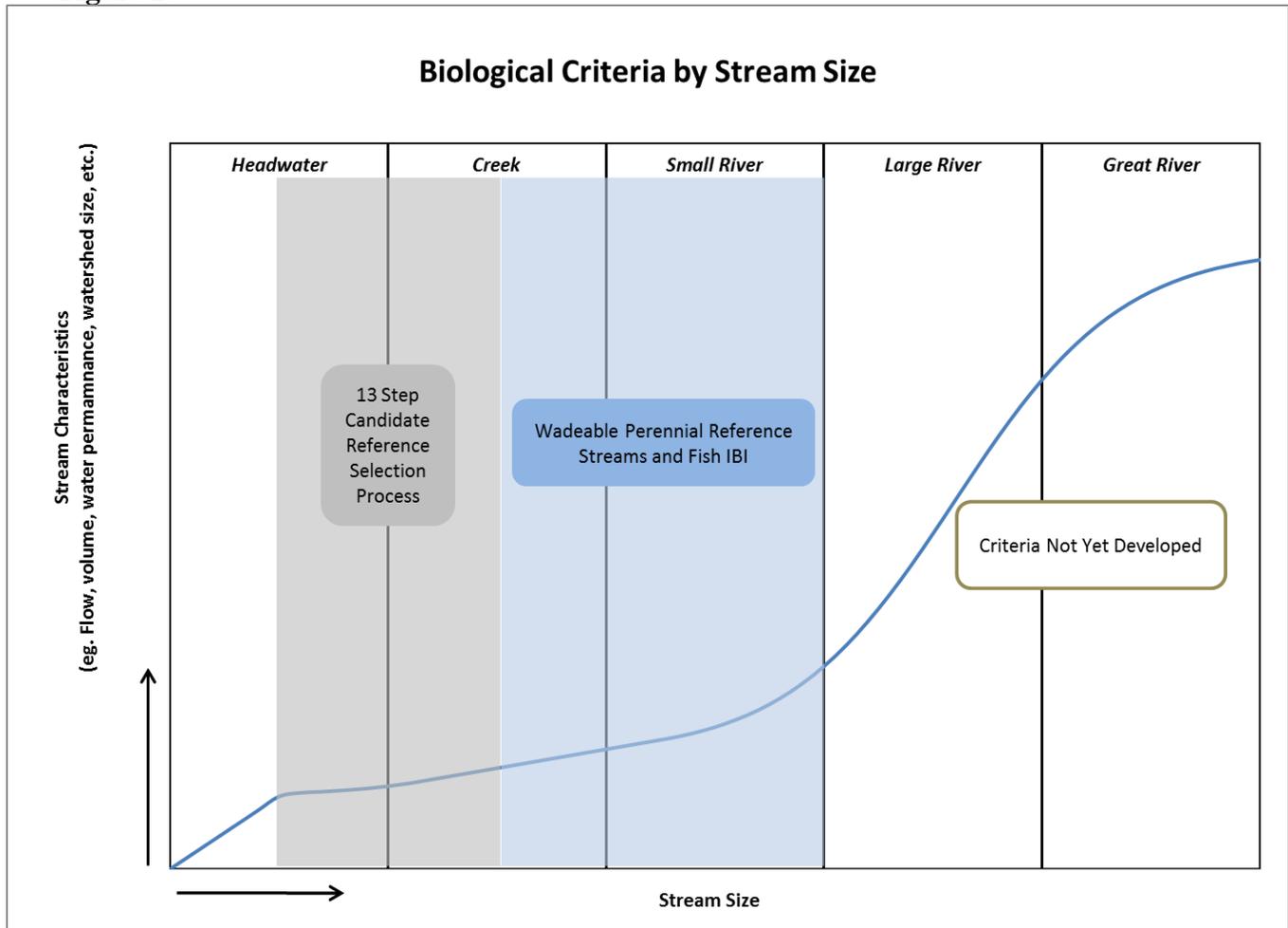
In natural channels, biological assessments will be based on criteria established from comparable stream size and permanence. The need for alternate criteria is supported by the higher failure rate (70%) for small size streams when scored using wadeable/perennial reference stream biological criteria (MDNR, unpublished data). The 2014 revision of Missouri's Water Quality Standards codified size classification for rivers and streams based on five size categories for Warm Water, Cool Water and Cold Water Habitats. The size classifications are defined as Headwater, Creek, Small River, Large River and Great River.

Biological criteria have not been established for the size categories of Great River, Large River, or Headwater. Current WPRS criteria and the MDC fIBI metrics apply to Creek and Small River size categories. MDC fIBI metrics apply only in the Ozarks ecoregion.

Since headwater stream biological criteria have not been established, the utilization of candidate headwater reference streams and draft criteria will be necessary to perform

biological stream assessments of headwater size streams until scientifically defensible criteria have been developed.

Figure 2.



For test streams that are smaller than wadeable perennial reference streams, MDNR samples five candidate reference streams of same or similar size and Valley Segment Type (VST) in the same EDU twice during the same year the test stream is sampled (additional information about the selection small control streams is provided below). Although in most cases the MDNR samples small candidate reference streams concurrently with test streams, existing data may be used if a robust candidate reference stream data set exists for the EDU.

If the ten small candidate reference stream scores are similar to wadeable perennial reference stream criteria, then they and the test stream are considered to have a Class C or

Class P general warm water beneficial use, and the MSCI scoring system in the LMD should be used. If the small candidate reference streams have scores lower than the wadeable perennial reference streams, the assumption is that the small candidate reference streams, and the test stream, represent designated uses related to stream size that are not yet approved by EPA in the state's water quality standards. The current assessment method for test streams that are smaller than reference streams is stated below.

- If 75% of the ten candidate reference stream scores are 16 or greater when compared to WPRS criteria, then the test stream will be assessed using MSCI based procedures in the LMD.
- If 75% of the ten candidate reference stream scores are below 16 when compared to WPRS criteria then:
 - a) The test stream will be judged “unimpaired” if test stream scores meet criteria developed from the candidate reference stream scores. If 75% of the test stream scores are 16 or greater when compared to criteria developed from the candidate reference streams, the stream will be judged “unimpaired”.
 - b) The test stream will be assessed as having an “impaired” macroinvertebrate community if test stream scores do not meet criteria developed from the candidate reference stream scores. If 75% of the test stream scores are below 16 when compared to criteria developed from the candidate reference streams, the stream will be judged “impaired”.
 - c) The test stream will be judged “inconclusive” if the requirements in a) and b) are not met.

All work will be documented on the macroinvertebrate assessment worksheet and be made available during the public notice period.

Selecting Small Candidate Reference Streams

Accurately assessing streams that are smaller than reference streams begins with properly selecting small candidate reference streams. Candidate reference streams are smaller than WPRS streams and have been identified as “best available” reference stream segments in the same EDU as the test stream according to watershed, riparian, and in-channel conditions. The selection of candidate reference streams is consistent with framework provided by Hughes *et al.* (1986) with added requirements that candidate reference streams must be from the same EDU and have the same or similar values for VST parameters. If candidate reference streams perform well when compared to WPRS, then test streams of similar size and VST are expected to do so as well. VST parameters important for selection are based on temperature, stream size, flow, geology, and relative gradient, with emphasis placed on the first three parameters.

The stepwise process for candidate reference stream selection is listed below. Documentation of the steps in this process will be available upon request and will include but are not limited to: GIS layers used, segment IDs eliminated at the various steps, candidate stream list for field verification, etc.

1. Determine test stream reaches to be assessed. *Missouri Department of Natural Resources staff in the Water Protection Program's Monitoring and Assessment Unit will use data that indicates potential impairment to determine where additional studies are needed. Department staff with the Environmental Services Program's Aquatic Bioassessment Unit will be used to conduct studies requested by the WPP.*
2. Identify appropriate EDU. *The Ecological Drainage Unit in which the test stream is located will be identified so that applicable biological criteria can be used to score macroinvertebrate data collected by Department biologists.*
3. Determine five variable VST of test stream segments (1st digit = temperature; 2nd digit = size; 3rd digit = flow; 4th digit = geology; and 5th digit = relative gradient). *This five-digit VST code provides a description of the test stream for later use in selecting appropriate candidate reference streams that are similar to the test stream (giving temperature, size, and flow the highest importance).*
4. Filter all stream segments within the same EDU for the relevant five variable VSTs (1st and 2nd digits especially critical for small streams). *The five VST features of the test stream will be determined by checking the "AQUATIC.STRM_SEGMENTS" layer in GIS software (e.g. ArcMap). This layer has an associated Attribute Table that has, among many other features, the five-digit VST code for classified Missouri streams. During the filtering process, the five-digit code (listed as "VST_5VAR" in the Attribute Table) of the test stream is chosen in an ArcMap tool called "Select by Attributes." The five-digit code of the test stream is entered into this ArcMap tool, which can then be used to list only streams with the same five VST variables while excluding (i.e. "filtering out") all other streams with different variables.*
5. Filter all potential VST stream segments for stressors against available GIS layers (e.g. point sources, landfills, CAFOs, lakes, reservoirs, mining, etc.). *A GIS layer that includes the stream segments selected in Step 4 will be created. The proximity of these selected stream layers will be evaluated relative to stressor layers cataloged in GIS using filtering steps similar to those described above. Stream segments with stressors having documented impacts will be eliminated from further consideration. The presence of a single potential stressor will not automatically lead to a stream reach being rejected; rather, the aggregate of potential stressors in a watershed will be evaluated.*
6. Filter all potential VST stream segments against historical reports and databases. *Past accounts of occurrences that may result in a stream failing to meet the "best available, least impaired" criteria will be evaluated. These incidents may include events such as*

fish kills, combined sewer overflows, or past environmental emergencies (e.g. releases of toxic substances). Exceptions can be made when the cause of the incident no longer exists and there are no lingering effects. In contrast, historical reports may also include studies by other biologists that support the use of a stream segment as a candidate reference stream.

7. Calculate land use categories of candidate reference streams (e.g. percentage of forest, grassland, impervious surface, etc.) in GIS mapping software using available land cover datasets (Sources of land use data that are currently used are NLCD 2011 and MoRAP 2005¹⁹). Candidate reference streams with the same or similar AES type as the test stream (within the EDU) will be given preference throughout the selection process. In addition, candidate reference streams should also be chosen from candidate reference stream watersheds whose land use composition is representative of test stream's AES, and generally representative of EDU land uses. Candidate reference stream watersheds will be excluded if impervious area covers greater than 10% of the watershed area (*Center for Watershed Protection, 2003*).

8. Develop candidate stream list with coordinates for field verification.

9. Field verify candidate list for actual use (e.g. animal grazing, in-stream habitat, riparian habitat), migration barriers (e.g. culverts, low water bridge crossings) representativeness, (gravel mining, and other obvious human stressors). *Biologists can make additional fine-scale adjustments to the list of candidate streams by visiting sites in person. Certain features visible on-site may have been missed with GIS and other computer based filtering. Stream flow must be field verified to be similar to test streams.*

10. *Of the sites remaining after field verification and elimination, at least five of the top ranked candidate sites will be subjected to additional evaluation outlined below.*

For steps 4-9: These steps occur at the EDU level identified in step 2. These steps look at all streams within the identified EDU including those in the same Aquatic Ecological System (AES) Type as the test stream. Streams in the same AES Type as the test stream (within the identified EDU) will be given preference and be selected to go through the remaining steps (10-13) below.

11. Collect chemical, biological, habitat, and possibly sediment field data. *Collection of physical samples is the ultimate manner in which the quality of a stream is judged. Although factors evaluated in the previous steps are good indicators of whether a stream is of reference quality, it is the evaluation of chemical, physical and biological attributes in relation to other candidate reference streams that is the final determinant. If chemical*

¹⁹ Missouri Resource Assessment Partnership 2005 Landcover project. <https://morap.missouri.edu/index.php/land-cover/>

sampling documents an exceedance of water quality standards, the candidate reference stream will be eliminated from consideration.

12. After multiple sampling events evaluate recent field data against available historical chemical, physical, biological, and land use data from each corresponding candidate reference stream. *Aquatic systems are subject to fluctuation due to weather, stream flow, and other climatic conditions. Land use in the watershed of a candidate reference also can change over time. It is therefore important to compare recent data to available historical data to evaluate if watershed conditions have changed over time. If this evaluation indicates that the candidate reference stream conditions are similar to or have improved relative to historical conditions, they will be retained. If historical data are not available to make the comparisons, the candidate reference streams will be retained.*

13. If field data are satisfactory, retain candidate reference stream label in database. *Reference streams and candidate reference streams are labeled as such in a database maintained by the Department's Aquatic Bioassessment Unit in Jefferson City, Missouri*

Fish Community Data

The department utilizes fish community data to determine if aquatic life use is supported in certain types of Missouri streams. When properly evaluated, fish communities serve as important indicators of stream health. In Missouri, fish communities are surveyed by the MDC. MDC selects an aquatic subregion to sample each year, and therein, surveys randomly selected streams of 2nd to 5th order in size. Fish sampling follows procedures described in the document *Resource Assessment and Monitoring Program: Standard Operational Procedures--Fish Sampling* (Combes 2011). Numeric biocriteria for fish are represented by the fish Index of Biotic Integrity (fIBI). Development of the fIBI is described in the document *Biological Criteria for Stream Fish Communities of Missouri* (Doisy *et al.* 2008).

The fIBI is a multi-metric index made up of nine individual metrics, which include:

- number (#) of native individuals;
- # of native darter species;
- # of native benthic species;
- # of native water column species;
- # of native minnow species;
- # of all native lithophilic species;
- percentage (%) of native insectivore cyprinid individuals;
- % of native sunfish individuals; and,
- % of the three top dominant species.

Values for each metric, as directly calculated from the fish community sample, are converted to unitless scores of 1, 3, or 5 according to criteria in Doisy *et al.* (2008). The fIBI is then calculated by adding these unitless values together for a total possible score of 45. Doisy *et al.* (2008) established an impairment threshold of 36 (where the 25th percentile of reference sites represented a score of 37), with values equal to or greater than 36 representing unimpaired communities, and values less than 36 representing impaired communities. For more information regarding fIBI scoring, please see Doisy *et al.* (2008).

Based on consultation between the department and MDC, the fIBI impairment threshold value of 36 was used as the numeric biocriterion translator for making an attainment decision for aquatic life (Appendix C). Work by Doisy *et al.* (2008) focused on streams 3rd to 5th order in size, and the fIBI was only validated for streams in the Ozark ecoregion, not for streams in the Central Plains and Mississippi Alluvial Basin. Therefore, when assessing streams with the fIBI, the index may only be applied to streams 3rd to 5th order in size from the Ozark ecoregion. Assessment procedures are outlined below.

Full Attainment

- For seven or fewer samples and following MDC RAM fish community protocols, 75% of fIBI scores must be 36 or greater. Fauna achieving these scores are considered to be very similar to Ozark reference streams.
- For eight or more samples, the percent of samples scoring 36 or greater must be statistically similar to representative reference or control streams. To determine statistical similarity, a binomial probability Type I error rate (0.1) is calculated based on the null hypothesis that the test stream would have the same percentage (75%) of fIBI scores greater than 36 as reference streams. If the Type I error rate is more than the significance level $\alpha=0.1$, the fish community would be rated as unimpaired.

Non-Attainment

- For seven or fewer samples and following MDC RAM fish community protocols, 75% of the fIBI scores must be lower than 36. Fauna achieving these scores are considered to be substantially different than regional reference streams.
- For eight or more samples, the percent of samples scoring 36 or less must be statistically dissimilar to representative reference or control streams. To determine statistical dissimilarity, a binomial probability Type I error rate is calculated based on the null hypothesis that the test stream would have the same percentage (75%) of fIBI scores greater than 36 as reference streams. If the Type I error rate is less than 0.1, the null hypothesis is rejected and the fish community would be rated as impaired.

Data will be judged inconclusive when outcomes do not meet requirements for decisions of full or non-attainment.

With the exception of two subtle differences, use of the binomial probability for fish community samples will follow the example provided for macroinvertebrate samples in the previous section. First, instead of test stream samples being compared to reference streams of the same EDU, they will be compared to reference streams from the Ozark ecoregion. Secondly, the probability of success used in the binomial distribution equation will always be set to 0.70 since Appendix D states to “rate a stream as impaired if biological criteria reference stream frequency of fully biologically supporting scores is greater than five percent more than the test stream.”

Although 1st and 2nd order stream data will not be used to judge a stream as impaired for Section 303(d) purposes, the department may use the above assessment procedures to judge 1st and 2nd order streams as unimpaired. Moreover, should samples contain fIBI scores less than 29, the department may judge the stream as “suspected of impairment” using the above procedures.

Considerations for the Influence of Habitat Quality and Sample Representativeness

Low fIBI scores that are substantially different than reference streams could be the result of water quality problems, habitat problems, or both. When low fIBI scores are established, it is necessary to review additional information to differentiate between an impairment caused by water quality and one that is caused by habitat. The collection of a fish community sample is also accompanied by a survey of physical habitat from the sampled reach. MDC sampling protocol for stream habitat follows procedures provided by Peck *et al.* (2006). With MDC guidance, the department utilizes this habitat data and other available information to assure that an assessment of aquatic life attainment based on fish data is only the result of water quality, and that an impairment resulting from habitat is categorized as such. This section describes the procedures used to assure low fIBI scores are the result of water quality problems and not habitat degradation. The information below outlines the department's provisional method to identify unrepresentative samples and low fIBI scores with questionable habitat condition, and ensure corresponding fish IBI scores are not used for Section 303(d) listing.

- a) Following recommendations from the biocriteria workgroup, the department will consult MDC about the habitat condition of particular streams when assessing low fIBI scores.
- b) Samples may be considered for Section 303(d) listing ONLY if they were collected in the Ozark ecoregion, and the samples were collected during normal representative conditions, based upon best professional judgment from MDC staff,. Samples collected from the Central Plains and Mississippi Alluvial Basin are excluded from Section 303(d) listing.
- c) Only samples from streams 3rd to 5th order in size may be considered for Section 303(d) listing. Samples from 1st or 2nd order stream sizes are excluded from Section 303(d) consideration; however, they may be placed into Categories 2B and 3B if impairment is suspected, or into Categories 1, 2A, or 3A if sample scores indicate a stream is unimpaired. Samples from lower stream orders are surveyed under a different RAM Program protocol than 3rd to 5th order streams.
- d) Samples that are ineligible for Section 303(d) listing include those collected from losing streams, as defined by the Department of Geology and Land Survey, or collected in close proximity to losing streams. Additionally, ineligible samples may include those collected on streams that were considered to have natural flow issues (such as streams reduced predominately to subsurface flow) preventing good fish IBI scores from being obtained, as determined through best professional judgment of MDC staff.
- e) Fish IBI scores must be accompanied by habitat samples with a QCPH1 habitat index score. MDC was asked to analyze meaningful habitat metrics

and identify samples where habitat metrics seemed to indicate potential habitat concerns. As a result, a provisional index named QCPH1 was developed. QCPH1 values less than 0.39 indicate poor habitat, and values greater than 0.39 suggest adequate habitat is available. The QCPH1 comprises six sub-metrics indicative of substrate quality, channel disturbance, channel volume, channel spatial complexity, fish cover, and tractive force and velocity.

The QCPH1 index is calculated as follows:

$$\text{QCPH1} = ((\text{Substrate Quality} * \text{Channel Disturbance} * \text{Channel Volume} * \text{Channel Spatial Complexity} * \text{Fish Cover} * \text{Tractive Force \& Velocity})^{1/6})$$

Where sub-metrics are determined by:

Substrate Quality = [(embeddedness + small particles)/2] * [(filamentous algae + aquatic macrophyte)/2] * bedrock and hardpan

Channel Disturbance = concrete * riprap * inlet/outlet pipes * relative bed stability * residual pool observed to expected ratio

Channel Volume = [(dry substrate+width depth product + residual pool + wetted width)/4]

Channel Spatial Complexity = (coefficient of variation of mean depth + coefficient of variation of mean wetted width + fish cover variety)/3

Fish Cover = [(all natural fish cover + ((brush and overhanging vegetation + boulders + undercut bank + large woody debris)/4) + large types of fish cover)/3]

Tractive Force & Velocity = [(mean slope + depth * slope)/2]

Unimpaired fish IBI samples (fIBI \geq 36) with QCPH1 index scores below the 0.39 threshold value, or samples without a QCPH1 score altogether, are eliminated from consideration for Category 5 and instead placed into Categories 2B or 3B should an impairment be suspected. Impaired fish communities (fIBI <36) with QCPH1 scores <0.39 can be placed into Category 4C (non-discrete pollutant/habitat impairment). Impaired fish communities (fIBI <36) with adequate habitat scores (QCPH1 >0.39) can be placed into Category 5. Appropriate streams with unimpaired fish communities and adequate habitat (QCPH1 >0.39) may be used to judge a stream as unimpaired.

Similar to macroinvertebrates, assessment of fish community information must be based on data coded level three or four as described in Section II.C of this document. Data coded as

levels three and four represent environmental data with the greatest degree of assurance, and thus, assessments will include multiple samples from a single site, or samples from multiple sites within a single reach.

Following the department's provisional methodology, fish community samples available for assessment (using procedures in Appendix C & D include only those from 3rd to 5th order Ozark Plateau streams, collected under normal, representative conditions, where habitat seemed to be good, and where there were no issues with inadequate flow or water volume.

IV. Other Biological Data

On a case by case basis, the department may use biological data other than MSCI or FIBI scores for assessing attainment of aquatic life. Other biological data may include information on single indicator aquatic species that are ecologically or recreationally important, or individual measures of community health that respond predictably to environmental stress. Measures of community health could be represented by aspects of structure, composition, individual health, and processes of the aquatic biota. Examples could include measures of density or diversity of aquatic organisms, replacement of pollution intolerant taxa, or even the presence of biochemical markers.

Acute or Chronic Toxicity Tests

If toxicity tests are to be used as part of the weight of evidence then accompanying media (water or sediment) analysis must accompany the toxicity test results. (e.g. Metals concentrations in the sediment sample used for an acute toxicity test must accompany the toxicity test results if metals are a concern; or if PAHs are a concern then TOC must accompany toxicity test results). The organism, its developmental stage used for the toxicity test, and the duration of the test must also accompany the results.

Other biological data should be collected under a well vetted study that is documented in a scientific report, a weight of evidence approach should be established, and the report should be referenced in the 303(d) listing worksheet. If other biological data is a critical component of the community and has been adversely affected by the presence of a pollutant or stressor, then such data would indicate a water body is impaired. The department's use of other biological data is consistent with EPA's policy on independent applicability for making attainment decisions, which is intended to protect against dismissing valuable information when diagnosing an impairment of aquatic life.

The use of other biological data in water body assessments occurs infrequently, but when available, it is usually assessed in combination with other information collected within the water body of interest. The department will avoid using other biological data as the sole justification for a Section 303(d) listing; however, other biological data will be used as part of a weight of evidence analysis for making the most informed assessment decision.

V. Toxic Chemicals

Water

For the interpretation of toxicity test data, standard acute or chronic bioassay procedures using freshwater aquatic fauna such as, but not limited to, *Ceriodaphnia dubia*, Fathead Minnows (*Pimephales promelas*), *Hyalella azteca*, or Rainbow Trout (*Oncorhynchus mykiss*)²⁰ will provide adequate evidence of toxicity for 303(d) listing purposes.

Microtox[®] toxicity tests may be used to list a water as affected by “toxicity” only if there are data of another kind (freshwater toxicity tests, sediment chemistry, water chemistry, or biological sampling) that indicate water quality impairment.

For any given water, available data may occur throughout the system and/or be concentrated in certain areas. When the location of pollution sources are known, the department reserves the right to assess data representative of impacted conditions separately from data representative of unimpacted conditions. Pollution sources include those that may occur at discrete points along a water body, or those that are more diffuse.

Chronic Toxicity Events

Parameters in WQS that are labeled as chronic criterion can be assessed in two ways:

1. Continuous Data Sondes
 - a. For data that has been collected consecutively over time, (eg. A data sonde collecting pH every 15 minutes or a two week time period) the data will be used as is after QA/QC procedures.
2. Grab Samples
 - a. For samples that have not been collected consecutively, (eg. Grab sample collected once a week) the hydrologic flow conditions of the stream or the closest USGS gage will be used to verify the sample was collected during stable flow conditions. If the flow conditions were unstable then the sample will not be assessed against the chronic criterion. If the flow conditions were stable then the sample will be assessed against the chronic criterion. There are three categories of stable flow conditions: High, Medium, and Low.
 - i. High Stable Flow – is greater than the 50th percentile exceedance flow and less than 10% change in flow over a 48 hour period.
 - ii. Medium Stable Flow – is between the 90th percentile exceedance flow and the 50th percentile exceedance flow and less than 15% change in flow over a 48 hour period.
 - iii. Low Stable Flow – is less than the 90th percentile exceedance flow or less than one cubic foot per second and less than 20% change in flow over a 48 hour period.

Sediment

For toxic chemicals occurring in benthic sediments, data interpretation will include calculation of a geometric mean for specific toxins from an adequate number of samples, and comparing that value to a corresponding Probable Effect Concentration (PEC) given by MacDonald *et al.* (2000). The PEC is the level of a pollutant above which harmful effects

²⁰ Reference 10 CSR 20-7.015(9)(L) for additional information

on the aquatic community are likely to be observed. MacDonald (2000) gave an estimate of accuracy for the ability of individual PECs to predict toxicity. For all metals except arsenic, pollutant geometric means will be compared to 150% of the recommended PEC values. These comparisons should meet confidence requirements applied elsewhere in this document. When multiple metal contaminants occur in sediment, toxicity may occur even though the level of each individual pollutant does not reach toxic levels. The method of estimating the synergistic effects of multiple metals in sediments is described below.

The sediment PECs given by MacDonald *et al.* (2000) are based on some additional data assumptions. Those assumptions include a 1% Total Organic Carbon (TOC) content and that the sample has been sieved to less than 2mm.

The department uses 150% of the PEC values to account for some variability in our assessment of sediment toxicity. Also see the ***Equilibrium Partitioning Sediment Benchmark*** section on page 39 for information on TOC and sulfide considerations for metals toxicity in sediment.

For the sample sieving assumption, the department will use non-sieved (bulk) sediment concentrations for screening level data (Data Code One). Current impairments that have used bulk sediment data as evidence for impairment will remain on the list of impaired streams until sieved data can be collected to show either that it should remain on the list or that the sieved concentrations are below the 150% PEC values. Data that has been sieved to less than 2mm or smaller will be used for comparison to the 150% PEC values.

The Meaning of the Sediment Quotient and How to Calculate It

Although sediment criteria in the form of a PEC are given for several individual contaminants, it is recognized that when multiple contaminants occur in sediment, toxicity may occur even though the level of each individual pollutant does not reach toxic levels. The method of estimating the synergistic effects of multiple pollutants in sediments given in MacDonald *et al.* (2000) includes the calculation of a PECQ. PECQs greater than 0.75 will be judged as toxic.

This calculation is made by dividing the pollutant concentration in the sample by the PEC value for that pollutant. For single samples, the quotients are summed, and then normalized by dividing that sum by the number of pollutants in the formula. When multiple samples are available, the geometric mean (as calculated for specific pollutants) will be placed in the numerator position for each pollutant included in the equation.

Example: A sediment sample contains the following results in mg/kg:

Arsenic 2.5, Cadmium 4.5, Copper 17, Lead 100, and Zinc 260.

The PEC values for these five pollutants in respective order are:

33, 4.98, 149, 128, and 459 mg/kg.

PECQ =

$$[(2.5/33) + (4.5/4.98) + (17/149) + (100/128) + (260/459)]/5 = 0.488$$

Using PECQ to Judge Metals Toxicity

Based on research by MacDonald *et al.* (2000) 83% of sediment samples with a PECQ less than 0.5 were non-toxic while 85% of sediment samples with a PECQ greater than 0.5 were toxic. Therefore, to accurately assess the synergistic effects of sediment contaminants on aquatic life, the department will judge PECQ greater than 0.75 as toxic.

Using Total PAHs to Judge Toxicity

Polycyclic Aromatic Hydrocarbons (PAHs) are organic compounds containing carbon and hydrogen forming aromatic rings (cyclic molecular shapes). The presence of PAHs in the environment when not expected (natural sources can be coal and oil deposits) result from the use and breakdown hydrocarbon compounds. There are three different sources of hydrocarbon compounds: plants (Phytogenic), petroleum (Petrogenic), and the combustion of petroleum, wood, coal etc. (Pyrogenic). Most common sources of PAHs in stream are sealants (coal tar) and other treatments of roads, driveways, and parking lots.

Mount *et al.* (2003) indicates that individual PAH sediment guidelines (PECs) are based on the samples also having an elevated presence of additional PAHs, potentially overestimating the actual toxicity of an individual PAH PEC value. The use of a Total PAH guideline (PEC) reduces variability and provides a better representation of toxicity than the use of individual PAH PECs.

Based on research by MacDonald *et al.* (2000) 81.5% of sediment samples with a Total PAH value less than 22.8 mg/kg (ppm) were non-toxic while 100% of sediment samples with a Total PAH value greater than 22.8 mg/kg (ppm) were toxic. Therefore, to accurately assess the toxicity to aquatic life of total PAHs in sediment, the department will judge Total PAH values greater than 150% of the PEC value (34.2 mg/kg) as toxic. For PAHs the sum of the geometric means for all PAH compounds will be compared to 150% of the recommended PEC value for total PAHs.

What compounds are considered in calculating Total PAHs and how will they be compared to the 150% PEC value?

To calculate Total PAHs for a sample, Mount *et al.* (2003) recommends following United States Environmental Protection Agency, Environmental Monitoring Assessment Program's definition of Total PAHs. This definition includes 34 PAH compounds; 18 parent PAHs and 16 alkylated PAHs. (See Table 3 below for a list of these compounds.) Mount *et al.* (2003) shows that using less than the 34 PAH compounds can underestimate the toxicity of PAHs in sediment. Total Organic Carbon (TOC) has the potential to affect the bio-

availability of PAHs. Organic carbon can provide a binding phase for PAHs, but the extent of that binding capacity is unknown. Through the Weight of Evidence approach (see section D II) the department will consider the effects of TOC on a case by case basis.

Commonly only 14 to 18 of the 34 PAH compounds are requested for analysis. Therefore the process to judge toxicity due to total PAHs is as follows:

- If samples are analyzed for fewer than the 34 PAH compounds then
 - If the sum (sum of the geometric means for more than one sample) of those compounds is greater than the 150% PEC then the sample(s) will be judged as toxic.
 - If the sum (sum of the geometric means for more than one sample) of those compounds is greater than the 100% PEC but less than 150% of the PEC then the sample(s) will be judged as inconclusive.
 - If the sum (sum of the geometric means for more than one sample) of those compounds is less than the 100% PEC then the values will be judged as non-toxic.
- If samples are analyzed for the 34 PAH compounds then
 - If the sum (sum of the geometric means for more than one sample) of those compounds is greater than the 150% PEC then the sample(s) will be judged as toxic.
 - If the sum (sum of the geometric means for more than one sample) of those compounds is less than the 150% PEC then the values will be judged as non-toxic.

Table 3. List of 34 polycyclic aromatic hydrocarbon (PAH) compounds that are considered for the calculation of total PAHs.

Parent PAHs	Alkylated PAHs
Acenaphthene	C1-Benzanthracene/chrysenes
Acenaphthylene	C1-Fluorenes
Anthracene*	C1-Naphthalenes
Benz(a)anthracene*	C1-Phenanthrene/anthracenes
Benzo(a)pyrene*	C1-Pyrene/fluoranthenes
Benzo(b)fluoranthene	C2-Benzanthracene/chrysenes
Benzo(e)pyrene	C2-Fluorenes
Benzo(g,h,i)perylene	C2-Naphthalenes
Benzo(k)fluoranthene	C2-Phenanthrene/anthracenes

Chrysene*	C3-Benzanthracene/chrysenes
Dibenz(a,h)anthracene	C3-Fluorenes
Fluoranthene*	C3-Naphthalenes
Fluorene*	C3-Phenanthrene/anthracenes
Indeno(1,2,3-cd)pyrene	C4-Benzanthracene/chrysenes
Naphthalene*	C4-Naphthalenes
Perylene	C4-Phenanthracene/anthracenes
Phenanthrene*	
Pyrene*	
<i>*Listed in Table 3 of MacDonald et.al (2000)</i>	

Equilibrium Partitioning Sediment Benchmark (ESB) Data

Another type of analysis of the toxicity of metals in sediment is based on the EPA (2006) paper that discusses ESBs and their use. The department will not be collecting this type of data but will consider the data under the weight of evidence approach. To be considered the data must be accompanied by the name of the laboratory that completed the analysis and a copy of their laboratory procedures and QC documentation. Sieved sediment samples will be judged as toxic for metals in sediment if the sum of the simultaneously extracted metals minus acid volatile sulfides then divided by the fractional organic carbon $[(\Sigma SEM - AVS)/FOC]$ is greater than 3000. If additional sieved sediment samples also show toxicity for a particular metal(s) then that particular metal(s) will be identified as the cause for toxicity.

Pictorial Representations (flow charts) for how these different sediment toxicity procedures could be used in the weight of evidence procedure are displayed in Appendix E.

VI. Duration of Assessment Period

Except where the assessment period is specifically noted in Appendix B, the time period during which data will be used in making the assessments will be determined by data age and data code considerations, as well as representativeness considerations such as those described in footnote 14.

VII. Assessment of Tier Three Waters

Waters given Tier Three protection by the anti-degradation rule at 10 CSR 20-7.031(2) shall be considered impaired if data indicate water quality has been reduced in comparison to its historical quality. Historical quality is determined from past data that best describes a

water body's water quality following promulgation of the anti-degradation rule and at the time the water was given Tier Three protection.

Historical data gathered at the time waters were given Tier Three protection will be used if available. Because historical data may be limited, the historical quality of the waters may be determined by comparing data from the assessed segment with data from a "representative" segment. A representative segment is a body or stretch of water that best reflects the conditions that probably existed at the time the anti-degradation rule first applied to the waters being assessed. Examples of possible representative data include 1) data from stream segments upstream of assessed segments that receive discharges, and 2) data from other water bodies in the same ecoregion having similar watershed and landscape characters. These representative stream segments also would be characterized by receiving discharges similar to the quality and quantity of historic discharges of the assessed segment. The assessment may also use data from the assessed segment gathered between the time of the initiation of Tier Three protection and the last known time in which upstream discharges, runoff, and watershed conditions remained the same, provided that the data do not show any significant trends of declining water quality during that period.

The data used in the comparisons will be tested for normality and an appropriate statistical test will be applied. The null hypothesis for statistical analysis will be that water quality at the test segment and representative segment is the same. This will be a one-tailed test (the test will consider only the possibility that the assessed segment has poorer water quality) with the alpha level of 0.1, meaning that the test must show greater than a 90 percent probability that the assessed segment has poorer water quality than the representative segment before the assessed segment can be listed as impaired.

VIII. Other Types of Information

1. Observation and evaluation of waters for noncompliance with state narrative water quality criteria. Missouri's narrative water quality criteria, as described in 10 CSR 20-7.031 Section (3), may be used to evaluate waters when a quantitative (narrative) value can be applied to the pollutant. These narrative criteria apply to both classified and unclassified waters and prohibit the following in waters of the state:
 - a. Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly, or harmful bottom deposits or prevent full maintenance of beneficial uses;
 - b. Waters shall be free from oil, scum, and floating debris in sufficient amounts to be unsightly or prevent full maintenance of beneficial uses;
 - c. Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor, or prevent full maintenance of beneficial uses;
 - d. Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal, or aquatic life;

- e. There shall be no significant human health hazard from incidental contact with the water;
 - f. There shall be no acute toxicity to livestock or wildlife watering;
 - g. Waters shall be free from physical, chemical, or hydrologic changes that would impair the natural biological community;
 - h. Waters shall be free from used tires, car bodies, appliances, demolition debris, used vehicles or equipment, and solid waste as defined in Missouri's Solid Waste Law, section 260.200, RSMo, except as the use of such materials is specifically permitted pursuant to sections 260.200–260.247, RSMo;
2. Habitat assessment protocols for wadeable streams have been established and are conducted in conjunction with sampling aquatic macroinvertebrates and fish. Methods for evaluating aquatic macroinvertebrate and fish community data include assessment procedures that account for the presence or absence of representative habitat quality. The department will not use habitat data alone for assessment purposes.

E. Other 303(d) Listing Considerations

- Adding to the Existing List or Expanding the Scope of Impairment to a Previously Listed Water.

The listed portion of impaired water bodies may be increased based on recent monitoring data following the guidelines in this document. One or more new pollutants may be added to the listing for a water body already on the list based on recent monitoring data following these same guidelines. Waters not previously listed may be added to the list following the guidelines in this document.

- Deleting from the Existing List or Decreasing the Scope of Impairment to a Previously Listed Water

The listed portion of an impaired water body may be decreased based on recent monitoring data following the guidelines in this document. One or more pollutants may be deleted from the listing for a water body already on the list based on recent monitoring data following guidelines in Appendix D. Waters may be completely removed from the list for several reasons²¹; the most common being (1) water has returned to compliance with water quality standards, or (2) the water has an approved TMDL study or Permit in Lieu of a TMDL.

- Listing Length of Impaired Segments

The length of a 303(d) listing is currently based on the WBID length from the Missouri WQS. The department is using the WBID as the assessment unit to report to USEPA.

²¹ See, "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act". USEPA, Office of Water, Washington DC.

When the department gains the database capability to further refine assessment units into segments smaller than WBIDs while maintain a transparent link to the WBID and Missouri's WQS, then the department will do so and will provide justification for splitting the WBID up into smaller assessment units in the assessment worksheets and can be discussed during the public notice process.

F. Prioritization of Waters for TMDL Development

Section 303(d) of the Clean Water Act and federal regulation 40 CFR 130.7(b)(4) requires states to submit a priority ranking of waters requiring TMDLs. The department will prioritize development of TMDLs based on several variables including:

- social impact/public interest and risk to public health
- complexity and cost (including consideration of budget constraints), availability of data of sufficient quality and quantity for TMDL modeling
- court orders, consent decrees, or other formal agreements
- source of impairments
- existence of appropriate numeric quality criteria
- implementation potential and amenability of the problem to treatment, and
- Integrated Planning efforts by municipalities and other entities

The department's TMDL schedule will represent its prioritization. The TMDL Program develops the TMDL schedule and maintains it at the following website:

<http://www.dnr.mo.gov/env/wpp/tmdl/>.

G. Resolution of Interstate/International Disagreements

The department will review the draft 303(d) Lists of all other states with which it shares a border (Missouri River, Mississippi River, Des Moines River and the St. Francis River) or other interstate waters. Where the listing for the same water body in another state is different than the one in Missouri, the department will request the data and the listing justification. These data will be reviewed following the evaluation guidelines in this document. The Missouri Section 303(d) list may be changed pending the evaluation of this additional data.

H. Statistical Considerations

The most recent EPA guidance on the use of statistics in the 303(d) listing methodology document is given in Appendix A. Within this guidance there are three major recommendations regarding statistics:

- Provide a description of analytical tools the state uses under various circumstances
- When conducting hypothesis testing, explain the various circumstances under which the burden of proof is placed on proving the water is impaired and when it is placed on proving the water is unimpaired, and
- Explain the level of statistical significance (α) used under various circumstances.

- Description of Analytical Tools

Appendix D, describes the analytical tools the department will use to determine whether a water body is impaired and whether or when a listed water body is no longer impaired.

- Rationale for the Burden-of-Proof

Hypothesis testing is a common statistical practice. The procedure involves first stating a hypothesis you want to test, such as “the most frequently seen color on clothing at a St. Louis Cardinals game is red” and then the opposite or null hypothesis “red is not the most frequently seen color on clothing at a Cardinals game.” Then a statistical test is applied to the data (a sample of the predominant color of clothing worn by 200 fans at a Cardinals game on July 12) and based on an analysis of that data, one of the two hypotheses is chosen as correct.

In hypothesis testing, the burden-of-proof is always on the alternate hypothesis. In other words, there must be very convincing data to make us conclude that the null hypothesis is not true and that we must accept the alternate hypothesis. How convincing the data must be is stated as the “significance level” of the test. A significance level of $\alpha=0.10$ means that there must be at least a 90 percent probability that the alternate hypothesis is true before we can accept it and reject the null hypothesis.

For analysis of a specific kind of data, either the test significance level or the statement of null and alternative hypotheses, or both, can be varied to achieve the desired degree of statistical rigor. The department has chosen to maintain a consistent set of null and alternate hypotheses for all our statistical procedures. The null hypothesis will be that the water body in question is unimpaired and the alternate hypothesis will be that it is impaired. Varying the level of statistical rigor will be accomplished by varying the test significance level. For determining impairment (Appendix D) test significance levels are set at either $\alpha=0.1$ or $\alpha=0.4$, meaning the data must show at minimum 90% or 60% probability, respectively that the water body is impaired. However, if the department retained these same test significance levels in determining when an impaired water body had been restored to an unimpaired status (Appendix D) some undesirable results can occur.

For example, using a 0.1 significance level for determining both impairment and non-impairment, if the sample data indicate the stream had a 92 percent probability of being impaired, it would be rated as impaired. If subsequent data were collected and added to the database, and the data now showed the water had an 88 percent chance of being impaired, it would be rated as unimpaired. Judging as unimpaired a water body with only a 12 percent probability of being unimpaired is clearly a poor decision. To correct this problem, the department will use a test significance level of 0.4 for some analytes and 0.6 for others. This will increase our confidence in determining compliance with criteria to 40 percent and 60 percent, respectively under the worst case conditions, and for most databases will provide an even higher level of confidence.

- Level of Significance Used in Tests

The choice of significance levels is largely related to two concerns. The first concern is with matching error rates with the severity of the consequences of making a decision error. The second addresses the need to balance, to the degree practicable, Type I and Type II error rates. For relatively small number of samples, the disparity between Type I and Type II errors can be large. The tables 4 and 5 below shows error rates calculated using the binomial distribution for two very similar situations. Type I error rates are based on a stream with a 10 percent exceedance rate of a standard, and Type II error rates are based on a stream with a 15 percent exceedance rate of a standard. Note that when sample size remains the same, Type II error rates increase as Type I error rates decrease (Table 4). Also note that for a given Type I error rate, the Type II error rate declines as sample size increases (Table 5).

Table 4.

Effects of Type I error rates on Type II error rates. Type I error rates are based on a stream with a 10 percent exceedance rate of a standard and Type II error rates for a stream with a 15 percent exceedance rate of a standard.

Total No. of Samples	No. Samples Meeting Std.	Type I Error Rate	Type II Error Rate
18	17	0.850	0.479
18	16	0.550	0.719
18	15	0.266	0.897
18	14	0.098	0.958
18	13	0.028	0.988

Table 5.

Effects of Type I error rates and sample size on Type II error rates. Type I error rates are based on a stream with a 10 percent exceedance rate of a standard and Type II error rates for a stream with a 15 percent exceedance rate of a standard.

Total No. of Samples	No. Samples Meeting Std.	Type I Error Rate	Type II Error Rate
6	5	0.469	0.953
11	9	0.303	0.930
18	15	0.266	0.897
25	21	0.236	0.836

- Use of the Binomial Probability Distribution for Interpretation of the 10 Percent Rule

There are two options for assessing data for compliance with the 10 percent rule. One is to simply calculate the percent of time the criterion value is not met, and to judge the water to be impaired if this value is greater than 10 percent. The second method is to use some evaluative procedure that can review the data and provide a probability statement regarding compliance

with the 10 percent rule. Since the latter option allows assessment decisions relative to specific test significance levels and the first option does not, the latter option is preferred. The procedure chosen is the binomial probability distribution and calculation of the Type I error rate.

- Other Statistical Considerations

Prior to calculation of confidence limits, the normality of the data set will be evaluated. If normality is improved by a data transformation, the confidence limits will be calculated on the transformed data.

Time of sample collection may be biased and interfere with an accurate measurement of frequency of exceedance of a criterion. Data sets composed mainly or entirely of storm water data or data collected only during a season when water quality problems are expected could result in a biased estimate of the true exceedance frequency. In these cases, the department may use methods to estimate the true annual frequency and display these calculations whenever they result in a change in the impairment status of a water body.

For waters judged to be impaired based on biological data where data evaluation procedures are not specifically noted in Table 1, the statistical procedure used, test assumptions, and results will be reported.

- Examples of Statistical Procedures

Two Sample “t” Test for Color

Null Hypothesis: Amount of color is no greater in a test stream than in a control stream. As stated, this is a one-sided test, meaning that we are only interested in determining whether or not the color level in the test stream is greater than in a control stream. If the null hypothesis had been “amount of color is different in the test and control streams,” we would have been interested in determining if the amount of color was either less than or greater than the control stream, a two-sided test.

Significance Level: $\alpha=0.10$

Data Set: Platinum-Cobalt color units data for the test stream and a control stream samples collected at each stream on same date.

Test Stream	70	45	35	45	60	60	80
Control Stream	50	40	20	40	30	40	75
Difference (T-C)	20	5	15	5	30	20	5

Statistics for the Difference: Mean = 14.28, standard deviation = 9.76, $n = 7$
Calculated “t” value = (square root of n)(mean)/standard deviation = 3.86

Tabular “t” value is taken from a table of the “t” distribution for 2 alpha (0.20) and n-1 degrees of freedom. Tabular “t” = 1.44.

Since calculated “t” value is greater than tabular t value, reject the null hypothesis and conclude that the test stream is impaired by color.

Statistical Procedure for Mercury in Fish Tissue

Data Set: data in $\mu\text{g/Kg}$ 130, 230, 450. Mean = 270, Standard Deviation = 163.7

The 60% Lower Confidence Limit Interval = the sample mean minus the quantity:
 $((0.253)(163.7)/\text{square root } 3) = 23.9$. Thus the 60% LCL Confidence Interval is 246.1 $\mu\text{g/Kg}$.

The criterion value is 300 $\mu\text{g/Kg}$. Therefore, since the 60% LCL Confidence Interval is less than the criterion value, the water is judged to be unimpaired by mercury in fish tissue, and the water body is placed in either Category 2B or 3B.

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Appendix A

Excerpt from *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act*. July 29, 2005. USEPA pp. 39-41.

The document can be read in its entirety from the US. EPA web site:
<http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/2006irg-report.pdf>

G. How should statistical approaches be used in attainment determinations?

The state's methodology should provide a rationale for any statistical interpretation of data for the purpose of making an assessment determination.

- *Description of statistical methods to be employed in various circumstances*

The methodology should provide a clear explanation of which analytic tools the state uses and under which circumstances. EPA recommends that the methodology explain issues such as the selection of key sample statistics (arithmetic mean concentration, median concentration, or a percentile), null and alternative hypotheses, confidence intervals, and Type I and Type II error thresholds. The choice of a statistic tool should be based on the known or expected distribution of the concentration of the pollutant in the segment (e.g., normal or log normal) in both time and space.

Past EPA guidance (1997 305(b) and 2000 CALM) recommended making non-attainment decisions, for "conventional pollutants"²² — TSS, pH, BOD, fecal coliform bacteria, and oil and grease — when more than "10% of measurements exceed the water quality criterion." (However, EPA guidance has not encouraged use of the "10% rule" with other pollutants, including toxics.) Use of this rule when addressing conventional pollutants, is appropriate if its application is consistent with the manner in which applicable WQC are expressed. An example of a WQC for which an assessment based on the ten percent rule would be appropriate is the EPA acute WQC for fecal coliform bacteria, applicable to protection of water contact recreational use. This 1976-issued WQC was expressed as, "...no more than ten percent of the samples exceeding 400 CFU per 100 ml, during a 30-day period." Here, the assessment methodology is clearly reflective of the WQC.

On the other hand, use of the ten percent rule for interpreting water quality data is usually not consistent with WQC expressed either as: 1) instantaneous maxima not to be surpassed at any time, or 2) average concentrations over specified times. In the case of "instantaneous maxima (or minima) never to occur" criteria use of the ten percent rule typically leads to the belief that segment conditions are equal or better than specified by the WQC, when they in fact are considerably worse. (That is,

²² There are a variety of definitions for the term "conventional pollutants." Wherever this term is referred to in this guidance, it means "a pollutant other than a toxic pollutant."

pollutant concentrations are above the criterion-concentration a far greater proportion of the time than specified by the WQC.) Conversely, use of this decision rule in concert with WQC expressed as average concentrations over specific times can lead to concluding that segment conditions are worse than WQC, when in fact they are not.

If the state applies different decision rules for different types of pollutants (e.g., toxic, conventional, and non-conventional pollutants) and types of standards (e.g., acute vs. chronic criteria for aquatic life or human health), the state should provide a reasonable rationale supporting the choice of a particular statistical approach to each of its different sets of pollutants and types of standards.

- 1. Elucidation of policy choices embedded in selection of particular statistical approaches and use of certain assumptions EPA strongly encourages states to highlight policy decisions implicit in the statistical analysis that they have chosen to employ in various circumstances. For example, if hypothesis testing is used, the state should make its decision-making rules transparent by explaining why it chose either “meeting WQS” or “not meeting WQS” as the null hypothesis (rebuttable presumption) as a general rule for all waters, a category of waters, or an individual segment. Starting with the assumption that a water is “healthy” when employing hypothesis testing means that a segment will be identified as impaired, and placed in Category 4 or 5, only if substantial amounts of credible evidence exist to refute that presumption. By contrast, making the null hypothesis “WQS not being met” shifts the burden of proof to those who believe the segment is, in fact, meeting WQS.*

Which “null hypothesis” a state selects could likely create contrasting incentives regarding support for additional ambient monitoring among different stakeholders. If the null hypothesis is “meeting standards,” there were no previous data on the segment, and no additional existing and readily available data and information are collected, then the “null hypothesis” cannot be rejected, and the segment would not be placed in Category 4 or 5. In this situation, those concerned about possible adverse consequences of having a segment declared “impaired” might have little interest in collection of additional ambient data. Meanwhile, users of the segment would likely want to have the segment monitored, so they can be ensured that it is indeed capable of supporting the uses of concern. On the other hand, if the null hypothesis is changed to “segment not meeting WQS,” then those that would prefer that a particular segment not be labeled “impaired” would probably want more data collected, in hopes of proving that the null hypothesis is not true.

Another key policy issue in hypothesis testing is what significance level to use in deciding whether to reject the null hypothesis. Picking a high level of significance for rejecting the null hypothesis means that great emphasis is being placed on avoiding a Type I error (rejecting the null hypothesis, when in fact, the null hypothesis is true). This means that if a 0.10 significance level is chosen, the state wants to keep the chance of making a Type I error at or below ten percent. Hence, if the chosen null hypothesis is “segment meeting

WQS,” the state is trying to keep the chance of saying a segment is impaired – when in reality it is not – under ten percent.

An additional policy issue is the Type II errors (not rejecting the null hypothesis, when it should have been). The probability of Type II errors depends on several factors. One key factor is the number of samples available. With a fixed number of samples, as the probability of Type I error decreases, the probability of a Type II error increases. States would ideally collect enough samples so the chances of making Type I and Type II errors are simultaneously small. Unfortunately, resources needed to collect such numbers of samples are quite often not available.

The final example of a policy issue that a state should describe is the rationale for concentrating limited resources to support data collection and statistical analysis in segments where there are documented water quality problems or where the combination of nonpoint source loadings and point source discharges would indicate a strong potential for a water quality problem to exist.

EPA recommends that, when picking the decision rules and statistical methods to be utilized when interpreting data and information, states attempt to minimize the chances of making either of the two following errors:

- Concluding the segment is impaired, when in fact it is not, and*
- Deciding not to declare a segment impaired, when it is in fact impaired.*

States should specify in their methodology what significance level they have chosen to use, in various circumstances. The methodology would best describe in “plain English” the likelihood of deciding to list a segment that in reality is not impaired (Type I error if the null hypothesis is “segment not impaired”). Also, EPA encourages states to estimate, in their assessment databases, the probability of making a Type II error (not putting on the 303(d) list a segment that in fact fails to meet WQS), when: 1) commonly-available numbers of grab samples are available, and 2) the degree of variance in pollutant concentrations are at commonly encountered levels. For example, if an assessment is being performed with a WQC expressed as a 30-day average concentration of a certain pollutant, it would be useful to estimate the probability of a Type II error when the number of available samples over a 30 day period is equal to the average number of samples for that pollutant in segments state-wide, or in a given group of segments, assuming a degree of variance in levels of the pollutant often observed over typical 30 day periods.

Appendix B

METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

DESIGNATED USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS ⁱ	Notes
Overall use protection (all designated uses)	No data. Evaluated based on similar land use/ geology as stream with water quality data.	Not applicable	Given same rating as monitored stream with same land use and geology.	Data Type Note: This data type is used only for wide-scale assessments of aquatic biota and aquatic habitat for 305(b) Report purposes. This data type is not used in the development of the 303(d) List.
Any designated uses	No data available or where only effluent data is available. Results of dilution calculations or water quality modeling	Not applicable	Where models or other dilution calculations indicate noncompliance with allowable pollutant levels and frequencies noted in this table, waters may be added to Category 3B and considered high priority for water quality monitoring.	
Protection of Aquatic Life	Dissolved oxygen, water temperature, pH, total dissolved gases, oil and grease.	1-4	<p><u>Full:</u> No more than 10% of all samples exceed criterion.</p> <p><u>Non-Attainment:</u> Requirements for full attainment not met.</p> <p><u>Requirements:</u> A minimum sample size of 10 samples during the assessment period (see Section VI above).</p>	<p>Compliance with Water Quality Standards Note: Some sampling periods are wholly or predominantly during the critical period of the year when criteria violations occur. Where the monitoring program presents good evidence of a demarcation between seasons where criteria exceedances occur and seasons when they do not, the 10% exceedance rate will be based on an annual estimate of the frequency of exceedance.</p> <p>Continuous (e.g. sonde) data with a quality rating of excellent or good will be used for assessments.</p> <p>Chronic pH will be used in the LMD only if these criteria appear in the Code of State</p>

Appendix B

METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

DESIGNATED USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS ⁱ	Notes
				Regulations, and approved by the U.S. Environmental Protection Agency.
Losing Streams	<i>E. coli</i> bacteria	1-4	<p><u>Full</u>: No more than 10% of all samples exceed criterion.</p> <p><u>Non-Attainment</u>: Requirements for full attainment not met.</p> <p>The criterion for <i>E. coli</i> is 126 counts/100ml. 10 CSR 20-7.031 (4)(C)</p>	
Protection of Aquatic Life	Toxic chemicals	1-4	<p><u>Full</u>: No more than one acute toxic event in three years that results in a documented die-off of aquatic life such as fish, mussels, and crayfish (does not include die-offs due to natural origin). No more than one exceedance of acute or chronic criterion in the last three years for which data is available.</p> <p><u>Non-Attainment</u>: Requirements for full attainment not met.</p>	<p>Compliance with Water Quality Standards Note: For hardness based metals with eight or fewer samples, the hardness value associated with the sample will be used to calculate the acute or chronic thresholds.</p> <p>For hardness based metals with more than eight samples, the hardness definition provided in state water quality standards will be used to calculate the acute and chronic thresholds.</p>
Protection of Aquatic Life	Nutrients in Lakes (total phosphorus, total nitrogen, and chlorophyll-a)	1-4	<p><u>Full</u>: Nutrient levels do not exceed water quality standards following procedures stated in Appendix D and F.</p> <p><u>Non-Attainment</u>: Requirements for full attainment not met.</p>	<p>Compliance with Water Quality Standards Note: Ecoregional nutrient criteria will be used only if these criteria are approved by the U.S. Environmental Protection Agency.</p>
Human Health - Fish Consumption	Chemicals (water)	1-4	<p><u>Full</u>: Water quality does not exceed water quality standards following procedures stated in Appendix D.</p> <p><u>Non-Attainment</u>: Requirements for full attainment not met.</p>	

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METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

DESIGNATED USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS ⁱ	Notes
Drinking Water Supply -Raw Water.	Chemical (toxics)	1-4	<u>Full</u> : Water Quality Standards not exceeded following procedures stated in Appendix D. <u>Non-Attainment</u> : Requirements for full attainment not met.	Designated Use Note: Raw water is water from a stream, lake or groundwater prior to treatment in a drinking water treatment plant.
Drinking Water Supply- Raw Water	Chemical (sulfate, chloride, fluoride)	1-4	<u>Full</u> : Water quality standards not exceeded following procedures stated in Appendix D. <u>Non-Attainment</u> : Requirements for full attainment not met.	
Drinking Water Supply-Finished Water	Chemical (toxics)	1-4	<u>Full</u> : No Maximum Contaminant Level (MCL) violations based on Safe Drinking Water Act data evaluation procedures. <u>Non-Attainment</u> : Requirements for full attainment not met.	Compliance with Water Quality Standards Note: Finished water data will not be used for analytes where water quality problems may be caused by the drinking water treatment process such as the formation of Trihalomethanes (THMs) or problems that may be caused by the distribution system (bacteria, lead, copper).
Whole-Body-Contact Recreation and Secondary Contact Recreation	Fecal coliform or <i>E. coli</i> count	2-4	Where there are at least five samples per year taken during the recreational season: <u>Full</u> : Water quality standards not exceeded as a geometric mean, in any of the last three years for which data is available, for samples collected during seasons for which bacteria criteria apply. <u>Non-Attainment</u> : Requirements for full attainment not met.	Compliance with Water Quality Standards Note: A geometric mean of 206 cfu/100 ml for <i>E. coli</i> will be used as a criterion value for Category B Recreational Waters. Because Missouri’s Fecal Coliform Standard ended December 31, 2008, any waters appearing on the 2008 303(d) List as a result of the Fecal Coliform Standard will be retained on the list with the pollutant listed as “bacteria” until sufficient <i>E. coli</i> sampling has determined the status of the water.

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METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NUMERIC CRITERIA THAT ARE INCLUDED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

DESIGNATED USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDSⁱ	Notes
Irrigation, Livestock and Wildlife Water	Chemical	1-4	<p><u>Full</u>: Water quality standards not exceeded following procedures stated in Appendix D.</p> <p><u>Non-Attainment</u>: Requirements for full attainment not met.</p>	

¹ See section on Statistical Considerations, Appendix C & D.

Appendix C

METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDSⁱⁱ	Notes
Overall use protection (all beneficial uses)	Narrative criteria for which quantifiable measurements can be made.	1-4	<p><u>Full</u>: Stream condition typical of reference or appropriate control streams in this region of the state.</p> <p><u>Non-Attainment</u>: The weight of evidence, based on the narrative criteria in 10 CSR 20-7.031(3), demonstrates the observed condition exceeds a numeric threshold necessary for the attainment of a beneficial use.</p> <p>For example: Color: Color as measured by the Platinum-Cobalt visual method (SM 2120 B) in a water body is statistically significantly higher than a control water.</p> <p>Objectionable Bottom Deposits: The bottom that is covered by sewage sludge, trash, or other materials reaching the water due to anthropogenic sources exceeds the amount in reference or control streams by more than 20 percent.</p> <p>Note: Waters in mixing zones and unclassified waters that support aquatic life on an intermittent basis shall be subject to acute toxicity criteria for protection of aquatic life. Waters in the initial Zone of Dilution shall not be subject to acute toxicity criteria.</p>	

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METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS ⁱⁱ	Notes
Protection of Aquatic Life	Toxic Chemicals	1-4	<p><u>Full</u>: No more than one acute toxic event in three years (does not include die-offs of aquatic life due to natural origin). No more than one exceedance of acute or chronic criterion in three years for all toxics.</p> <p><u>Non-Attainment</u>: Requirements for full attainment not met.</p>	<p>Compliance with Water Quality Standards Note: The test result must be representative of water quality for the entire time period for which acute or chronic criteria apply. For ammonia the chronic exposure period is 30 days, for all other toxics 96 hours. The acute exposure period for all toxics is 24 hours, except for ammonia which has a one hour exposure period. The department will review all appropriate data, including hydrographic data, to ensure only representative data are used. Except on large rivers where storm water flows may persist at relatively unvarying levels for several days, grab samples collected during storm water flows will not be used for assessing chronic toxicity criteria.</p> <p>Compliance with Water Quality Standards Note: In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the need for further evaluation will be the Probable Effect Concentrations proposed in “Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems” by MacDonald, D.D. <i>et al.</i> Arch. Environ. Contam. Toxicol. 39,20-31 (2000). These Probable Effect Concentrations are as follows: 33 mg/kg As; 4.98 mg/kg Cd; 111 mg/kg Cr; 149 mg/kg Cu; 48.6 mg/kg Ni; 128 mg/kg Pb; 459 mg/kg Zn; 561 µg/kg naphthalene; 1170 µg/kg phenanthrene; 1520 µg/kg pyrene; 1050 µg/kg benzo(a)anthracene, 1290 µg/kg chrysene; 1450 µg/kg benzo(a)pyrene; 22,800 µg/kg total polycyclic aromatic hydrocarbons; 676 µg/kg total PCBs; chlordane 17.6 ug/kg; Sum DDE 31.3 ug/kg; lindane (gamma-BHC) 4.99 ug/kg. Where multiple sediment contaminants exist, the Probable Effect Concentrations Quotient shall not exceed 0.75. See Appendix D and Section II. D for more information on the Probable Effect Concentrations Quotient.</p>

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METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDSⁱⁱ	Notes
Protection of Aquatic Life	Biological: Aquatic Macro-invertebrates sampled using DNR Protocol.	3-4	<p><u>Full:</u> For seven or fewer samples and following DNR wadeable streams macroinvertebrate sampling and evaluation protocols, 75% of the stream condition index scores must be 16 or greater. Fauna achieving these scores are considered to be very similar to regional reference streams. For greater than seven samples or for other sampling and evaluation protocols, results must be statistically similar to representative reference or control stream.</p> <p><u>Non-Attainment:</u> For seven or fewer samples and following DNR wadeable streams macroinvertebrate sampling and evaluation protocols, 75% of the stream condition index scores must be 14 or lower. Fauna achieving these scores are considered to be substantially different from regional reference streams. For more than seven samples or for other sampling and evaluation protocols, results must be statistically dissimilar to control or representative reference streams.</p>	<p>Data Type Note: DNR invert protocol will not be used for assessment in the Mississippi Alluvial Basin (bootheel area) due to lack of reference streams for comparison.</p> <p>Data Type Note: See Section II.D. for additional criteria used to assess biological data.</p> <p>Compliance with Water Quality Standards Note: See Appendix D. For test streams that are significantly smaller than bioreference streams where both bioreference streams and small candidate reference streams are used to assess the biological integrity of the test stream, the assessment of the data should display and take into account both biocriteria reference streams and candidate reference streams.</p>
Protection of Aquatic Life	Biological: MDC Fish Community (RAM) Protocol (Ozark Plateau only)	3-4	<p><u>Full:</u> For seven or fewer samples and following MDC RAM fish community protocols, 75% of the fIBI scores must be 36 or greater. Fauna achieving these scores are considered to be very similar to regional reference streams. For greater than seven samples or for other sampling</p>	<p>Data Type Note: See Section II.D. for additional criteria used to assess biological data.</p> <p>Compliance with Water Quality Standards Note: MDC fIBI scores are from “Biological Criteria for Streams and Fish Communities in Missouri” by Doisy et al. (2008). If habitat limitations (as measured by either the QCPH1 index or other appropriate methods) are judged to contribute to low fish</p>

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METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDSⁱⁱ	Notes
			<p>and evaluation protocols, results must be statistically similar to representative reference or control streams.</p> <p><u>Suspected of Impairment:</u> Data not conclusive (Category 2B or 3B). For first and second order streams FIBI score < 29.</p> <p><u>Non-Attainment:</u> First and second order streams will not be assessed for non-attainment. When assessing third to fifth order streams with data sets of seven or fewer samples collected by following MDC RAM fish community protocols, 75% of the FIBI scores must be lower than 36. Fauna achieving these scores are considered to be substantially different from regional reference streams. For more than seven samples or for other sampling and evaluation protocols, results must be statistically dissimilar to control or representative reference streams.</p>	<p>community scores and this is the only type of data available, the water body will be included in Category 4C, 2B, or 3B. If other types of data exist, the weight of evidence approach will be used as described in this document.</p> <p>Compliance with Water Quality Standards Note: For determining influence of poor habitat on those samples that are deemed as impaired, consultation with MDC RAM staff will be utilized. If, through this consultation, habitat is determined to be a significant possible cause for impairment, the water body will not be rated as impaired, but rather as suspect of impairment (categories 2B or 3B).</p> <p>Compliance with Water Quality Standards Note: See Appendix D. For test streams that are significantly smaller than bioreference streams where both bioreference streams and small candidate reference streams are used to assess the biological integrity of the test stream, the assessment of the data should display and take into account both biocriteria reference streams and candidate reference streams.</p>
Protection of Aquatic Life	Other Biological Data	3-4	<p><u>Full:</u> Results must be statistically similar to representative reference or control streams.</p> <p><u>Non-Attainment:</u> Results must be statistically dissimilar to control or representative reference streams.</p>	<p>Data Type Note: See Section II.D. for additional criteria used to assess biological data</p>

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METHODS FOR ASSESSING COMPLIANCE WITH WATER QUALITY STANDARDS USED FOR 303(d) LISTING PURPOSES: NARRATIVE CRITERIA BASED ON NUMERIC THRESHOLDS NOT CONTAINED IN STATE WATER QUALITY STANDARDS (10 CSR 20-7.031)

BENEFICIAL USES	DATA TYPE	DATA QUALITY CODE	COMPLIANCE WITH WATER QUALITY STANDARDS ⁱⁱ	Notes
Protection of Aquatic Life	Toxicity testing of streams or lakes using aquatic organisms	2	<p><u>Full:</u> No more than one test result of statistically significant deviation from controls in acute or chronic test in a three-year period.</p> <p><u>Non-Attainment:</u> Requirements for full attainment not met.</p>	
Human Health - Fish Consumption	Chemicals (tissue)	1-2	<p><u>Full:</u> Contaminant levels in fish tissue levels in filets, tissue plugs, and eggs do not exceed guidelines.</p> <p><u>Non-Attainment:</u> Requirements for full attainment not met.</p>	<p>Compliance with Water Quality Standards Note: Fish tissue threshold levels are; chlordane 0.1 mg/kg (Crellin, J.R. 1989, <i>“New Trigger Levels for Chlordane in Fish-Revised Memo”</i> Mo. Dept. of Health inter-office memorandum. June 16, 1989); mercury 0.3 mg/kg based on “Water Quality Criterion for Protection of Human Health: Methylmercury” EPA-823-R-01-001. Jan. 2001. http://www.epa.gov/waterscience/criteria/methylmercury/merctitl.pdf; PCBs 0.75 mg/kg, MDHSS Memorandum August 30, 2006 <i>“Development of PCB Risk-based Fish Consumption Limit Tables;”</i> and lead 0.3- mg/kg (World Health Organization 1972. <i>“Evaluation of Certain Food Additives and the Contaminants Mercury, Lead and Cadmium.”</i> WHO Technical Report Series No. 505, Sixteenth Report on the Joint FAO/WHO Expert Committee on Food Additives. Geneva 33 pp. Assessment of Mercury will be based on samples solely from the following higher trophic level fish species: Walleye, Sauger, Trout, Black Bass, White Bass, Striped Bass, Northern Pike, Flathead Catfish and Blue Catfish. In a 2012 DHSS memorandum (not yet approved, but are being considered for future LMD revisions) threshold values are proposed to change as follows: chlordane 0.2 mg/kg ; mercury 0.27 mg/kg ; and PCBs = 0.540 ; lead has not changed, but they do add atrazine and PDBEs (Fish Fillet Advisory Concentrations (FFACs) in Missouri).</p>

ⁱⁱ See section on Statistical Considerations and Appendix D.

Appendix D

DESCRIPTION OF ANALYTICAL TOOLS USED FOR DETERMINING THE STATUS OF MISSOURI WATERS (11" X 14" FOLD OUT)

Designated Use	Analytes	Analytical Tool	Determining when waters are impaired			Determining when waters are no longer impaired			Notes
			Decision Rule/ Hypothesis	Criterion Used with the Decision Rule ⁱⁱⁱ	Significance Level (α)	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule	Significance Level (α)	
Narrative Criteria	Color	Hypothesis Test: Two Sample, one tailed t-Test	Null Hypothesis: There is no difference in color between test stream and control stream.	Reject Null Hypothesis if calculated "t" value exceeds tabular "t" value for test alpha	0.1	Same Hypothesis	Same Criterion	Same Significance Level	
	Bottom deposits	Hypothesis Test, Two Sample, one tailed "t" Test	Null Hypothesis: Solids of anthropogenic origin cover less than 20% of stream bottom where velocity is less than 0.5 feet/second.	Reject Null Hypothesis if 60% Lower Confidence Limit (LCL) of mean percent fine sediment deposition (pfsd) in stream is greater than the sum of the pfsd in the control and 20 % more of the stream bottom. i.e., where the pfsd is expressed as a decimal, test stream pfsd > (control stream pfsd)+(0.20)	0.4	Same Hypothesis	Same Criterion	Same Significance Level	Criterion Note: If data is non-normal a nonparametric test will be used as a comparison of medians. The same 20% difference still applies. With current software the Mann-Whitney test is used.

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Designated Use	Analytes	Analytical Tool	Determining when waters are impaired			Determining when waters are no longer impaired			Notes	
			Decision Rule/ Hypothesis	Criterion Used with the Decision Rule ⁱⁱⁱ	Significance Level (α)	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule	Significance Level (α)		
Aquatic Life	Biological monitoring (Narrative)	For DNR Invert protocol: Sample sizes of 7 or less, 75% of samples must score 14 or lower.	Using DNR Invert. Protocol: Null Hypothesis: Frequency of full sustaining scores for test stream is the same as for biological criteria reference streams.	Reject Null Hypothesis if frequency of fully sustaining scores on test stream is significantly less than for biological criteria reference streams.	Not Applicable	Same Hypothesis	Same Criterion	Same Significance Level		
		For RAM Fish IBI protocol: Sample sizes of 7 or less, 75% of samples must score less than 36.								
		For DNR Invert protocol and sample size of 8 or more: Binomial Probability	A direct comparison of frequencies between test and biological criteria reference streams will be made.	Rate as impaired if biological criteria reference stream frequency of fully biologically supporting scores is greater than five percent more than test stream.	0.1	Same Hypothesis	Same Criterion	Same Significance Level		Criterion Note: For inverts, the reference number will change depending on which EDU the stream is in (X%-5%), for RAM samples the reference number will always be 70 (75%-5%).
		For RAM Fish IBI protocol and sample size of 8 or more: Binomial Probability.								
Aquatic Life	For other biological data an appropriate parametric or	Null Hypothesis, Community metric(s) in test	Reject Null Hypothesis if metric scores for test stream are	0.1	Same Hypothesis	Same Criterion	Same Significance Level			

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Designated Use	Analytes	Analytical Tool	Determining when waters are impaired			Determining when waters are no longer impaired			Notes
			Decision Rule/ Hypothesis	Criterion Used with the Decision Rule ⁱⁱⁱ	Significance Level (α)	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule	Significance Level (α)	
(cont.)		nonparametric test will be used.	stream is the same as for a reference stream or control streams.	significantly less than reference or control streams.					
			Other biological monitoring to be determined by type of data.	Dependent upon available information.	Dependent upon available information.	Same Hypothesis	Same Criterion	Same Significance Level	
	Toxic chemicals in water: (Numeric)	Not applicable	No more than one toxic event, toxicity test failure or exceedance of acute or chronic criterion in 3 years.	Not applicable	Not applicable	Same Hypothesis	Same Criterion	Same Significance Level	
Toxic chemicals in sediments: (Narrative)	Comparison of geometric mean to PEC value, or calculation of a PECQ value.	Waters are judged to be impaired if parameter geomean exceeds PEC, or site PECQ is exceeded.	For metals use 150% PEC threshold. The PECQ threshold value is 0.75.	Not applicable	Water is judged to be unimpaired if parameter geomean is equal to or less than PEC, or site PECQ equaled or not exceeded.	For metals use 150% of PEC threshold. The PECQ threshold value is 0.75.	Not applicable	<p>Compliance with Water Quality Standards Note: In the case of toxic chemicals occurring in benthic sediment rather than in water, the numeric thresholds used to determine the need for further evaluation will be the Probable Effect Concentrations proposed in "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems" by MacDonald, D.D. <i>et al.</i> Arch. Environ. Contam. Toxicol. 39,20-31 (2000). These Probable Effect Concentrations are as follows: 33 mg/kg As; 4.98 mg/kg Cd; 111 mg/kg Cr; 149 mg/kg Cu; 48.6 mg/kg Ni; 128 mg/kg Pb; 459 mg/kg Zn; 561 µg/kg naphthalene; 1170</p>	

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DESCRIPTION OF ANALYTICAL TOOLS USED FOR DETERMINING THE STATUS OF MISSOURI WATERS (11" X 14" FOLD OUT)

Designated Use	Analytes	Analytical Tool	Determining when waters are impaired			Determining when waters are no longer impaired			Notes
			Decision Rule/ Hypothesis	Criterion Used with the Decision Rule ⁱⁱⁱ	Significance Level (α)	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule	Significance Level (α)	
Aquatic Life (cont.)									$\mu\text{g/kg}$ phenanthrene; 1520 $\mu\text{g/kg}$ pyrene; 1050 $\mu\text{g/kg}$ benzo(a)anthracene, 1290 $\mu\text{g/kg}$ chrysene; 1450 $\mu\text{g/kg}$ benzo(a)pyrene; 22,800 $\mu\text{g/kg}$ total polycyclic aromatic hydrocarbons; 676 $\mu\text{g/kg}$ total PCBs; chlordane 17.6 $\mu\text{g/kg}$; Sum DDE 31.3 $\mu\text{g/kg}$; lindane (gamma-BHC) 4.99 $\mu\text{g/kg}$. Where multiple sediment contaminants exist, the Probable Effect Concentrations Quotient shall not exceed 0.75. See Appendix D and Section II. D for more information on the Probable Effect Concentrations Quotient.
	Temperature, pH, total diss. gases, oil and grease, diss. oxygen (Numeric)	Binomial probability	Null Hypothesis: No more than 10% of samples exceed the water quality criterion.	Reject Null Hypothesis if the Type I error rate is less than 0.1.	Not applicable	Same Hypothesis	Same Criterion	Same Significance Level	Continuous Sampling (i.e. time series or sonde data collection): Data collected in a time series fashion will be looked at on a 4 day period. If an entire 4 day period is outside of the 6.5 – 9.0 criterion range that will count as a chronic toxicity event. More than one of these events will constitute an impairment listing of the stream. Grab Samples: Data collected as grab samples will be treated as is and the binomial probability calculation will be used for assessment.
Losing Streams	<i>E.coli</i>	Binomial probability	Null Hypothesis: No more than 10% of samples exceed the water quality criterion.	Reject Null Hypothesis if the Type I error rate is less than 0.1.	0.1	Same Hypothesis	Same Criterion	Same Significance Level	

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DESCRIPTION OF ANALYTICAL TOOLS USED FOR DETERMINING THE STATUS OF MISSOURI WATERS (11" X 14" FOLD OUT)

Designated Use	Analytes	Analytical Tool	Determining when waters are impaired			Determining when waters are no longer impaired			Notes
			Decision Rule/ Hypothesis	Criterion Used with the Decision Rule ⁱⁱⁱ	Significance Level (α)	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule	Significance Level (α)	
Human Health – Fish Consumption	Toxic chemicals in water (Numeric)	Hypothesis test: 1-sided confidence limit	Null Hypothesis: Levels of contaminants in water do not exceed criterion.	Reject Null Hypothesis if the 60% LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject Null Hypothesis if the 60% UCL is greater than the criterion value.	Same Significance Level	
	Toxic chemicals in tissue (Narrative)	Four or more samples: Hypothesis test 1-sided confidence limit	Null Hypothesis: Levels in fillet samples or fish eggs do not exceed criterion.	Reject Null Hypothesis if the 60% LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60% UCL is greater than the criterion value.	Same Significance Level	
Drinking Water Supply (Raw)	Toxic chemicals (Numeric)	Hypothesis test: 1-sided confidence limit	Null Hypothesis: Levels of contaminants do not exceed criterion.	Reject Null Hypothesis if the 60% LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60% UCL is greater than the criterion value.	Same Significance Level	
	Non-toxic chemicals (Numeric)	Hypothesis test: 1-sided confidence limit	Null Hypothesis: Levels of contaminants do not exceed criterion.	Reject Null Hypothesis: if the 60% LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60% UCL is greater than the criterion value.	Same Significance Level	
Drinking Water Supply (Finished)	Toxic chemicals	Methods stipulated by Safe Drinking Water Act.	Methods stipulated by Safe Drinking Water Act.	Methods stipulated by Safe Drinking Water Act.	Methods stipulated by Safe Drinking Water Act.	Same Hypothesis	Same Criterion	Same Significance Level	

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DESCRIPTION OF ANALYTICAL TOOLS USED FOR DETERMINING THE STATUS OF MISSOURI WATERS (11" X 14" FOLD OUT)

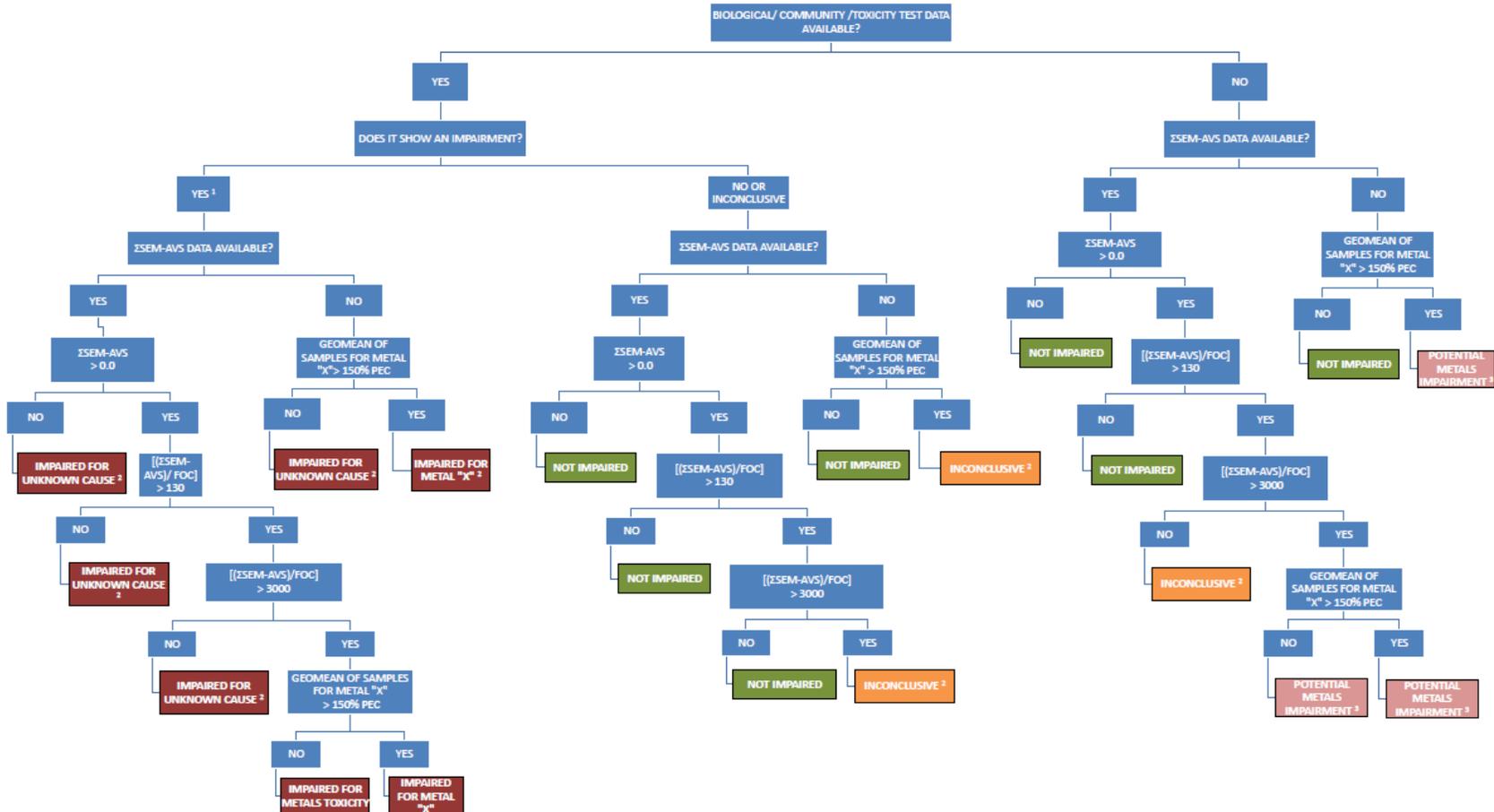
Designated Use	Analytes	Analytical Tool	Determining when waters are impaired			Determining when waters are no longer impaired			Notes
			Decision Rule/ Hypothesis	Criterion Used with the Decision Rule ⁱⁱⁱ	Significance Level (α)	Decision Rule/ Hypothesis	Criterion Used with the Decision Rule	Significance Level (α)	
Whole Body Contact and Secondary	Bacteria (Numeric)	Geometric mean	Null Hypothesis: Levels of contaminants do not exceed criterion.	Reject Null Hypothesis: if the geometric mean is greater than the criterion value.	Not Applicable	Same Hypothesis	Same Criterion	Not applicable	
Irrigation & Livestock Water	Toxic chemicals (Numeric)	Hypothesis test 1-Sided confidence limit	Null Hypothesis: Levels of contaminants do not exceed criterion.	Reject Null Hypothesis if the 60% LCL is greater than the criterion value.	0.4	Same Hypothesis	Reject null hypothesis if the 60% UCL is greater than the criterion value.	Same Significance Level	
Protection of Aquatic Life	Nutrients in lakes (Numeric – Site Specific)	Hypothesis test	Null hypothesis: Criteria are not exceeded.	Reject Null Hypothesis if 60% LCL value is greater than criterion value.	0.4	Same Hypothesis	Same Criterion	Same Significance Level	Hypothesis Test Note: State nutrient criteria require at least four samples per year taken near the outflow point of the lake (or reservoir) between May 1 and August 31 for at least four different, not necessarily consecutive, years.
Protection of Aquatic Life	Nutrients in lakes (Numeric – Ecogregional)	See Nutrient Implementation Plan	Methods stipulated by Nutrient Implementation Plan	Methods stipulated by Nutrient Implementation Plan	Methods stipulated by Nutrient Implementation Plan	Same Hypothesis	Same Criterion	Same Significance Level	Nutrient Implementation Plan was developed as an additional aspect of the Lake Nutrient Criteria package submitted to EPA. This implementation plan spells out how ecoregional lake nutrient criteria will be assessed. See Appendix F for the implementation plan.

ⁱⁱⁱ Where hypothesis testing is used for media other than fish tissue, for data sets with five samples or fewer, a 75 percent confidence interval around the appropriate central tendencies will be used to determine use attainment status. Use attainment will be determined as follows: (1) If the criterion value is above this interval (all values within the interval are in conformance with the criterion), rate as unimpaired; (2) If the criterion value falls within this interval, rate as unimpaired and place in Category 2B or 3B; (3) If the criterion value is below this interval (all values within the interval are not in conformance with the criterion), rate as impaired. For fish tissue, this procedure will be used with the following changes: (1) it will apply only to sample sizes of less than four and, (2) a 50% confidence interval will be used in place of the 75% confidence interval.

Appendix E

PICTORIAL REPRESENTATIONS OF THE WEIGHT OF EVIDENCE PROCEDURE FOR JUDGING TOXICITY OF SEDIMENT DUE TO METALS AND PAHS

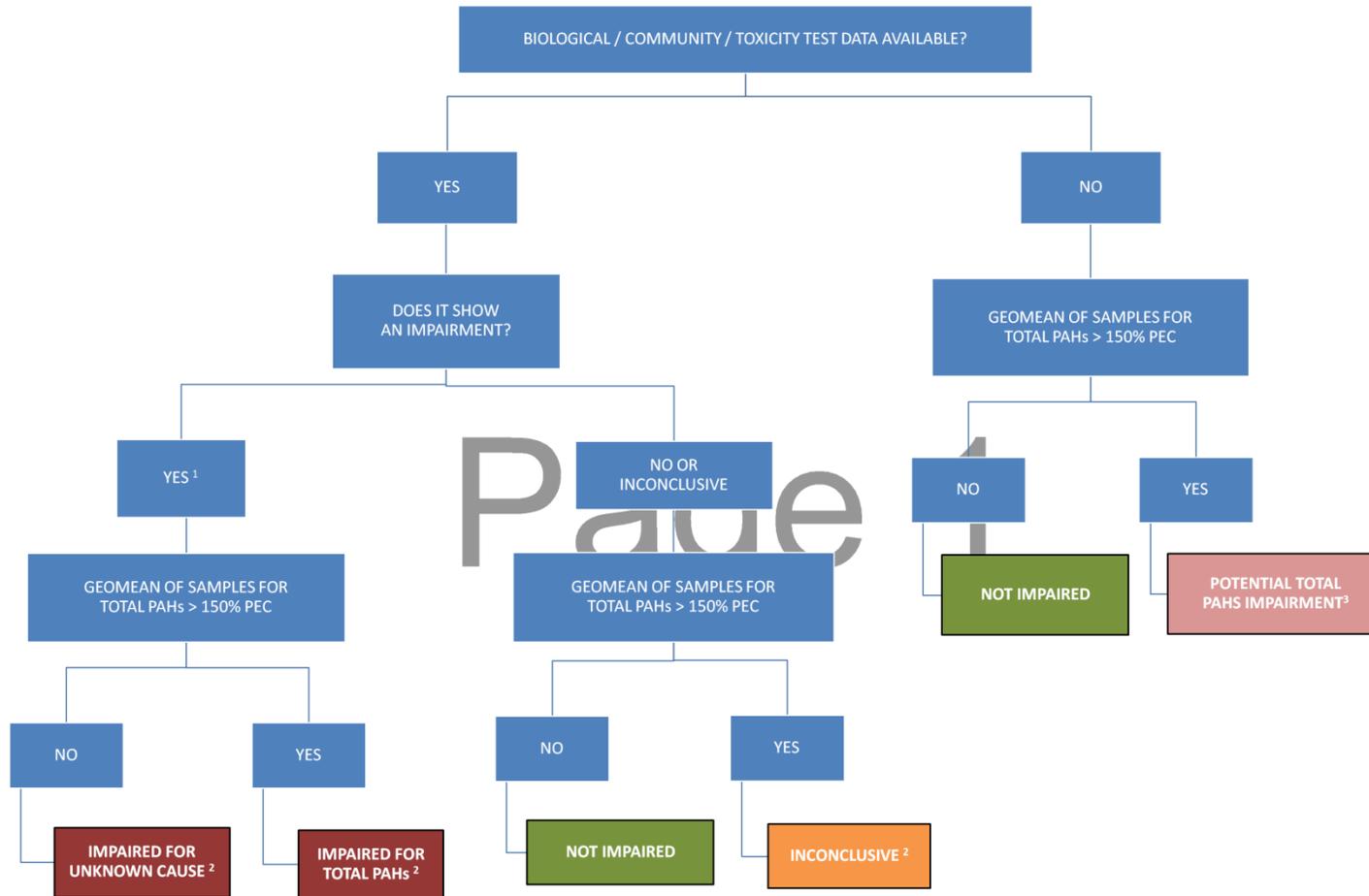
Biological Weight of Evidence Decision Chart - Sediment Toxicity (Metals)



Notes:

- 1 - If there are Numeric WQS violations (unrelated to sediment) then follow LMD Procedure in LMD Appendix B. **Do Not Continue.**
- 2 - Note waterbody for further investigation related to metals or habitat issues.
- 3 - Note waterbody for Biological Sampling.

Biological Weight of Evidence Decision Chart - Sediment Toxicity (PAHs)



Notes:

1 - If there are Numeric WQS violations (unrelated to sediment) then follow LMD Procedure in LMD Appendix B. Do Not Continue.

2 - Note waterbody for further investigation.

3 - Note waterbody for Biological Sampling.

Appendix F

NUTRIENT CRITERIA IMPLEMENTATION PLAN



Nutrient Criteria Implementation Plan

July 27, 2018

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Purpose

Section 304(a) of the federal Clean Water Act provides the framework for states to develop Water Quality Standards (WQS) that protect the physical, chemical, and biological integrity of their waters. The Missouri Department of Natural Resources (Department) is fully delegated by the US Environmental Protection Agency (EPA) to conduct WQS revisions pursuant to the federal Clean Water Act. Changes to Missouri's WQS [10 Code of State Regulations (CSR) 20-7.031] were published on March 31, 2018. One major revision to the WQS is the incorporation of numeric nutrient criteria for lakes.

This plan describes how the Department intends to implement nutrient criteria in accordance with the newly revised WQS. This plan does not prohibit establishing alternative methods of analysis, permit limits, or requirements provided that the alternatives are technically sound, consistent with state and federal regulations, and are protective of water quality. All permitting will be consistent with federal and state requirements.

Background

Eutrophication is the process by which a body of water becomes enriched in nutrients, such as nitrogen and phosphorus, which stimulate the excessive growth of algae and other plants. Eutrophication may be accelerated by human activities. It is well documented that enrichment of nutrients can lead to increased production of algae and aquatic plants in freshwater systems. This increased production may result in nonattainment of beneficial uses under certain environmental conditions. Aquatic life protection uses can be negatively impacted by excess nutrient loading, which may increase the likelihood of fish kills caused by the depletion of dissolved oxygen (DO). Aquatic diversity can be undermined by creating conditions favorable to fast-growing species, such as carp and other benthivores, at the expense of other species (Edgerton and Downing, 2004).

The Department utilizes regulatory and incentive-based approaches to ensure excessive nutrients do not impair or degrade beneficial uses. Regulatory approaches such as nutrient effluent limitations and nutrient WQS are implemented by the Department's Water Protection Program. Incentive-based approaches to nutrient reduction through education, outreach, and the execution of best management practices are implemented by the Department's Soil and Water Conservation Program using federal and state funds.

Missouri's Nutrient Criteria

Missouri Lakes and Reservoirs

For the purposes of Missouri's nutrient criteria and this document, all lakes and reservoirs are referred to as "lakes" [10 CSR 20-7.031(5)(N)1.A.]. Missouri's lakes are more appropriately classified as impoundments and have very different physical, chemical, and biological characteristics when compared to naturally-formed glacial or mountainous lakes found in other states. Many of Missouri's major lakes were constructed primarily for flood control, hydroelectric power, and water supply. The riverine habitats and species that existed before impoundment over time transitioned into the current state of aquatic life dominated by self-sustaining populations of sport and non-sport fishes. The numeric nutrient criteria and implementation methods proposed by the Department are structured to ensure the deleterious impacts of nutrient enrichment to Missouri's lakes are mitigated without adverse impacts to the health and vitality of the self-sustaining populations of aquatic life that live there.

Missouri's nutrient criteria apply to all lakes that are waters of the state and have an area of at least ten (10) acres during normal pool condition, except the natural lakes (oxbows) in the Big River Floodplain ecoregion [10 CSR 20-7.031(5)(N)2.]. The criteria apply to, and assessments will be conducted for, the entire water body as found in Missouri's WQS regulation. As noted in the *Rationale for Missouri Lake Nutrient Criteria* (DNR, 2017), the Department has structured Missouri's nutrient criteria as a decision framework that applies at an ecoregional basis. This decision framework integrates causal and response parameters into one water quality standard that accounts for uncertainty in linkages between causal and response parameters. The decision framework includes response impairment thresholds, nutrient screening thresholds, and response assessment endpoints. This framework appropriately integrates causal and response parameters and is based on the bioconfirmation guiding principles that EPA (2013) has suggested as an approach for developing nutrient criteria.

Numeric Criteria for Lakes [10 CSR 20-7.031(5)(N)]

Missouri's WQS contain response impairment threshold values for chlorophyll-a (Chl-a) and screening threshold values for total nitrogen (TN), total phosphorus (TP), and Chl-a, all of which vary by the dominant watershed ecoregion. Lakes are determined to be impaired if the geometric mean of samples taken between May and September in a calendar year exceeds the Chl-a response impairment threshold value more than once in three years' time. A duration of three or more years is necessary to account for natural variations in nutrient levels due to climatic variability (Jones and Knowlton, 2005). If a lake exceeds a screening threshold value, it will be designated as impaired if any of five response assessment endpoints also are identified in the same calendar year.

Lake Ecoregion	Chl-a Response Impairment Thresholds (µg/L)	Nutrient Screening Thresholds (µg/L)		
		TP	TN	Chl-a
Plains	30	49	843	18
Ozark Boarder	22	40	733	13
Ozark Highland	15	16	401	6

The five response assessment endpoints are:

- Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms
- Epilimnetic excursions from dissolved oxygen or pH criteria
- Cyanobacteria counts in excess of 100,000 cells/mL
- Observed shifts in aquatic diversity attributed to eutrophication
- Excessive levels of mineral turbidity that consistently limit algal productivity during the period of May 1 – September 30

All scientific references used for numeric nutrient criteria derivation are contained in the *Rationale for Missouri Lake Nutrient Criteria* (DNR, 2017) and supplemental materials maintained by the Department. The Department maintains a copy of these references and makes them available to the public for inspection and copying at no more than the actual cost of reproduction.

Narrative Criteria [10 CSR 20-7.031(4)]

Missouri's WQS contain general (narrative) water quality criteria that are used to protect waters from nutrient enrichment caused by excessive nitrogen and/or phosphorous loading. Missouri's general criteria protect waters from "unsightly or harmful bottom deposits" and "unsightly color or turbidity," which are potential consequences of excess nutrients in freshwater systems. Narrative criteria do not provide numeric thresholds or concentrations above which impacts to designated uses are likely to occur. However, because the bioconfirmation approach integrates causal and response variables to ensure attainment of the aquatic habitat protection use, the proposed numeric nutrient criteria and screening thresholds serve as an enforceable interpretation of Missouri's general criteria at 10 CSR 20-7.031(4). Additionally, implementation of the numeric nutrient criteria and screening thresholds also will ensure protection of downstream waters as required by 10 CSR 20-7.031(4)(E) and 40 CFR 131.10(b).

Site-Specific Numeric Criteria [10 CSR 20-7.031(5)(N)]

Missouri's WQS also contain numeric nutrient criteria for specific lakes. Each of the lakes listed in Table N of the WQS have site-specific criteria for TN, TP, and Chl-a, based on the annual geometric mean of a minimum of three years of data and characteristics of the lake. Additional site-specific criteria may be developed to account for the unique characteristics of a water body.

Part I. Monitoring and Assessment

Monitoring Efforts

The Department currently has data on approximately 12% of Missouri lakes, representing 83% of lake acres. Based on past resources and progress, the Department expects to have data on most lakes that are subject to the WQS within ten years. The Department will prioritize data collection on lakes without sufficient data by identifying relevant bodies of water that, because of location or activity, are most likely to have an impairment or are most vulnerable to the impacts of nutrients. Missouri has identified this gap (GAP 5.2) in our Monitoring Strategy Document found at <https://dnr.mo.gov/env/wpp/waterquality/303d/docs/2015-monitoring-strategy-final.pdf>. The Department coordinates with EPA to update the Monitoring Strategy Document every five years.

The Department has a cooperative agreement with the University of Missouri (MU) to collect data on lakes statewide. This cooperative agreement utilizes Section 319 funds, as well as match funds from MU, to collect data sufficient to characterize and assess lake water quality in accordance with Sections 303(d) and 305(b) of the federal Clean Water Act. MU operates two programs that are funded through the cooperative agreement: 1) the Statewide Lake Assessment Program, and 2) the Lakes of Missouri Volunteer Program. MU has been collecting and analyzing data on lakes throughout the state since 1989.

As part of the cooperative agreement, these programs submit, and the Department approves, Quality Assurance Project Plans (QAPPs) that detail the following:

- Parameters – data to be collected
- Sampling Methods – how the data are collected
- Personnel – who collects the data
- Analytical Methods – how the data are analyzed
- Laboratory – who analyzes the data
- Quality Assurance Review – who quality assures the data
- Reporting – to whom the data are reported

Lakes of Missouri Volunteer Program (LMVP)

The LMVP identifies volunteers to assist MU in collecting information on lakes across Missouri. Volunteers are trained by MU staff and follow the approved protocols in the QAPP. The samples collected are analyzed by the MU laboratory. Volunteer data are checked through MU audits to ensure their data are of the same quality as data collected by MU staff. These data typically are collected 4-8 times per year from April through September.

The samples collected by LMVP volunteers are analyzed for:

- Total Nitrogen
- Total Phosphorus
- Total Chlorophyll
- Chlorophyll-a
- Pheophytin-a
- Inorganic Suspended Solids
- Organic Suspended Solids
- Total Suspended Solids
- Microcystin
- Cylindrospermopsin

*Water temperature and Secchi depth also are recorded with each sample.

Statewide Lake Assessment Program (SLAP)

The SLAP is composed of MU staff who collect water samples, as well as depth profiles, on lakes across the state.

The samples collected by SLAP staff are analyzed for:

- Total Nitrogen
- Total Phosphorus
- Total Chlorophyll
- Chlorophyll-a
- Pheophytin-a
- Inorganic Suspended Solids
- Organic Suspended Solids
- Total Suspended Solids
- Microcystin*
- Cylindrospermopsin*
- Anatoxin-a*
- Saxitoxin*

*Algal toxins started in summer of 2018.

The depth profiles consist of a composite sample of the epilimnion and include continuous sonde measurements for:

- Depth
- Temperature
- Dissolved Oxygen % Saturation
- Dissolved Oxygen Concentration
- Conductivity
- pH
- Turbidity
- Phycocyanins
- Chlorophyll
- Oxidizing/Reducing Potential

In addition to these parameters, in 2018 MU will begin collecting light-availability data through the use of a Li-Cor quantum sensor. Data collected with this equipment consist of light attenuation and photosynthetically active radiation (PAR).

The SLAP collects long-term data on 38 lakes throughout the state to assess water quality and to conduct long-term trend analysis. The SLAP also collects data on approximately 40 lakes which can be rotated every 3-4 years. Starting in 2019, the Department will work with the SLAP to expand monitoring or add priority lakes for additional data collection needs. See Assessment Methodology Section for identification of priorities during assessment.

Data Requirements for Assessment

In order to assess a lake against the numeric nutrient criteria in 10 CSR 20-7.031(5)(N), the following data requirements must be met:

1. At least four samples collected between May 1 and September 30 under representative conditions;
2. Each sample must have been analyzed for at least Chl-a, TN, TP, and Secchi depth;
3. At least three years of samples (years do not have to be consecutive). Data older than seven years will not be considered, consistent with the Department's Listing Methodology (see Appendix B);
4. Data collected under a QAPP.

If these requirements are not met, the lake will be placed into Category 3 of Missouri's Integrated Water Quality Report (i.e., Missouri's 305(b) Report) until further information can be collected. In the case of lakes that have some data, but not enough to make an assessment, these lakes will be prioritized for additional sampling. Lakes with limited data where water quality trends or field observations point to possible impairment will receive the highest priority.

Criteria for Assessment

Each lake will be evaluated against the appropriate ecoregional or site-specific criteria located in Tables L, M, and N of 10 CSR 20-7.031 (reproduced below).

Table L: Lake Ecoregion Chl-a Response Impairment Threshold Values (µg/L)

Lake Ecoregion	Chl-a Response Impairment Thresholds
Plains	30
Ozark Border	22
Ozark Highland	15

Table M: Lake Ecoregion Nutrient Screening Threshold Values (µg/L)

Lake Ecoregion	Nutrient Screening Thresholds		
	TP	TN	Chl-a
Plains	49	843	18
Ozark Border	40	733	13
Ozark Highland	16	401	6

Table N: Site-Specific Nutrient Criteria

Lake Ecoregion	Lake	County	Site-Specific Criteria (µg/L)		
			TP	TN	Chl-a
Plains	Bowling Green Lake	Pike	21	502	6.5
	Bowling Green Lake (old)	Pike	31	506	5
	Forest Lake	Adair	21	412	4.3
	Fox Valley Lake	Clark	17	581	6.3
	Hazel Creek Lake	Adair	27	616	6.9
	Lincoln Lake – Cuivre River State Park	Lincoln	16	413	4.3
	Marie, Lake	Mercer	14	444	3.6
	Nehai Tonkaia Lake	Chariton	15	418	2.7
	Viking, Lake	Daviess	25	509	7.8
	Waukomis Lake	Platte	25	553	11
Ozark Border	Weatherby Lake	Platte	16	363	5.1
	Goose Creek Lake	St Francois	12	383	3.2
Ozark Highland	Wauwanoka, Lake	Jefferson	12	384	6.1
	Clearwater Lake	Wayne-Reynolds	13	220	2.6
	Council Bluff Lake	Iron	7	229	2.1
	Crane Lake	Iron	9	240	2.6
	Fourche Lake	Ripley	9	236	2.1
	Loggers Lake	Shannon	9	200	2.6
	Lower Taum Sauk Lake	Reynolds	9	203	2.6
	Noblett Lake	Douglas	9	211	2
	St. Joe State Park Lakes	St Francois	9	253	2
	Sunnen Lake	Washington	9	274	2.6
	Table Rock Lake	Stone	9	253	2.6
	Terre du Lac Lakes	St Francois	9	284	1.7
Timberline Lakes	St Francois	8	276	1.5	

Assessment Methodology

The Department requests and actively seeks out readily available data on all waters within the state. These data are reviewed for proper quality assurance and quality control measures, and then the data are compiled by the Department into Missouri's Water Quality Assessment database.

Every two years, the Department assesses the designated uses of all waters protected by 10 CSR 20-7.031. Once assessments have been completed, the Department creates spreadsheets of data for all impaired (303(d) List) and delisted waters. The Department then places the spreadsheets, as well as the list of impaired waters, on the Department's website for a 90-day public notice period. After the public notice period ends, the Department responds to any public comments and makes any applicable changes to the spreadsheets or the list of impaired waters. The Department then asks the Missouri Clean Water Commission to approve the impaired waters list. After the Commission's approval, the Department submits all of the information used in the assessment decision process to EPA for approval.

1. Site-Specific Lake Nutrient Criteria

Lakes with site-specific numeric nutrient criteria (see Table N of 10 CSR 20-7.031) will be assessed using the current listing methodology. Missouri has a state regulation, 10 CSR 20-7.050, which requires a methodology be created and followed for the development of an impaired waters list. Missouri develops and provides public notice of the methodology every two years concurrently with the 303(d) List. The methodology is approved by the Missouri Clean Water Commission before the Department can use it for assessments. The Department currently assesses against the existing site-specific lake nutrient criteria in the water quality standards (now Table N of 10 CSR 20-7.031). See the Department's 2020 Listing Methodology in Appendix B for details. Table 1 below shows the current list of impaired lakes assessed according to the site-specific criteria.

Table 1. List of Impaired Lakes with Site-Specific Criteria

Year	WBID	Waterbody	WB Size	Units	IU	Pollutant
2014	7003	Bowling Green Lake - Old	7	Acres	AQL	Chl-a
2012	7003	Bowling Green Lake - Old	7	Acres	AQL	TN
2012	7003	Bowling Green Lake - Old	7	Acres	AQL	TP
2014	7326	Clearwater Lake	1635	Acres	AQL	Chl-a
2016	7326	Clearwater Lake	1635	Acres	AQL	TP
2016	7334	Crane Lake	109	Acres	AQL	Chl-a
2016	7334	Crane Lake	109	Acres	AQL	TP
2010	7151	Forest Lake	580	Acres	AQL	Chl-a
2010	7151	Forest Lake	580	Acres	AQL	TN
2010	7151	Forest Lake	580	Acres	AQL	TP
2018	7324	Fourche Lake	49	Acres	AQL	Chl-a
2018	7324	Fourche Lake	49	Acres	AQL	TN
2014	7008	Fox Valley Lake	89	Acres	AQL	Chl-a
2014	7008	Fox Valley Lake	89	Acres	AQL	TN
2010	7008	Fox Valley Lake	89	Acres	AQL	TP
2010	7152	Hazel Creek Lake	453	Acres	AQL	Chl-a
2018	7152	Hazel Creek Lake	453	Acres	AQL	TN
2018	7049	Lake Lincoln	88	Acres	AQL	Chl-a
2018	7301	Monsanto Lake	18	Acres	AQL	Chl-a
2016	7301	Monsanto Lake	18	Acres	AQL	TN
2018	7301	Monsanto Lake	18	Acres	AQL	TP
2014	7316	Noblett Lake	26	Acres	AQL	Chl-a
2014	7316	Noblett Lake	26	Acres	AQL	TP
2002	7313	Table Rock Lake	41747	Acres	AQL	Chl-a
2002	7313	Table Rock Lake	41747	Acres	AQL	TN
2012	7071	Weatherby Lake	185	Acres	AQL	Chl-a
2010	7071	Weatherby Lake	185	Acres	AQL	TN
2014	7071	Weatherby Lake	185	Acres	AQL	TP

2. Ecoregional Lake Nutrient Criteria

Lakes with ecoregional nutrient criteria (see Tables L and M of 10 CSR 20-7.031) will be assessed using the following methodology:

- a. For lakes with ecoregional criteria, a yearly geometric mean for Chl-a, TN, and TP will be calculated for the period of record. The latest three years (do not have to be consecutive) of data will be used for assessment. These data are collected by the SLAP and the LMVP.
- b. If the geometric mean of Chl-a exceeds the response impairment threshold in more than one of the latest three years of available data, the lake will be placed into Category 5 of Missouri's Integrated Report (IR) and go on the 303(d) List for Chl-a. If only two years of data are available and the geometric mean of Chl-a exceeds the response impairment threshold in both years, the lake will be placed into Category 5 of Missouri's IR and go on the 303(d) List for Chl-a.

- c. If the geometric mean of Chl-a, TN, or TP exceeds the nutrient screening threshold, then additional response assessment endpoints will be evaluated (see Assessment Methodology Section #3 “Additional Lake Response Assessment Endpoints” below). If data for any of the response assessment endpoints indicates impairment in the same year that Chl-a, TN, or TP exceeds the nutrient screening threshold, the lake will be placed into Category 5 of Missouri’s IR. If sufficient data are not available to assess the response assessment endpoints or they do not show impairment, then the water will be placed into Category 3B or 2B, respectively (assuming other uses are attaining) and prioritized for additional monitoring and ongoing evaluation of response assessment endpoints (see Monitoring Efforts Section). If a lake that is sampled in the LMVP is placed in Category 3B or 2B, then it may be moved to the SLAP to ensure all nutrient screening threshold data needed to complete a full assessment are available. The Department is committed to providing the data needed to complete the full assessment.
- d. If the geometric mean of Chl-a, TN, or TP does not exceed the nutrient screening threshold, the water will be placed into the appropriate IR category based on the attainment of the other uses.
- e. The period of record for the lake will be reviewed for the purpose of determining long-term trends in water quality. If a lake is determined to be trending towards potential impairment, the lake will be further scrutinized and prioritized for additional monitoring (see Monitoring Efforts and Trend Analysis Sections).
- f. The Department’s Listing Methodology Document will be updated to reflect the methodology outlined in this implementation plan as soon as possible after EPA approval of the ecoregional lake nutrient criteria.

3. Additional Lake Response Assessment Endpoints

For lakes where the geometric mean of Chl-a, TN, or TP exceeds the ecoregional nutrient screening thresholds, the additional response assessment endpoints listed below will be evaluated. Each of these endpoints is linked to the protection of the aquatic habitat designated use and will be used to assess compliance with the numeric nutrient criteria when screening values are exceeded. When one of these endpoints indicate a eutrophication impact in the same year as a nutrient screening threshold exceedance, the lake will be placed into Category 5 and on the 303(d) List.

Response assessment endpoints observed in lakes without sufficient data for Chl-a, TP, or TN will be prioritized highest for additional sampling of Chl-a, TP, and TN.

- a. 10 CSR 20-7.031(5)(N)6.A. – Occurrence of eutrophication-related mortality or morbidity events for fish and other aquatic organisms (i.e., fish kills)
 - Following the Department’s Listing Methodology Document (see Appendix B), two or more fish kills within the last three years of available data will result in the water being placed into Category 5 as well as the 303(d) List.

- Fish kills as a result of nutrient enrichment (eutrophication) in a lake indicate that current water quality may not be protective of the aquatic habitat designated use. The Department maintains contact with the Missouri Department of Conservation (MDC) on fish kills that occur throughout the state. MDC, as well as the Department's Environmental Emergency Response and Water Protection Program, receive notifications of observed fish kills. MDC investigates all reported fish kills and provides a summary report of the species, size, and number of fish and other aquatic organisms killed. These reports are provided shortly after the investigation. Annual fish kill reports are compiled and provided to the Department.

One such example of a fish kill annual report is MDC's Missouri Pollution and Fish Kill Investigations 2017 (published April 2018). The Department will continue to request these data and annual reports from MDC. This document includes fish kill data and causes as well as describes the methods used by MDC to assess fish kills.

- The Department will review reports for information pertaining to the cause of death as well as the potential sources. Fish populations can have seemingly random small die-offs related to disease, virus, or other natural causes. The Department will focus on die-offs related to dissolved oxygen, temperature, pH, algal blooms, and the toxins associated with algal blooms. More than one fish kill within ten years or one large (>100 fish and covering more than ten percent of the lake area) fish kill documented to be caused by dissolved oxygen excursions, pH, algal blooms, or the toxins associated with algal blooms will constitute evidence of impairment.

b. 10 CSR 20-7.031(5)(N)6.B. – Epilimnetic excursions from dissolved oxygen or pH criteria

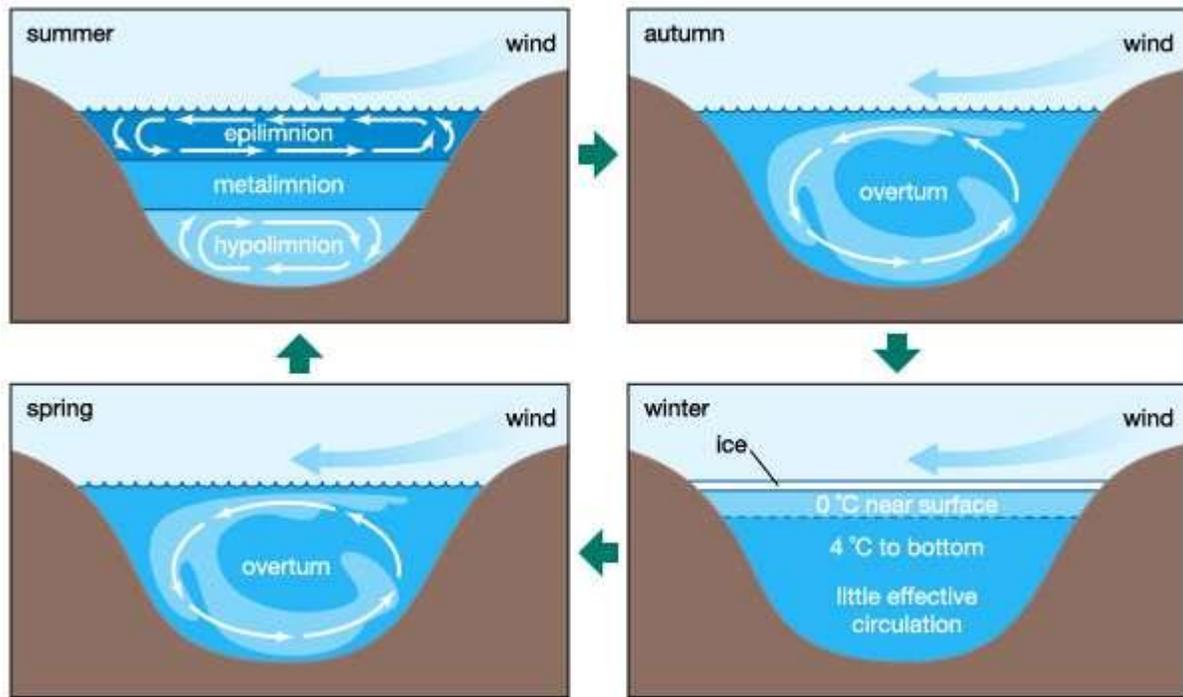
In lakes, DO is produced by atmospheric reaeration and the photosynthetic activity of aquatic plants and consumed through respiration. DO production by aquatic plants (primarily phytoplankton in Missouri reservoirs) is limited to the euphotic zone where sufficient light exists to support photosynthesis. In some lakes, reaeration and photosynthesis may be sufficient to support high DO levels throughout the water column during periods of complete mixing. Missouri lakes however, do not stay completely mixed and thermally stratify during the summer (Figure 1). The duration, depth, and areal extent of stratification in any lake is a function of site-specific lake variables and environmental factors. During the stratified period, the epilimnion (surface water layer) receives oxygen from the atmosphere and is dominated by primary production from phytoplankton and other aquatic plants. In contrast, the hypolimnion (deep, cool water zone) is largely separated from the epilimnion (surface layer) and is dominated by respiratory processes that use organic matter derived from autochthonous (in-lake) and allochthonous (watershed) sources. The strong temperature gradient between the epilimnion and hypolimnion generally restricts gas and nutrient circulation and limits the movement of phytoplankton between the layers. As a result, respiration in the hypolimnion creates hypoxic conditions during the stratification period.

Data collected by the MU demonstrates that hypoxic hypolimnetic conditions (absent of DO) consistently occur during the summer in Missouri lakes regardless of trophic

condition. Further, anoxic hypolimnetic conditions have even been measured in Missouri's high-quality oligotrophic lakes. It is apparent from the science and available data that low hypolimnetic DO conditions are the result of natural processes and should be expected in all lakes across the state. Thermal stratification and resulting anoxic hypolimnia limit the area where some more sensitive fish species thrive to the epilimnion. Assessment of DO in the epilimnion of lakes will ensure the protection of aquatic life and aquatic habitat designated use and the maintenance of a robust aquatic community. Therefore, it would be inappropriate to apply the 5.0 milligrams per liter DO criterion throughout the entire water column.

DO and pH criterion will apply only to the epilimnion during thermal stratification. DO and pH criteria will apply throughout the water column outside of thermal stratification.

Figure 1. Diagram of Typical Lake Stratification in Missouri



Excess nutrient input into lakes causes an increase in primary productivity of a lake. This increase in productivity comes with an increasing demand for DO through both the living and the decaying portions of aquatic life. Increased productivity also causes algal populations to have exponential growth and decay rates that can cause swings in DO concentrations. Sudden drops in DO concentrations or low levels of DO concentrations can cause fish kills.

Similar to DO, water column pH levels are linked to photosynthesis and impacted by thermal stratification. During periods of high photosynthesis, carbon dioxide (CO₂) is removed from the water column and pH increases. Conversely, when respiration and decomposition is high, CO₂ levels increase and pH decreases. As described above, the natural temperature gradients during the summer growing season create conditions whereby the epilimnion is dominated by primary production and the hypolimnion is dominated by respiration. Therefore, the pH

levels will typically be higher in the epilimnion and lower in the hypolimnion. Because the nutrient criteria are focused on the biological response variable Chl-a, which is highest in the epilimnion in the summer, it is appropriate to limit pH assessments to the epilimnion.

Excessive algal production can cause the pH of the epilimnion to rise above 9.0 in some cases. When pH falls outside of this range due to algal blooms and their eventual decomposition, aquatic life which requires a stable range of pH conditions to survive can suffer. As mentioned for dissolved oxygen, assessment of pH in the epilimnion of lakes against WQS will ensure the protection of aquatic life and the aquatic habitat designated use, and the maintenance of a robust aquatic community.

- At the time of sample collection, DO, water temperature, and pH will be measured near the surface as well as via sonde probe throughout the depth of the epilimnion (water surface to the thermocline). The sonde probe continuously collects data for a short period of time as it is lowered through the water column. This data is currently collected by the SLAP.
 - Following the Listing Methodology Document procedure for DO: If more than 10% of the measurements are below the 5.0 mg/L minimum to protect aquatic life, the binomial probability will be used for to determine whether the criterion has been exceeded.
 - Following the Listing Methodology Document procedure for pH: If more than 10% of the measurements are outside the 6.5 to 9.0 range to protect aquatic life, the binomial probability will be used to determine whether the criterion has been exceeded.
- c. 10 CSR 20-7.031(5)(N)6.C. – Cyanobacteria counts in excess of one hundred thousand (100,000) cells per milliliter (cells/mL)

Cell counts of cyanobacteria (blue-green algae) greater than 100,000 can be indicative of a harmful algal bloom (HAB) and the increased probability of algal toxins in the lake. Certain species of blue-green algae can produce toxins harmful to both aquatic life and terrestrial life (including humans and pets). *Microcystis* can produce microcystin (liver toxin) and anatoxin-a (neurotoxin). *Dolichospermum*, in addition to producing microcystin and anatoxin-a, also can produce cylindrospermopsin (liver toxin) and saxitoxin (nerve toxin). These toxins can cause adverse effects on aquatic life, as well as humans recreating on surface waters. The Oregon Health Authority has developed recreational guidelines for issuing public health advisories in relation to algal toxins (Oregon Health Authority, 2018). Until EPA develops Section 304(a) criteria for algal toxins, the values contained in the Oregon Health Authority document will serve as a surrogate indicator that Section 101(a) uses (i.e., aquatic habitat protection and recreational uses) are not being met. Direct measurement of cyanobacteria cell counts is limited and currently prohibitively expensive. Until this method becomes more widely adopted or technology improves to reduce the cost, the Department will collect data on algal toxin concentrations as a surrogate indicator for cyanobacteria counts.

- Cyanobacteria counts greater than 100,000 cells/mL suggest the presence and impact of a HAB in the water body. HABs and the algal toxins they produce pose a threat to the aquatic habitat protection and recreational designated uses (Oregon Health Authority, 2018). This data may be collected by agencies or county governments and, when available, the Department will request and use this information. The cyanobacteria cell count is based on the threat of unacceptable levels of algal toxins, which are currently being collected by the SLAP and the LMVP.
- Any algal toxin values exceeding the following thresholds during the same year one of the nutrient screening levels was exceeded will constitute evidence of impairment. Two of these toxins currently are collected by the SLAP and the LMVP. The SLAP will begin collecting all four in 2018.

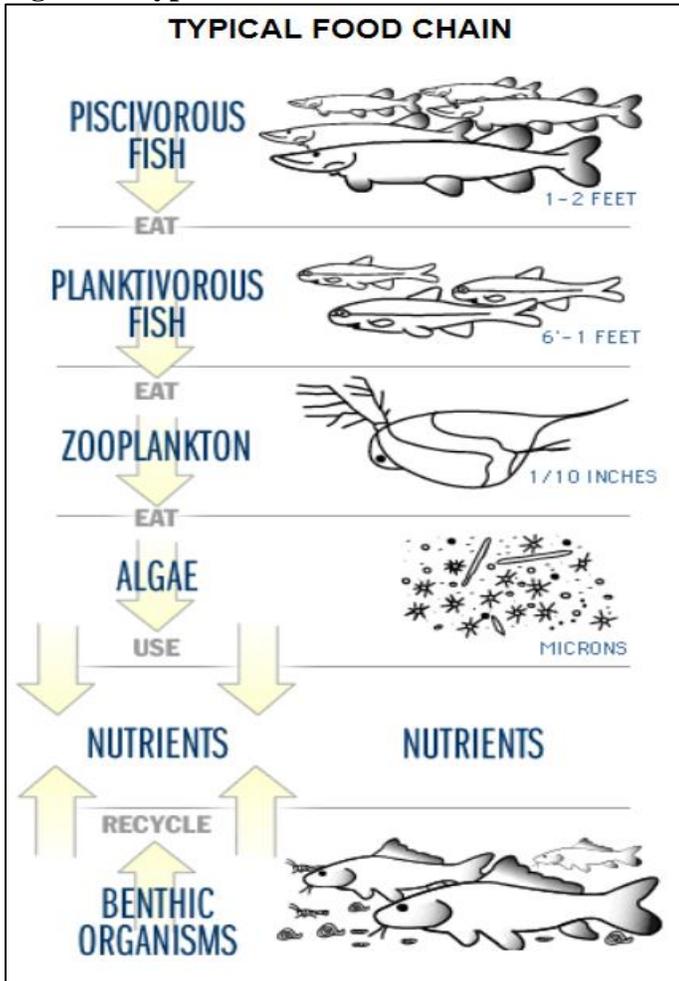
Microcystin	4.0 µg/L
Cylindospermopsin	8.0 µg/L
Anatoxin-a	8.0 µg/L
Saxitoxin	4.0 µg/L

These toxin levels are associated with a total toxigenic algal species cell count greater than or equal to 100,000 cells/mL. They also are associated with an algal cell count of greater than or equal to 40,000 cells/mL of Microcystis or Planktothrix species.

- d. 10 CSR 20-7.031(5)(N)6.D. – Observed shifts in aquatic diversity attributed to eutrophication

The health of an ecosystem can be assessed by looking at different aspects, one of which is the food web or chain (Figure 2). Chemical measurements can be taken to assess the nutrients and chlorophyll (as a surrogate for algae). Relative abundances of fish at the various levels of the food chain can be surveyed to see if it is in balance. High nutrient inputs along with high levels of suspended solids can cause a decrease in the number of sight-feeding predators and an increase in the number of the prey that the predators are unable to catch. More numerous prey put a strain on the resources available, resulting in smaller prey and smaller, less numerous predators. This imbalance in the number and/or size of fish, or a shift to less sight-feeding fish in favor of bottom-feeding fish such as carp, due to eutrophication is a cause for concern.

Figure 2. Typical Food Chain in Missouri Lakes



<http://www.lakeaccess.org>

As the state agency responsible for the protection and management of fish, forest, and wildlife resources, MDC regularly monitors populations of primary sport fishes (black bass, crappie, catfish) in major reservoirs (typically annually) to ensure the agency has appropriate regulations in place to manage these fish populations for today and into the future. These populations of piscivorous (i.e., fish eating) sport fish, and the many planktivorous (i.e., plankton eating) non-sport fish that are their prey, are self-sustaining in Missouri’s major reservoirs. Correspondence with MDC Fisheries Division confirms the agency does not conduct supplemental stocking for primary sport fishes (i.e., apex predators), nor does the agency conduct supplemental stocking of non-sport fish lower down the food chain (MDC, 2018).

Although MDC does not stock the primary sport and non-sport fishes noted above, MDC does stock additional fish species to provide a “bonus” or “specialty” sport fishing opportunity. Species included in the bonus or specialty fishing opportunities include (but are not limited to) paddlefish, rainbow trout, brown trout, striped bass, hybrid striped bass, walleye, and muskellunge. Many of these fish species are non-native and would not be capable of reproducing or sustaining populations in Missouri lakes.

MDC uses various sampling techniques including electrofishing, netting, creel surveys, and angler surveys to collect information related to fish populations and angler satisfaction over time. These data help to inform MDC's regulations for the capture of fish within Missouri lakes to ensure self-sustaining populations of sport- and non-sport fishes. The Department, in consultation with MDC, will use these data to determine whether shifts in aquatic diversity attributed to eutrophication are occurring in a lake. These data are contained within MDC's Fisheries Information Network System (FINS) and annual reports of fish stocking activities such as the "Fish Stocking for Public Fishing and Aquatic Resource Education." In support of this approach, the last eight calendar year reports (CY 2010 – 2017) generated by MDC and supporting data have been included with this submittal.

- The Department will request any available information on the potential biological shifts in fish or invertebrate communities related to eutrophication. This includes data from other agencies (such as the U.S. Fish and Wildlife Service) that monitor the populations of game fish.
 - The MDC regularly monitors fish populations of primary sport fishes (black bass, crappie, and catfish) in major reservoirs (typically annually) to ensure the agency has appropriate regulations in place to manage these fish populations for today and into the future. These populations of sport-fish, and the non-sportfish that are their prey, are self-sustaining in Missouri's major reservoirs.
 - The MDC uses various sampling techniques including electrofishing, netting, creel surveys, and angler surveys to collect information related to fish populations and angler satisfaction over time. These data in consultation with MDC will be used to determine whether shifts in aquatic diversity attributed to eutrophication are occurring in a lake.
 - The MDC produces annual fishery management reports for Missouri's major lakes and reservoirs that detail the health of the fishery and includes number of species, catch per unit effort, relative density of fish and measures of fish condition and population size structure. One such example of an annual fishery management report is the Stockton Reservoir 2017 Annual Lake Report (published March 2018). The data supporting MDC's annual fishery management reports can also be made available to the Department. The Missouri Department of Natural Resources will request these annual reports and data from MDC.
- e. 10 CSR 20-7.031(5)(N)6.E. – Excessive levels of mineral turbidity that consistently limit algal productivity during the period May 1 – September 30 (i.e., light limitations)

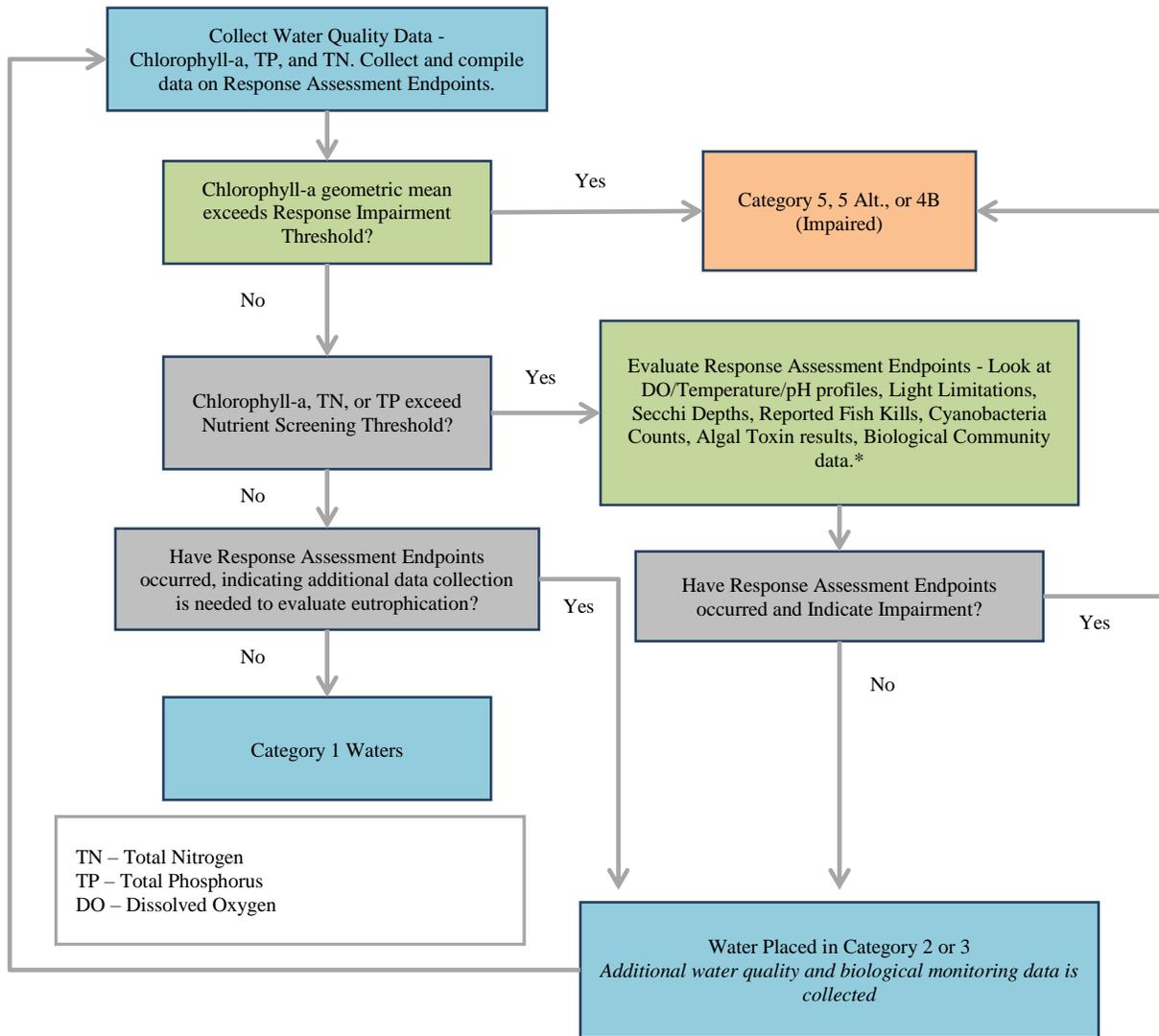
It is widely recognized that mineral turbidity reduces transparency and thereby limits algal production (Jones and Hubbart, 2011). Excessive mineral turbidity and reduced water column transparency can suppress Chl-a levels despite high levels of nutrients. Pronounced and extended turbidity events could have the effect of reducing Chl-a on an average annual basis but still allow for periodically high peaks or algal blooms after sedimentation of mineral turbidity and increased transparency. Under such conditions, waterbodies experiencing harmful algal blooms may go undetected when assessed as an

average annual geomean. The intent of this response variable is to identify such waterbodies that might otherwise go unidentified as impaired.

There are several ways to determine light availability in a lake. Some examples include: Secchi depth, light attenuation and photosynthetically active radiation (PAR), Chl-a/TP ratios, and measurements for turbidity and suspended sediments. All of these methods can provide additional information on the amount of light available in the epilimnion and how deep it penetrates into the lake. These data will be used to determine whether the lake has excess sediment in relation to nutrients for eutrophication impacts to occur.

- Excessive mineral turbidity can reduce light penetration within the photic zone of lakes and limit algal productivity due to the lack of sunlight. Water clarity can be expressed through measurements such as Secchi depth, turbidity, and suspended solids. These data are collected by the SLAP and the LMVP under a cooperative agreement with the Department.
- Measured lake Secchi depths less than 0.6 meters in the Plains, 0.7 meters in the Ozark Border, and 0.9 meters in the Ozark Highlands is likely an indicator of excessive mineral turbidity that limits algal productivity in the water body (MDC 2012). This data is collected by the SLAP and the LMVP under a cooperative agreement with the Department. Yearly average Secchi depths below the applicable ecoregional value may constitute evidence of impairment. Additional analysis of average Chl-a/TP ratios will also be conducted before determining impairment status, as described below.
- The ratio of the average Chl-a to the average TP is an additional indicator of chlorophyll suppression in lakes due to mineral turbidity. A mean Chl-a/TP ratio less than or equal to 0.15 and a mean inorganic suspended solids value greater than or equal to 10 mg/L is suggestive of excessive mineral turbidity which limits algal productivity (Jones and Hubbart, 2011). Unless attributed to other physical factors, Chl-a/TP ratios at or below 0.15 and an ISS value greater than or equal to 10 mg/L as determined by yearly means will serve as an indicator of excessive mineral turbidity and constitute evidence of impairment. Assessment threshold values for Secchi depth, Chl-a/TP ratio, and ISS shall all be exceeded before determining a water is impaired.
- The Department will use data collected using a Li-Cor quantum sensor. Data collected with this equipment consists of light attenuation and photosynthetically active radiation (PAR). Until scientific literature on this new technology can be developed, the Department will rely on best professional judgment for when the data indicate light availability is limiting algal production to the point that if there were less or no limitation then the Chl-a values would be likely to exceed the criterion. This data will be collected by the SLAP starting in 2018 under a cooperative agreement with the Department.

Figure 3. Missouri Ecoregional Numeric Nutrient Criteria Decision Framework based on the Bioconfirmation Approach.



Trend Analysis

The Department currently reports on physiographic region trends in Missouri’s 305(b) Report. The latest version as well as past versions can be found on Missouri’s 303(d) website: <https://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm>. These trends have been reported every cycle in the 305(b) Report since 1990. Trends for the physiographic regions are calculated based on at least 20 years of data. Trends are developed for Secchi depth, total phosphorus, total nitrogen, total chlorophyll, nonvolatile suspended solids, and volatile suspended solids.

The Department will evaluate individual lake trends for total phosphorus, total nitrogen, and Chl-a. Nutrients and chlorophyll can be seasonally variable, as well as wet and dry weather dependent. A minimum of ten years of data will be necessary to confidently evaluate water quality trends in Missouri lakes due to significant annual variability and differing hydrologic conditions. Longer time periods are needed for more accurate predictions of impairment.

- When evaluating trends, confounding, or exogenous variables, such as natural phenomena (e.g., rainfall, flushing rate and temperature), must be controlled for.
- The trend must be statistically significant. This process involves standard statistical modeling, such as least squares regression or Locally Weighted Scatterplot Smoothing (LOWESS) analysis. To be considered statistically significant, the p value associated with the residuals trend analysis must be less than 0.05.
- Impairment decisions based on trend analysis should, at a minimum, demonstrate that the slope of the projected trend line is expected to exceed the chlorophyll criterion within 5 years and that there is evidence of anthropogenic nutrient enrichment. If the slope of the projected trend line is expected to exceed the chlorophyll criterion in greater than 5 years, the lake will be prioritized for additional monitoring and identified as a potential project for a 319 protection plan. A list of lakes that have increasing trends of nutrients or Chl-a will be added as an appendix to Missouri's future 305(b) Reports.

The Department will look for statistically significant trends in the DO/pH profile of lakes throughout the entire water column. Areas the Department will look at may include, but are limited to: mixing volumes, mixing depths, and severity of anoxia in the hypolimnion.

Examples of Assessments

Example 1

Lake Girardeau is in the Ozark Border ecoregion of Missouri. The Chl-a response impairment threshold for the Ozark Border is 22µg/L. The nutrient screening thresholds for the Ozark Border are: Chl-a = 13µg/L; TP =40µg/L; and TN = 733µg/L. Lake Girardeau was sampled in 1994, 2004, 2005, 2008, and 2015. The geometric means for Chl-a, TN, and TP are in Table 2. The Chl-a geometric mean was higher than the response impairment threshold in 2015. The nutrient screening thresholds for TN and TP were also exceeded that year.

- The sample data do not show any excursions of the DO and pH criteria
- The average Secchi depths during both years of nutrient screening threshold exceedance are greater than 0.7 meters
- Chl-a/TP ratio is above 0.15 and inorganic suspended solids/nonvolatile suspended solids (ISS/NVSS) is less than or equal to 10 mg/L

There is not enough data to evaluate a trend. Therefore, Lake Girardeau would be placed into category 2B and would be placed into the high priority list for additional data collection.

Table 2. Lake Girardeau Yearly Geometric Means

Year	Chl-a Geomean (µg/L)	TN Geomean (µg/L)	TP Geomean (µg/L)	Avg. Secchi Depth (m)
1994		1266	68	0.6
2004	21.5	582	30	0.89
2005	10.5	541	24	1.58
2008	18.5	528	28	1.27
2015	34.2	853	40	0.87

Example 2

Lake DiSalvo is in the Ozark Highlands ecoregion of Missouri. The Chl-a response impairment threshold for the Ozark Highlands is 15µg/L. The nutrient screening thresholds for the Ozark Highlands are: Chl-a = 6µg/L; TP =16µg/L; and TN = 401µg/L. Lake DiSalvo was sampled in 2011, 2012, 2014, 2015, and 2016. The geometric means for Chl-a, TN, and TP are in Table 3. The geometric mean for Chl-a exceeded the response impairment threshold every year since 2011.

Lake DiSalvo would be placed into category 5 and the 303(d) list for Chl-a.

Table 3. Lake DiSalvo Yearly Geometric Means

Year	Chl-a Geomean (µg/L)	TN Geomean (µg/L)	TP Geomean (µg/L)
2011	47.7	768	77
2012	58.7	941	107
2014	105.8	1508	119
2015	82.8	1079	82
2016	44.1	928	77

Example 3

Henry Sever Lake is in the Plains ecoregion of Missouri. The Chl-a response impairment threshold for the Plains is 30µg/L. The nutrient screening thresholds for the Plains are: Chl-a = 18µg/L; TP =49µg/L; and TN = 843µg/L. Henry Sever Lake was sampled in 2011, 2012, 2014, 2015, and 2016. The geometric means for Chl-a, TN, and TP are in Table 4. The geometric mean for Chl-a did not exceed the response impairment threshold in any of these years. Some or all of the nutrient screening thresholds were exceeded in 2012 and 2014. Figure 4 shows the scatter plot, trend line, Mann-Kendall trend test and the Theil-Sen Slope for Chl-a in Henry Sever Lake.

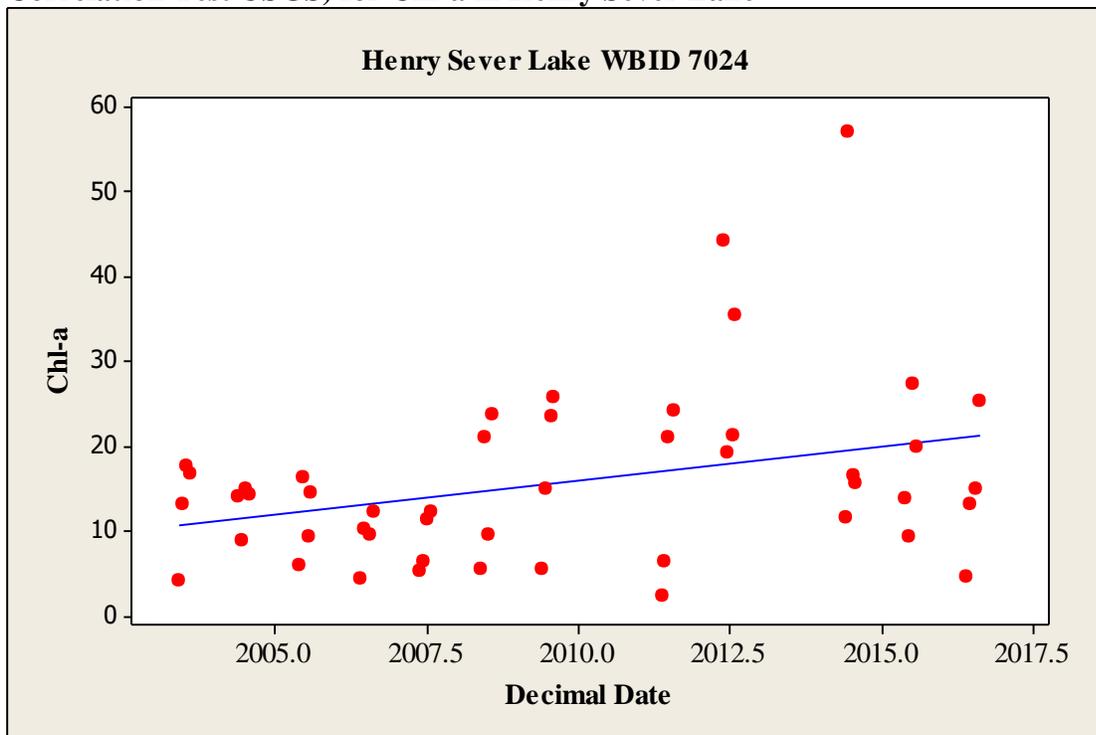
- Half of the pH values in 2012 exceed the pH criteria. None of the DO values exceed the criteria.
- The average Secchi depth during the years of nutrient screening threshold exceedance is 1.12 meters (2012) and 1.11 (2014) meters
- Chl-a/TP ratio is above 0.15
- Mann-Kendall Trend test is significant
- Trend data (Figure 4) shows a scatter plot with a trendline. The Theil-Sen slope of 0.6223 µg/L per year shows it is estimated to reach 30 µg/L theoretically in 2034.

Therefore, Henry Sever Lake would go into category 2B and will be placed into the priority list for additional data collection.

Table 4. Henry Sever Lake Yearly Geometric Means

Year	Chl-a Geomean (µg/L)	TN Geomean (µg/L)	TP Geomean (µg/L)
2003	11.19	742	43
2004	12.79	966	37
2005	10.70	1079	51
2006	8.47	871	43
2007	8.22	725	66
2008	12.61	1354	75
2009	14.90	838	65
2011	9.15	957	42
2012	28.30	898	41
2014	20.28	854	49
2015	16.21	772	36
2016	12.29	737	31

Figure 4. Scatter Plot Trend Line and Mann-Kendall Trend Test (Kendall's Tau Correlation Test USGS) for Chl-a in Henry Sever Lake



Kendall's tau Correlation Test, US Geological Survey, 2005

Data set: Henry Sever Lake Chl-a - Mann-Kendall test, input type 4

The tau correlation coefficient is 0.222

S = 250.0, z = 2.213, p = 0.0269

The relation may be described by the equation (Theil-Sen Slope estimator):

$$Y = -1235.9 + 0.6223 * X$$

Total Maximum Daily Load Development for Nutrient Impaired Waters

The Department will address water quality impairments of the numeric nutrient criteria or violations of narrative criteria where evidence shows excess nutrients to be a cause through the development of total maximum daily loads (TMDLs). TMDL development will occur in accordance with the schedules and priority rankings required as part of the biennial submittal of the state's 303(d) list of impaired waters per federal regulations at 40 CFR 130.7(b)(4). When developing TMDL priorities of 303(d)-listed waters, the Department will also consider alternative approaches that may result in attainment of water quality standards more quickly than a TMDL.

As with all TMDLs and in accordance with federal regulations at 40 CFR 130.7(c)(1), TMDLs developed by the Department to address nutrient impairments will be written to meet water quality standards, including narrative criteria or applicable numeric nutrient criteria. TMDLs developed to meet applicable numeric nutrient criteria will consider targets appropriate for attaining chlorophyll-a response impairment thresholds with consideration given to other causal and response parameter concentrations to ensure water quality standards are met and maintained. Depending upon the nature and source of impairment, TMDLs developed to address exceedances of narrative criteria may also target site-specific or reference chlorophyll-a response thresholds or a combination of other factors to ensure water quality standards are met, such as phosphorus, pH, and dissolved oxygen. Such factors and numeric translators used for developing TMDL targets to address a narrative criteria impairment will only be applicable to water bodies for which TMDLs have been developed and approved. As required by Section 303(d)(1)(C) of the Clean Water Act and federal regulations at 40 CFR 130.7(c)(1), all TMDLs will include an implicit and/or explicit margin of safety to provide additional certainty that the calculated TMDL allocations to point and nonpoint sources of nutrients will result in attainment of water quality standards.

During the development of nutrient TMDLs, the Department will evaluate available datasets and other relevant information to determine appropriate modeling approaches for calculating loading targets and estimating existing loads. One such model to be considered is BATHTUB, which was developed by the U.S. Army Corps of Engineers, and is currently in use for nutrient TMDL development by states within EPA Regions 5 and 7 to address lake eutrophication issues. Other models may be considered depending upon complexity and data needs. Estimates of upstream nutrient loading may be calculated directly where nutrient data is available or may be estimated through models, such as the Spreadsheet Tool for Estimating Pollutant Load (STEPL).

In conjunction with TMDL development, the Department also develops supplemental implementation plans for all TMDLs. These plans provide detailed strategies and actions that will achieve the established goals and water quality targets. TMDL implementation should follow an adaptive implementation approach that makes progress towards achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. The Department recognizes that technical guidance and support are critical to achieving the goals of most TMDLs. While a TMDL calculates the maximum loading that an impaired water body can assimilate and still meet water quality standards, the supplemental implementation plan provides additional information regarding best management practices, funding, and potential stakeholders in the watershed. These implementation plans

serve to provide a general guide to permit writers, nonpoint source program coordinators, and other department staff, as well as soil and water conservation districts, local governments, permitted entities, regional planning commissions, watershed managers, and citizen groups for achieving the calculated wasteload and load allocations. Although not required by EPA, TMDL implementation plans will be placed on public notice and made available for public comment along with the corresponding draft TMDLs, which are made available for public review as described in the State Continuing Planning Process as required by federal regulations at 40 CFR 130.7.

Part II. Permit Implementation

The Department is fully delegated by EPA through Section 402(b) of the Clean Water Act to administer its National Pollutant Discharge Elimination System Permitting Program. The “Missouri’s Nutrient Criteria” section of this document describes each part of Missouri’s WQS that contain nutrient criteria. Notwithstanding, all permitting will be consistent with federal and state requirements. The following are additional regulations that the Department uses to implement point source nutrient reductions.

Effluent Regulation [10 CSR 20-7.015(3)]

The Effluent Regulation requires dischargers to the Table Rock Lake watershed and Lake Taneycomo and its tributaries between Table Rock Dam and Power Site Dam to not exceed 0.5 mg/L of phosphorus as a monthly average.

Exemptions to this requirement:

- Facilities discharging to Lake Taneycomo and its tributaries between Table Rock Dam and Power Site Dam permitted prior to May 9, 1994, and with a design flow less than 22,500 gallons per day (GPD) that have not had an increase in capacity.
- Facilities discharging to the Table Rock Lake watershed permitted prior to November 30, 1999, and with a design flow less than 22,500 GPD that have not had an increase in capacity.

All dischargers to the White River basin are required to monitor for phosphorus.

Effluent Regulation [10 CSR 20-7.015(9)(D)7.]

The Effluent Regulation requires facilities that typically discharge nutrients with a design flow greater than 100,000 GPD to monitor discharges for TN and TP quarterly. Soon the Department will be proposing an amendment to the regulation that would expand the monitoring requirements in various ways. First, facilities with a design flow greater than 1,000,000 GPD will be required to monitor monthly instead of quarterly. Second, instead of reporting TN, facilities will need to report nitrogen’s constituents as: total Kjeldahl nitrogen, nitrate plus nitrite, and ammonia. Third, the facility will need to monitor influent for a period of time, in addition to effluent. The Department notes that many publicly-owned treatment works have voluntarily performed nutrient sampling at greater frequencies than required in the regulation.

Implementing a Three-Phase Nutrient Reduction Approach

The following implementation procedures for point source nutrient reduction are divided into three phases: Data Collection and Analysis, Plant Optimization, and Final Effluent Limitations. The three-phase approach is applicable for facilities that discharge to a lake watershed where the new numeric nutrient criteria apply; however, there are exceptions:

- Missouri’s effluent regulation [10 CSR 20-7.015(3)] requires phosphorus effluent limitations or monitoring requirements in permits for facilities discharging to the Table Rock Lake and Lake Taneycomo watersheds. The effluent regulation supersedes the implementation procedures of this plan except in situations where this plan is more stringent.
- This plan does not impact permit limitations that were established based on site-specific nutrient criteria found in Table N of the WQS.
- Industrial facilities that discharge elevated concentrations of nutrients may require alternate implementation measures to ensure that water quality is protected.

- Facilities that discharge to impaired lake watersheds based on either new or existing nutrient criteria will follow different procedures. See the “Impaired Lakes” section for further information.

This plan does not prohibit establishing alternative methods of analysis, permit limits, or requirements provided that the alternatives are technically sound, consistent with state and federal regulations, and are protective of water quality.

Phase 1 – Data Collection and Analysis

Nutrient data collection is a necessary first step for multiple reasons.

- 1) Facilities will use the data to determine current treatment capabilities regarding nutrient removal.
- 2) Permit writers will use the data in Phase 3 to determine if reasonable potential (RP) for a discharge to cause or contribute to an excursion of the nutrient criteria exists.
- 3) The data will aid the Department in conducting analyses to determine nutrient loading contributions from point sources versus nonpoint sources into lake watersheds.

The Effluent Regulation [10 CSR 20-7.015] requires facilities that typically discharge nutrients with a design flow greater than 100,000 GPD to monitor discharges for TN and TP quarterly. Currently, the Department is proposing an amendment to the regulation that would expand the monitoring requirements in various ways. First, facilities with a design flow greater than 1,000,000 GPD will be required to monitor monthly instead of quarterly. Second, instead of reporting TN, facilities will need to report nitrogen’s constituents as: total Kjeldahl nitrogen, nitrate plus nitrite, and ammonia. Third, the facility will need to monitor influent, for a period of time, in addition to effluent.

The Department will generally not require nutrient monitoring for facilities that discharge less than or equal to 100,000 GPD because it does not anticipate these discharges will contribute a significant portion to the total nutrient load in lake watersheds. The total design flow of Missouri’s domestic wastewater facilities is 1,324 million gallons per day. Facilities with a design flow greater than 100,000 GPD discharge 1,288 million gallons per day. While smaller facilities make up 82% of total facilities in number, they contribute only 3% of the total daily flow. Not only do facilities that discharge less than or equal to 100,000 GPD make up a minimal portion of the point source loading, but that contribution is made even more insignificant when considering the total nutrient load from both point and nonpoint sources. The USGS spatially referenced regression on watershed (SPARROW) attributes model provides estimates of sources of TN and TP transported from the Mississippi River Basin to the Gulf of Mexico (Robertson and Saad, 2013). At this basin scale, relative nutrient contribution from wastewater treatment plants is estimated to be only 7% of TN and 13% of TP. The Department will develop nutrient reduction requirements for facilities discharging below 100,000 GPD if localized impacts from specific small facilities are identified.

Permits for facilities that typically discharge nutrients with a design flow greater than 100,000 GPD will require monitoring of the influent and effluent for the following parameters:

- Total Phosphorus
- Total Kjeldahl Nitrogen
- Nitrate plus Nitrite
- Ammonia

Because there are existing numeric criteria for ammonia in the WQS, these facilities likely already have permit monitoring requirements and/or effluent limitations in their permits for ammonia.

Table 5. Sampling Frequency by Design Flow

Design flow in GPD	Sampling frequency
100,001-1,000,000	Quarterly
1,000,001 and greater	Monthly

Phase 2 – Voluntary Plant Optimization and Source Controls

After permittees have completed the data collection process outlined in Phase 1, permittees and the Department will have an understanding of current treatment capabilities of the facility. Permittees can then elect to study and implement plant optimization or source control measures where they anticipate being able to reduce nutrient discharges with minimal capital and/or operational costs. This voluntary phase of plant optimization and/or source controls will provide permittees with time (up to 5 years) to take cost-effective strategies for early nutrient reductions. If permittees elect to not take advantage of this Phase, then the Department will use data collected under Phase 1 to evaluate RP and develop nutrient permit limitations, if needed.

As a part of Missouri’s Nutrient Loss Reduction Strategy, the Department will be conducting a study to determine attainable nutrient reduction values based upon various wastewater treatment technologies. This entails an analysis of point source dischargers and available discharge data to determine nutrient removal rates of different technologies throughout the state. Depending on existing treatment process design, operational adjustments can potentially increase the removal efficiency of TN without significant capital investments on plant upgrades. This approach may be more difficult for TP; however, reducing phosphorus from entering the treatment plant can be an effective strategy. These cost-effective efforts may significantly reduce point source loading in the watershed.

Permits for facilities that typically discharge nutrients with a design flow of greater than 100,000 GPD and voluntarily engage into Phase 2 will include a special condition requiring the development and implementation of a Plant Optimization Plan and a Phosphorus Minimization Plan. Because Phase 2 is voluntary, Missouri affordability statutes do not apply to these permit conditions. The Department will develop and provide the following resources to permittees:

- Operator Training Workshops – Engineering staff and water specialists will offer training opportunities to operators on practical methods of improving treatment capabilities in current operations.
- Online Resources – The Department will provide online resources including fact sheets and links to information that will aid in the development of Plant Optimization Plans and

Phosphorus Minimization Plans. Easy-to-use templates for these plans will also be provided by the Department.

- Staff Assistance – Department staff are always available to assist permittees by phone and email. Permittees may request compliance assistance visits on-line at <https://dnr.mo.gov/cav/compliance.htm>.

During Phase 2, permittees will maintain the monitoring requirements established in Phase 1. With this data, removal efficiency and phosphorus minimization efforts can be tracked throughout Phase 2. Permittees who are able to show significant improvements in treatment plant operations are more likely to be issued permits with less stringent nutrient requirements as the improvements may show that there is no RP to cause or contribute to an excursion of the nutrient criteria. With some effort, plant optimization may be a more economically viable option than costly upgrades. However, depending on treatment processes, plant optimization efforts may detrimentally impact effluent performance for other important pollutants, such as biochemical oxygen demand and ammonia. In addition, plant optimization strategies for facilities below design capacity could use (on an interim or permanent basis) reserved treatment plant capacity (e.g., basin volumes) originally designed to serve community growth. Therefore, the Department will not establish nutrient reduction baselines for future limits based upon optimized plant loading. Rather, the Department will include technology-based effluent goals in permits that support plant optimization and/or source reduction goals.

Phase 3 – Final Effluent Limitations

During the third phase of the plan, final effluent limitations will be established in permits where RP exists. Chl-a data from Missouri's lakes are strongly correlated with TN and TP. However, studies show through regression models that TN accounts for less Chl-a variation compared to TP (Jones and Knowlton, 2005). This suggests that TP is the limiting nutrient in most of Missouri's lakes; therefore, phosphorus reductions made at wastewater facilities will strongly contribute to water quality improvements in lakes with elevated levels of Chl-a and TP. As a Missouri-specific demonstration, permits for facilities discharging to the Table Rock Lake and Lake Taneycomo watersheds have contained technology-based phosphorus effluent limitations for decades per Missouri's Effluent Regulation [10 CSR 20-7.015(3)]. Because of this requirement, most permittees in these areas have installed a chemical feed to their facilities' treatment processes to facilitate phosphorus removal which in turn has greatly reduced the number of algal blooms on these lakes. Water quality in these watersheds has improved since the requirements were first established, suggesting that phosphorus removal technologies from point sources are responsible for the improvement.

By Phase 1, or the voluntary Phase 2, facilities have collected and reported sufficient data for an RP determination to be made. Determining RP for a discharge to cause or contribute to an excursion of the nutrient criteria can be complicated using numeric nutrient criteria for Chl-a. Furthermore, the typical statistical analysis used by permit writers to determine RP for toxics cannot be used to determine RP for Chl-a because it is not a discharged pollutant that can be sampled from a facility's outfall. Because exceedance of the numeric Chl-a criteria is a response to excess TN and/or TP in the water body, regional correlations between nutrients and algal biomass will be used to set in-lake nutrient targets. Then, watershed modeling will be used to identify and estimate sources (both point and nonpoint sources) of TN and TP loads and quantify

the proportion of contributions from these sources into the watershed, which is necessary to make a RP determination for a specific facility.

Facilities that typically discharge nutrients with a design flow of greater than 100,000 GPD will be modeled. If watershed modeling shows that there is RP for a discharge to cause or contribute to an excursion of the Chl-a criteria, TP effluent limits (with a compliance schedule) will be established in the permit requiring the permittee to install phosphorus removal at the facility. This approach will need adjustments in situations where watershed modeling shows TN as the limiting pollutant over TP. Nutrient limits will be set to achieve in-lake nutrient targets based upon source sector contributions and within the point source sector, the relative contribution of each such source. Relative contribution should take into account early nutrient reduction actions by individual dischargers. The Department also intends to provide opportunities for watershed-based, bubble permitting to facilitate cost-effective point source nutrient reductions and compliance as well as fostering collaboration between permittees.

Impaired Lakes

In cases where a facility discharges to a watershed that contains a lake with nutrient impairments, supplemental procedures, in addition to those previously discussed in this plan, will be utilized. The first step is to determine if the facility's discharge is causing or contributing to the nutrient impairment. As discussed in Phase 3, watershed modeling will be used to identify the sources (both point and nonpoint) of TN and TP loads and quantify the proportion of contributions from these sources into the watershed, which is necessary to make the RP determination for specific facilities.

If, through modeling or other means, a determination is made that a particular facility *is not* causing or contributing to the impairment, then effluent limitations are not needed at that time to protect water quality. However, the permit writer may determine that nutrient monitoring is still needed to make future RP determinations.

If it is shown that the facility *is* causing or contributing to the impairment, effluent limitations will be established that are protective of water quality. This can be accomplished in several ways:

- The permit writer can establish TP effluent limitations based on the capabilities of specific treatment technologies with the supporting rationale that potential TP reductions made by the facility are protective of water quality.
- The permit writer can establish effluent limitations based on wasteload allocations identified through watershed and lake modeling based upon point source relative contribution.
- Following TMDL development, wasteload allocations will be established and permit writers will establish effluent limitations from those wasteload allocations.

Other methods of effluent limitation derivation are allowed with appropriate justification by the permit writer.

New and Expanding Sources and Antidegradation Review Requirements

Implementation procedures for new sources differ from those previously listed in this plan. For the purposes of this plan, “new sources” refers to new, altered, or expanding discharges of TP and/or TN. Per Missouri’s WQS [10 CSR 20-7.031(3)], for new sources, the Department will document by means of antidegradation review that the use of a water body’s available assimilative capacity is justified. Missouri’s Antidegradation Implementation Procedures provide a detailed process for conducting antidegradation reviews, which will be applicable to any new or expanding discharges of nutrients into lake watersheds. Permittees must submit an antidegradation review request to the Department prior to establishing, altering, or expanding discharges.

The following procedures for new sources are split between lakes with and without nutrient impairments.

Scenario 1: The new source requests to discharge to a watershed that contains a lake *with* a nutrient impairment. The Department will conduct watershed modeling to determine whether the facility’s discharge would cause or contribute to the nutrient impairment. Permitting decisions that fall under this scenario will be based upon a Tier 1 antidegradation review, which are designed to prohibit degradation that may cause or contribute to the impairment of a beneficial use. Increased pollutant loading is allowed as long as the discharge does not cause or contribute to the impairment.

- If the facility’s discharge is shown not to cause or contribute to the nutrient impairment, then the permit writer will establish best available technology limits for TP in the permit.
- If the facility’s discharge is shown to cause or contribute to the nutrient impairment, then the permittee will be required to utilize a more advanced level of wastewater treatment or find an alternative method of wastewater disposal.

Scenario 2: The new source requests to discharge to a watershed that contains a lake *without* a nutrient impairment. There is little need for the data collection and plant optimization conducted in Phases 1 and 2 for new facilities. Because of this, permits that fall under this scenario will include effluent limitations for TP in their initial permit based upon a Tier 2 antidegradation review.

Potential Flexibilities for Permittees

The Department has multiple tools to aid permittees with permit compliance. As permits are renewed, permittees may find it difficult to meet new effluent limitations and requirements. Depending on the situation, each flexibility listed below offers its own set of results and benefits.

Table 6. Regulatory Flexibilities for Permitting

Permit Flexibility	Quick Facts
Schedules of Compliance 10 CSR 20-7.015(9)(C)	<ul style="list-style-type: none"> • Allows permittees time to comply with newly established effluent limitations • Establishes yearly (or more frequent) milestones • Established using a cost analysis which takes into account a community’s socioeconomic and financial capability status for publicly-owned treatment works • Must comply with 40 CFR 122.47 • May be extended with proper justification • May extend beyond the permit term
WQS Variance 10 CSR 20-7.031(12)	<ul style="list-style-type: none"> • Variances are paths to improve water quality over the variance term • Provides permittees time to achieve incremental improvements to ultimately work toward compliance with WQS through a Pollutant Minimization Program • Establishes a time-limited WQS, and therefore, must be approved by the Missouri Clean Water Commission and EPA
Watershed-based Permits	<ul style="list-style-type: none"> • Watershed-based permitting is an approach to develop permits for multiple point sources located within a defined geographic area. • Allows the Department to consider watershed goals and the impact of multiple nutrient sources.
Water Quality Trading Missouri Water Quality Trading Framework	<ul style="list-style-type: none"> • Trading is a market-based approach for compliance with effluent limitations • Instead of, or in addition to, upgrading facilities, permittees can buy and sell water quality credits to meet effluent limitations • Point to point source trades or nonpoint source to point source trades can be made
Integrated Management Plans Missouri Integrated Planning Framework	<ul style="list-style-type: none"> • Allows communities to prioritize investments to meet environmental requirements • Plan development is voluntary and the responsibility of the community • Plan development is a method to include utility rate payers in the decision making process • May provide assurance which allows relaxation of timelines for regulatory requirements such as permit requirements, enforcement action, and TMDL development

Incentives for Early Nutrient Reduction

Receiving water quality may benefit from earlier nutrient reductions resulting from wastewater treatment optimization, pilot testing, stress testing, new technology trials, etc. as well as from trading for nutrient reductions or offsets. The Department encourages wastewater utilities to make voluntary reductions of nutrients earlier than required, improving the receiving water quality. In exchange, permittees will receive regulatory flexibilities, such as extended compliance schedules to achieve final effluent nutrient limits or other water quality-based effluent limits. In addition, permittees adopting early nutrient reduction strategies could balance other regulatory obligations through integrated planning. Permittees also may accrue credits for watershed-based trading.

Wastewater utility participation in an early nutrient reduction is voluntary. Any method of achieving early reductions in nutrients is allowable, whether achieved with nutrient removal optimization, a water quality trade, a source reduction plan, watershed nutrient reductions, or capital improvements to implement nutrient removal. If TMDLs or other watershed-based nutrient reduction strategies are developed, baselines for utilities will be established based upon point source sector reduction requirements in the absence of such early actions (i.e., facility-specific early action performance will not be set as the future regulatory requirement). This will eliminate regulatory disincentives for taking early nutrient reduction actions.

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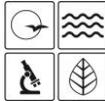
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Appendices

A – Missouri Department of Conservation Fish Stocking Information Letter

B – Methodology for the Development of the 2020 Section 303(d) List in Missouri

APPENDIX B – 2020 MISSOURI SECTION 303(D) LIST OF IMPAIRED WATERS



Missouri Department of Natural Resources
2020 Section 303(d) Listed Waters

Clean Water Commission Approved on April 2, 2020

Row #	Year	WBID	Waterbody	Class	Entire WB Imprd	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
1	2012	2188.00	Antire Cr.	P	Y	1.90	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	St. Louis	07140102		H	2025
2	2018	2668.00	Ashley Cr.	P	Y	2.50	Miles	WBC B	Escherichia coli (W)	Rural NPS	Dent	11010008		H	2025
3	2018	7637.00	August A Busch Lake Number 36	UL	Y	16.00	Acres	GEN	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009	4	L	> 10 years
4	2010	7627.00	August A Busch Lake Number 37	L3	Y	30.00	Acres	GEN	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009	4	L	> 10 years
5	2020	7239.00	Austin Community Lake	L3	Y	21.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Texas	10290201	1	L	> 10 years
6	2016	4083.00	Barker Creek tributary	C	Y	1.20	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Henry	10290108		L	> 10 years
7	2018	2693.00	Barn Hollow	C	Y	8.20	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Howell/Texas	11010008		L	> 10 years
8	2012	0752.00	Bass Cr.	C	Y	4.40	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		H	2023
9	2012	3240.00	Baynham Br.	P	Y	4.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070207	9	L	> 10 years
10	2014	3224.00	Beef Br.	P	Y	2.50	Miles	AQL	Cadmium (S)	Mill Tailings	Newton	11070207		M	2026 - 2030
11	2014	3224.00	Beef Br.	P	Y	2.50	Miles	AQL	Cadmium (W)	Mill Tailings	Newton	11070207		M	2026 - 2030
12	2014	3224.00	Beef Br.	P	Y	2.50	Miles	AQL	Lead (S)	Mill Tailings	Newton	11070207		M	2026 - 2030
13	2014	3224.00	Beef Br.	P	Y	2.50	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070207		M	2026 - 2030
14	2014	3224.00	Beef Br.	P	Y	2.50	Miles	AQL	Zinc (W)	Mill Tailings	Newton	11070207		M	2026 - 2030
15	2014	7309.00	Bee Tree Lake	L3	Y	10.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Louis	07140102		L	> 10 years
16	2006	7365.00	Belcher Branch Lake	L3	Y	42.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Buchanan	10240012		L	> 10 years
17	2020	2179.00	Belew Cr.	P	Y	7.00	Miles	AQL	Oxygen, Dissolved (W)	Municipal Point Source Discharges, Source Unknown	Jefferson	07140104		L	> 10 years
18	2018	7186.00	Ben Branch Lake	L3	Y	37.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Osage	10300102		L	> 10 years
19	2014	3980.00	Bens Branch	C	Y	5.80	Miles	AQL	Cadmium (S)	Oronogo/Duenweg Mining Belt	Jasper	11070207		H	2022
20	2018	3980.00	Bens Branch	C	Y	5.80	Miles	AQL	Cadmium (W)	Mill Tailings	Jasper	11070207		H	2022
21	2014	3980.00	Bens Branch	C	Y	5.80	Miles	AQL	Lead (S)	Oronogo/Duenweg Mining Belt	Jasper	11070207		H	2022
22	2014	3980.00	Bens Branch	C	Y	5.80	Miles	AQL	Zinc (S)	Oronogo/Duenweg Mining Belt	Jasper	11070207		H	2022
23	2016	3980.00	Bens Branch	C	Y	5.80	Miles	AQL	Zinc (W)	Oronogo/Duenweg Mining Belt	Jasper	11070207		H	2022
24	2010	2916.00	Big Cr.	P	N (1.8)	34.10	Miles	AQL	Cadmium (S)	Glover smelter	Iron	08020202		M	2026 - 2030
25	2010	1578.00	Big Piney R.	P	N (4)	7.80	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Texas	10290202	2	M	2026 - 2030
26	2006	2080.00	Big R.	P	N (52.8)	81.30	Miles	AQL	Cadmium (S)	Old Lead Belt tailings	St. Francois/Jefferson	07140104		H	2024
27	2012	2080.00	Big R.	P	Y	81.30	Miles	AQL	Zinc (S)	Old Lead Belt tailings	St. Francois/Jefferson	07140104		H	2024
28	2020	7185.00	Binder Lake	L3	Y	127.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cole	10300102	1	L	> 10 years
29	2006	3184.00	Blackberry Cr.	C	N (3.5)	6.50	Miles	AQL	Chloride (W)	Asbury Power Plant	Jasper	11070207		M	2026 - 2030
30	2008	3184.00	Blackberry Cr.	C	N (3.5)	6.50	Miles	AQL	Sulfate + Chloride (W)	Asbury Power Plant	Jasper	11070207		M	2026 - 2030
31	2020	0112.00	Black Cr.	C	Y	21.80	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Shelby	07110005		L	> 10 years
32	2006	3825.00	Black Creek	P	Y	5.60	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		H	2025
33	2002	2769.00	Black R.	P	Y	47.10	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Butler	11010007	2	L	> 10 years
34	2002	2784.00	Black R.	P	Y	39.00	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Wayne/Butler	11010007	2	L	> 10 years
35	2020	7189.00	Blind Pony Lake	L3	Y	96.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Saline	10300104	1	L	> 10 years
36	2006	0417.00	Blue R.	P	Y	4.40	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2023
37	2006	0418.00	Blue R.	P	Y	9.40	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2023
38	2006	0419.00	Blue R.	P	Y	7.70	Miles	WBC A	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2023

Row #	Year	WBID	Waterbody	Class	Entire WB Imprd	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
39	2016	0417.00	Blue R.	P	Y	4.40	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2023
40	2016	0418.00	Blue R.	P	Y	9.40	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2023
41	2012	1701.00	Bonhomme Cr.	C	Y	2.50	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	10300200		M	2026 - 2030
42	2006	0750.00	Bonne Femme Cr.	P	Y	7.80	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		H	2023
43	2012	0753.00	Bonne Femme Cr.	C	Y	7.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	Boone	10300102		H	2023
44	2002	2034.00	Bourbeuse R.	P	Y	136.70	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Phelps/Franklin	07140103	2	L	> 10 years
45	2014	7003.00	Bowling Green Lake - Old	L1	Y	7.00	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Pike	07110004	1 2 7	L	> 10 years
46	2012	7003.00	Bowling Green Lake - Old	L1	Y	7.00	Acres	AQL	Nitrogen, Total (W)	Rural NPS	Pike	07110004	1 2 7	L	> 10 years
47	2012	7003.00	Bowling Green Lake - Old	L1	Y	7.00	Acres	AQL	Phosphorus, Total (W)	Rural NPS	Pike	07110004	1 2 7	L	> 10 years
48	2012	1796.00	Brazeau Cr.	P	Y	10.80	Miles	WBC B	Escherichia coli (W)	Rural NPS	Perry	07140105		M	2026 - 2030
49	2002	1371.00	Brush Cr.	P	Y	4.70	Miles	AQL	Oxygen, Dissolved (W)	Humansville WWTP	Polk/St. Clair	10290106		H	2020
50	2016	3986.00	Brush Creek	C	Y	5.40	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2023
51	2016	3986.00	Brush Creek	C	Y	5.40	Miles	AQL	Oxygen, Dissolved (W)	Nonpoint Source	Jackson	10300101		L	> 10 years
52	2016	7117.00	Buffalo Bill Lake	L3	Y	45.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	DeKalb	10280101		L	> 10 years
53	2012	3273.00	Buffalo Cr.	P	Y	8.00	Miles	AQL	Fishes Bioassessments/ Unknown (W)	Source Unknown	Newton/McDonald	11070208	5	M	2026 - 2030
54	2008	3118.00	Buffalo Ditch	P	Y	17.30	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Dunklin	08020204		M	2026 - 2030
55	2006	1865.00	Burgher Br.	C	Y	1.50	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Phelps	07140102		M	2026 - 2030
56	2018	3414.00	Burr Oak Cr.	C	Y	6.80	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
57	2018	3414.00	Burr Oak Cr.	C	Y	6.80	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
58	2020	3414.00	Burr Oak Cr.	C	Y	6.80	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Jackson	10300101		L	> 10 years
59	2020	7056.00	Busch W.A.- Kraut Run Lake	L3	Y	164.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Charles	07110009	1	L	> 10 years
60	2006	7057.00	Busch W.A. No. 35 Lake	L3	Y	51.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009		L	> 10 years
61	2020	7229.00	Butler Lake	L1	Y	71.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Bates	10290102	1 2	L	> 10 years
62	2020	7384.00	Cameron Lake #4 (Grindstone Reservoir)	L1	Y	173.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	1 2	L	> 10 years
63	2006	3234.00	Capps Cr.	P	Y	5.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Barry/Newton	11070207	9	L	> 10 years
64	2016	3241.00	Carver Br.	P	Y	3.00	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Newton	11070207	9	L	> 10 years
65	2020	7374.00	Catclaw Lake	L3	Y	42.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Jackson	10290108	1	L	> 10 years
66	2008	1344.00	Cedar Cr.	P	N (10.9)	31.00	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Cedar	10290106	5	M	2026 - 2030
67	2008	0737.00	Cedar Cr.	C	N (7.9)	37.40	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Boone	10300102	5	M	2026 - 2030
68	2010	1357.00	Cedar Cr.	C	Y	16.20	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Dade/Cedar	10290106	5	L	> 10 years
69	2016	1344.00	Cedar Cr.	P	Y	31.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Cedar	10290106		H	2020
70	2008	1357.00	Cedar Cr.	C	Y	16.20	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Dade/Cedar	10290106		M	2026 - 2030
71	2010	1344.00	Cedar Cr.	P	N (10.9)	31.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Cedar	10290106		M	2026 - 2030
72	2006	3203.00	Center Cr.	P	N (19)	26.80	Miles	AQL	Cadmium (S)	Tri-State Mining District	Jasper	11070207		H	2022
73	2008	3210.00	Center Cr.	P	Y	21.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton/Jasper	11070207	9	L	> 10 years
74	2010	3214.00	Center Cr.	P	Y	4.90	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence/Newton	11070207	9	L	> 10 years
75	2006	3203.00	Center Cr.	P	N (19)	26.80	Miles	AQL	Lead (S)	Tri-State Mining District	Jasper	11070207		H	2022
76	2016	5003.00	Center Creek tributary	C	Y	2.70	Miles	AQL	Cadmium (W)	Oronogo/Duenweg Mining Belt	Jasper	11070207		H	2022
77	2020	5003.00	Center Creek tributary	C	Y	2.70	Miles	AQL	Lead (W)	Mill Tailings	Jasper	11070207		H	2022
78	2016	5003.00	Center Creek tributary	C	Y	2.70	Miles	AQL	Zinc (W)	Oronogo/Duenweg Mining Belt	Jasper	11070207		H	2022
79	2014	7634.00	Chaumiere Lake	UL	Y	3.40	Acres	GEN	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Clay	10300101	4	M	2026 - 2030
80	2012	1781.00	Cinque Hommes Cr.	P	Y	17.10	Miles	WBC B	Escherichia coli (W)	Rural NPS	Perry	07140105		M	2026 - 2030

Row #	Year	WBID	Waterbody	Class	Entire WB Imprd	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
81	2016	1781.00	Cinque Hommes Cr.	P	Y	17.10	Miles	SCR	Escherichia coli (W)	Rural NPS	Perry	07140105		M	2026 - 2030
82	2018	1000.00	Clark Fk.	C	Y	6.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Cole	10300102		L	> 10 years
83	2006	3238.00	Clear Cr.	P	Y	11.10	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence/Newton	11070207	9	L	> 10 years
84	2002	3239.00	Clear Cr.	C	Y	3.50	Miles	AQL	Nutrient/Eutrophication Biol. Indicators (W)	Monett WWTP	Barry/Lawrence	11070207	1	H	2020
85	2002	3239.00	Clear Cr.	C	Y	3.50	Miles	AQL	Oxygen, Dissolved (W)	Monett WWTP	Barry/Lawrence	11070207		H	2020
86	2006	1333.00	Clear Cr.	P	Y	28.20	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon/St. Clair	10290105		M	2026 - 2030
87	2006	0935.00	Clear Fk.	P	N (3.1)	25.80	Miles	AQL	Oxygen, Dissolved (W)	Knob Noster WWTP	Johnson	10300104		H	2025
88	2014	7326.00	Clearwater Lake	L2	Y	1635.00	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Reynolds/Wayne	11010007	17	L	> 10 years
89	2002	7326.00	Clearwater Lake	L2	Y	1635.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Reynolds/Wayne	11010007	7	L	> 10 years
90	2016	7326.00	Clearwater Lake	L2	Y	1635.00	Acres	AQL	Phosphorus, Total (W)	Nonpoint Source	Reynolds/Wayne	11010007	17	L	> 10 years
91	2006	1706.00	Coldwater Cr.	C	Y	6.90	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	10300200		H	2025
92	2020	7378.00	Coot Lake	L3	Y	20.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Jackson	10290108	1	L	> 10 years
93	2016	7378.00	Coot Lake	L3	Y	20.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10290108		L	> 10 years
94	2016	7379.00	Cottontail Lake	L3	Y	22.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10290108		L	> 10 years
95	2020	3962.00	Crackerneck Creek	C	Y	6.00	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		L	> 10 years
96	2012	2382.00	Crane Cr.	P	Y	13.20	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Stone	11010002	5	M	2026 - 2030
97	2016	7334.00	Crane Lake	L3	Y	109.00	Acres	AQL	Chlorophyll-a (W)	Source Unknown	Iron	08020202	17	L	> 10 years
98	2016	7334.00	Crane Lake	L3	Y	109.00	Acres	AQL	Phosphorus, Total (W)	Source Unknown	Iron	08020202	17	L	> 10 years
99	2012	2816.00	Craven Ditch	C	Y	11.60	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Butler	11010007		L	> 10 years
100	2006	1703.00	Creve Coeur Cr.	C	Y	3.80	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	10300200		H	2025
101	2008	3961.00	Crooked Creek	C	Y	6.50	Miles	AQL	Cadmium (W)	Buick Lead Smelter	Iron/Crawford	07140102		M	2026 - 2030
102	2010	3961.00	Crooked Creek	C	Y	6.50	Miles	AQL	Copper (W)	Buick Lead Smelter	Iron/Crawford	07140102		M	2026 - 2030
103	2016	7135.00	Crowder St. Park Lake	L3	Y	18.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Grundy	10280102		L	> 10 years
104	2020	0152.00	Cuivre R.	P	Y	30.00	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Lincoln/St. Charles	07110008		L	> 10 years
105	2006	2636.00	Current R.	P	Y	124.00	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Shannon/Ripley	11010008		L	> 10 years
106	2018	2662.00	Current R.	P	Y	18.80	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Dent/Shannon	11010008		L	> 10 years
107	2018	0221.00	Dardenne Cr.	P	Y	16.50	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Charles	07110009		M	2026 - 2030
108	2020	0222.00	Dardenne Cr.	C	Y	8.50	Miles	WBC B	Escherichia coli (W)	Urban Runoff and Nonpoint Source	St. Charles	07110009		L	> 10 years
109	2006	0219.00	Dardenne Cr.	P1	Y	7.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	St. Charles	07110009		M	2026 - 2030
110	2006	3826.00	Deer Creek	P	Y	1.60	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis/St. Louis City	07140101		H	2025
111	2002	7015.00	Deer Ridge Community Lake	L3	Y	39.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Lewis	07110002		L	> 10 years
112	2020	7331.00	DiSalvo Lake	L3	Y	210.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Francois	08020202	1	L	> 10 years
113	2006	3109.00	Ditch #36	P	Y	7.80	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Dunklin	08020204		M	2026 - 2030
114	2006	3810.00	Douger Br.	C	Y	2.80	Miles	AQL	Lead (S)	Aurora Lead Mining District	Lawrence	11070207		M	2026 - 2030
115	2006	3810.00	Douger Br.	C	Y	2.80	Miles	AQL	Zinc (S)	Aurora Lead Mining District	Lawrence	11070207		M	2026 - 2030
116	2020	7228.00	Drexel Lake	L1	Y	28.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Bates	10290102	12	L	> 10 years
117	2008	3189.00	Dry Fk.	C	Y	10.20	Miles	WBC A	Escherichia coli (W)	Rural NPS	Jasper	11070207	9	L	> 10 years
118	2016	1792.00	Dry Fk.	C	Y	3.20	Miles	WBC B	Escherichia coli (W)	Source Unknown	Perry	07140105		M	2026 - 2030
119	2016	3163.00	Dry Hollow	C	Y	0.50	Miles	SCR	Escherichia coli (W)	Source Unknown	Lawrence	11070207		M	2026 - 2030
120	2016	3570.00	Dutro Carter Cr.	C	Y	0.50	Miles	SCR	Escherichia coli (W)	Source Unknown	Phelps	07140102		M	2026 - 2030
121	2016	3570.00	Dutro Carter Cr.	C	Y	0.50	Miles	WBC B	Escherichia coli (W)	Source Unknown	Phelps	07140102		M	2026 - 2030
122	2006	3569.00	Dutro Carter Cr.	P	N (0.5)	1.50	Miles	AQL	Oxygen, Dissolved (W)	Rolla SE WWTP	Phelps	07140102		M	2026 - 2030

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123	2016	3199.00	Duval Cr.	C	Y	7.00	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Jasper	11070207	9	L	> 10 years
124	2006	2166.00	Eaton Br.	C	Y	1.20	Miles	AQL	Cadmium (S)	Leadwood tailings pond	St. Francois	07140104		H	2024
125	2006	2166.00	Eaton Br.	C	Y	1.20	Miles	AQL	Cadmium (W)	Leadwood tailings pond	St. Francois	07140104		H	2024
126	2006	2166.00	Eaton Br.	C	Y	1.20	Miles	AQL	Lead (S)	Leadwood tailings pond	St. Francois	07140104		H	2024
127	2018	2166.00	Eaton Br.	C	Y	1.20	Miles	AQL	Lead (W)	Leadwood tailings pond	St. Francois	07140104		H	2024
128	2006	2166.00	Eaton Br.	C	Y	1.20	Miles	AQL	Zinc (S)	Leadwood tailings pond	St. Francois	07140104		H	2024
129	2006	2166.00	Eaton Br.	C	Y	1.20	Miles	AQL	Zinc (W)	Leadwood tailings pond	St. Francois	07140104		H	2024
130	2020	7026.00	Edina Reservoir	L1	Y	51.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Knox	07110003	1 2	L	> 10 years
131	2020	7192.00	Edwin A Pape Lake	L1	Y	272.50	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Lafayette	10300104	1 2	L	> 10 years
132	2010	0372.00	E. Fk. Crooked R.	P	Y	19.90	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Ray	10300101		M	2026 - 2030
133	2006	0457.00	E. Fk. Grand R.	P	Y	28.70	Miles	WBC A	Escherichia coli (W)	Rural NPS	Worth/Gentry	10280101	2	H	2020
134	2020	0428.00	E. Fk. L. Blue R.	C	N (2.6)	3.70	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Jackson	10300101		L	> 10 years
135	2020	0610.00	E. Fk. Locust Cr.	C	Y	15.70	Miles	AQL	Chloride (W)	Industrial Point Source Discharge	Sullivan	10280103		L	> 10 years
136	2008	0608.00	E. Fk. Locust Cr.	P	Y	16.70	Miles	WBC B	Escherichia coli (W)	Milan Lagoon and Nonpoint Source	Sullivan	10280103		H	2025
137	2008	0610.00	E. Fk. Locust Cr.	C	Y	15.70	Miles	WBC A	Escherichia coli (W)	Rural NPS	Sullivan	10280103		H	2025
138	2018	0608.00	E. Fk. Locust Cr.	P	Y	16.70	Miles	SCR	Escherichia coli (W)	Milan Lagoon and Nonpoint Source	Sullivan	10280103		H	2025
139	2018	1282.00	E. Fk. Tebo Cr.	C	Y	14.50	Miles	AQL	Ammonia, Total (W)	Municipal Point Source Discharges	Henry	10290108		L	> 10 years
140	2006	1282.00	E. Fk. Tebo Cr.	C	N (10.4)	14.50	Miles	AQL	Oxygen, Dissolved (W)	Windsor SW WWTP	Henry	10290108		M	2026 - 2030
141	2002	2593.00	Eleven Point R.	P	Y	22.70	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Oregon	11010011		L	> 10 years
142	2006	2597.00	Eleven Point R.	P	Y	11.40	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Oregon	11010011		L	> 10 years
143	2008	2601.00	Eleven Point R.	P	Y	22.30	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Oregon	11010011		L	> 10 years
144	2002	0189.00	Elkhorn Cr.	C	N (17.6)	21.40	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Montgomery	07110008		M	2026 - 2030
145	2020	7011.00	Ella Ewing Community Lake	L3	Y	15.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Scotland	07110002	1	L	> 10 years
146	2006	1283.00	Elm Br.	C	Y	3.00	Miles	AQL	Oxygen, Dissolved (W)	Windsor SE WWTP	Henry	10290108		M	2026 - 2030
147	2018	4110.00	Engelholm Creek	C	Y	3.00	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
148	2018	4110.00	Engelholm Creek	C	Y	3.00	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
149	2012	1704.00	Fee Fee Cr. (new)	P	Y	1.50	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	10300200		M	2026 - 2030
150	2012	1704.00	Fee Fee Cr. (new)	P	Y	1.50	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	10300200		H	2020
151	2012	7237.00	Fellows Lake	L1	Y	800.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Greene	10290106	2	L	> 10 years
152	2016	3595.00	Fenton Cr.	P	Y	0.50	Miles	AQL	Chloride (W)	Source Unknown	St. Louis	07140102		M	2026 - 2030
153	2012	3595.00	Fenton Cr.	P	Y	0.50	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140102		M	2026 - 2030
154	2012	2186.00	Fishpot Cr.	P	Y	3.50	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	07140102		M	2026 - 2030
155	2016	3220.00	Fivemile Cr.	P	N (4.9)	5.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070207	9	L	> 10 years
156	2016	0864.00	Flat Cr.	P	Y	23.70	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Pettis/Morgan	10300103		L	> 10 years
157	2006	2168.00	Flat River Cr.	C	N (4.7)	10.00	Miles	AQL	Cadmium (W)	Old Lead Belt tailings	St. Francois	07140104		H	2024
158	2012	3938.00	Flat River tributary	US	Y	0.30	Miles	GEN	Zinc (W)	Elvins Chat Pile	St. Francois	07140104	4	H	2024
159	2020	3587.00	Fleck Cr.	C	Y	4.30	Miles	AQL	Sulfate + Chloride (W)	Coal Mining	Barton	10290104		L	> 10 years
160	2010	7151.00	Forest Lake	L1	Y	580.00	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Adair	10280202	1 2 7	L	> 10 years
161	2016	7151.00	Forest Lake	L1	Y	580.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Adair	10280202	2 7	L	> 10 years
162	2016	3943.00	Foster Branch tributary	C	N (0.2)	2.00	Miles	AQL	Oxygen, Dissolved (W)	Ashland WWTF	Boone	10300102		M	2026 - 2030
163	2018	7324.00	Fourche Lake	L3	Y	49.00	Acres	AQL	Chlorophyll-a (W)	Source Unknown	Ripley	11010009	1 7	L	> 10 years
164	2018	7324.00	Fourche Lake	L3	Y	49.00	Acres	AQL	Nitrogen, Total (W)	Source Unknown	Ripley	11010009	1 7	L	> 10 years
165	2006	0747.00	Fowler Cr.	C	Y	6.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Boone	10300102		M	2026 - 2030

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166	2010	7382.00	Foxboro Lake	L3	Y	22.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Franklin	07140103		L	> 10 years
167	2008	0038.00	Fox R.	P	Y	42.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	Clark	07110001		M	2026 - 2030
168	2014	7008.00	Fox Valley Lake	L3	Y	89.00	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Clark	07110001	1 7	L	> 10 years
169	2014	7008.00	Fox Valley Lake	L3	Y	89.00	Acres	AQL	Nitrogen, Total (W)	Rural NPS	Clark	07110001	1 7	L	> 10 years
170	2010	7008.00	Fox Valley Lake	L3	Y	89.00	Acres	AQL	Phosphorus, Total (W)	Rural NPS	Clark	07110001	1 7	L	> 10 years
171	2020	7328.00	Fredricktown City Lake	L1	Y	80.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Madison	08020202	1 2	L	> 10 years
172	2002	7280.00	Frisco Lake	L3	Y	5.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Phelps	07140102		L	> 10 years
173	2016	4061.00	Gailey Branch	C	Y	3.20	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Pike	07110007		M	2026 - 2030
174	2012	1004.00	Gans Cr.	C	Y	5.50	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		M	2026 - 2030
175	2020	7426.00	Garden City New Lake	L1	Y	39.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1 2	L	> 10 years
176	2002	1455.00	Gasconade R.	P	Y	264.00	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Pulaski	10290203	2	L	> 10 years
177	2006	2184.00	Grand Glaize Cr.	C	Y	4.00	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	07140102		H	2025
178	2008	2184.00	Grand Glaize Cr.	C	Y	4.00	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140102		M	2026 - 2030
179	2002	2184.00	Grand Glaize Cr.	C	Y	4.00	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Louis	07140102		L	> 10 years
180	2006	0593.00	Grand R.	P	Y	56.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Livingston/Chariton	10280103	2	M	2026 - 2030
181	2006	1713.00	Gravois Creek	C	Y	10.70	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		H	2025
182	2008	1712.00	Gravois Creek	P	Y	2.30	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis/St. Louis City	07140101		M	2026 - 2030
183	2016	4051.00	Gravois Creek tributary	C	Y	1.90	Miles	WBC B	Escherichia coli (W)	Municipal, Urbanized High Density Area, Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
184	2020	7161.00	Green City Lake	L1	Y	57.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Sullivan	10280202	1 2	L	> 10 years
185	2006	1009.00	Grindstone Cr.	C	Y	2.50	Miles	WBC A	Escherichia coli (W)	Rural NPS	Boone	10300102		M	2026 - 2030
186	2020	7385.00	Harmony Mission Lake	L3	Y	96.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Bates	10290103	1	L	> 10 years
187	2020	7386.00	Harrison County Lake	L1	Y	280.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Harrison	10280101	1 2	L	> 10 years
188	2014	7386.00	Harrison County Lake	L1	Y	280.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Harrison	10280101	2	L	> 10 years
189	2020	7214.00	Harrisonville City Lake	L1	Y	419.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1 2	L	> 10 years
190	2010	7152.00	Hazel Creek Lake	L1	Y	518.00	Acres	AQL	Chlorophyll-a (W)	Rural NPS	Adair	10280201	1 2 7	L	> 10 years
191	2018	7152.00	Hazel Creek Lake	L1	Y	518.00	Acres	AQL	Nitrogen, Total (W)	Nonpoint Source	Adair	10280201	1 2 7	L	> 10 years
192	2020	7387.00	Hazel Hill Lake	L3	Y	62.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Johnson	10300104	1	L	> 10 years
193	2016	2196.00	Headwater Div. Chan.	P	Y	20.30	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cape Girardeau	07140105	2	L	> 10 years
194	2008	0848.00	Heaths Cr.	P	Y	21.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Pettis/Cooper	10300103		M	2026 - 2030
195	2006	3226.00	Hickory Cr.	P	Y	4.90	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton	11070207	9	L	> 10 years
196	2020	7190.00	Higginsville Reservoir (South)	L1	Y	147.10	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Lafayette	10300104	1 2	L	> 10 years
197	2012	1008.00	Hinkson Cr.	C	Y	18.80	Miles	WBC A	Escherichia coli (W)	Nonpoint Source	Boone	10300102		M	2026 - 2030
198	2016	1007.00	Hinkson Cr.	P	Y	7.60	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Boone	10300102		M	2026 - 2030
199	2016	7193.00	Holden City Lake	L1	Y	290.20	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Johnson	10300104	2	L	> 10 years
200	2012	1011.00	Hominy Br.	C	Y	1.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	Boone	10300102		M	2026 - 2030
201	2010	3169.00	Honey Cr.	P	Y	16.50	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
202	2010	3170.00	Honey Cr.	C	Y	2.70	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
203	2018	1251.00	Honey Cr.	C	Y	8.50	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Henry	10290108		L	> 10 years
204	2010	1348.00	Horse Cr.	P	Y	27.70	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Vernon/Cedar	10290106	5	L	> 10 years
205	2008	1348.00	Horse Cr.	P	Y	27.70	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon/Cedar	10290106		M	2026 - 2030
206	2014	3413.00	Horseshoe Cr.	C	Y	5.80	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Lafayette/Jackson	10300101		M	2026 - 2030
207	2002	7388.00	Hough Park Lake	L3	Y	10.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cole	10300102		L	> 10 years
208	2020	7029.00	Hunnewell Lake	L3	Y	228.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Shelby	07110004	1 8	L	> 10 years

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209	2012	7029.00	Hunnell Lake	L3	Y	228.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Shelby	07110004		L	> 10 years
210	2010	0420.00	Indian Cr.	C	Y	3.40	Miles	AQL	Chloride (W)	Road/Bridge Runoff, Non-construction	Jackson	10300101		M	2026 - 2030
211	2002	0420.00	Indian Cr.	C	Y	3.40	Miles	WBC A	Escherichia coli (W)	Leawood, KS WWTP	Jackson	10300101		H	2023
212	2008	7389.00	Indian Creek Community Lake	L3	Y	185.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Livingston	10280101		L	> 10 years
213	2014	3223.00	Jacobs Br.	P	Y	1.60	Miles	AQL	Cadmium (S)	Tri-State Mining District	Newton	11070207		M	2026 - 2030
214	2014	3223.00	Jacobs Br.	P	Y	1.60	Miles	AQL	Cadmium (W)	Tri-State Mining District	Newton	11070207		M	2026 - 2030
215	2014	3223.00	Jacobs Br.	P	Y	1.60	Miles	AQL	Lead (S)	Tri-State Mining District	Newton	11070207		M	2026 - 2030
216	2014	3223.00	Jacobs Br.	P	Y	1.60	Miles	AQL	Zinc (S)	Tri-State Mining District	Newton	11070207		M	2026 - 2030
217	2012	3223.00	Jacobs Br.	P	Y	1.60	Miles	AQL	Zinc (W)	Tri-State Mining District	Newton	11070207		M	2026 - 2030
218	2020	2365.00	James R.	P	Y	39.00	Miles	WBC A	Escherichia coli (W)	Source Unknown	Greene	11010002	2	L	> 10 years
219	2012	3207.00	Jenkins Cr.	P	Y	2.80	Miles	WBC A	Escherichia coli (W)	Rural NPS	Jasper	11070207	9	L	> 10 years
220	2014	3208.00	Jenkins Cr.	C	Y	4.80	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton/Jasper	11070207	9	L	> 10 years
221	2012	3205.00	Jones Cr.	P	Y	7.50	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton/Jasper	11070207	9	L	> 10 years
222	2016	5006.00	Joplin Creek	C	Y	3.90	Miles	AQL	Cadmium (W)	Mill Tailings	Jasper	11070207		L	> 10 years
223	2018	5006.00	Joplin Creek	C	Y	3.90	Miles	AQL	Zinc (W)	Mill Tailings	Jasper	11070207		L	> 10 years
224	2014	3374.00	Jordan Cr.	P	Y	3.80	Miles	AQL	Polycyclic Aromatic Hydrocarbons-PAHs (S)	Urban NPS	Greene	11010002		L	> 10 years
225	2012	3592.00	Keifer Cr.	P	Y	1.20	Miles	WBC A	Escherichia coli (W)	Rural NPS	St. Louis	07140102		M	2026 - 2030
226	2016	7657.00	Knox Village Lake	L3	Y	3.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101		L	> 10 years
227	2016	2171.00	Koen Cr.	C	Y	1.00	Miles	AQL	Lead (S)	Mine Tailings	St. Francois	07140104		H	2024
228	2020	7023.00	Labelle Lake #2	L1	Y	98.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Lewis	07110003	1 2	L	> 10 years
229	2016	7023.00	Labelle Lake #2	L1	Y	98.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Lewis	07110003	2	L	> 10 years
230	2010	7297.00	Lac Capri	L3	Y	106.00	Acres	AQL	Nitrogen, Total (W)	Rural, Residential Areas	St. Francois	07140104	1 6 7	L	> 10 years
231	2016	7659.00	Lake Boutin	L3	Y	20.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cape Girardeau	07140105		L	> 10 years
232	2002	7469.00	Lake Buteo	L3	Y	7.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Johnson	10300104		L	> 10 years
233	2020	7311.00	Lake Girardeau	L3	Y	144.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cape Girardeau	07140107	1	L	> 10 years
234	2020	7332.00	Lake Killarney	L3	Y	61.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Iron	08020202	1	L	> 10 years
235	2018	7049.00	Lake Lincoln	L3	Y	88.00	Acres	AQL	Chlorophyll-a (W)	Source Unknown	Lincoln	07110008	1 7	L	> 10 years
236	2002	7436.00	Lake of the Woods	L3	Y	3.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Boone	10300102		L	> 10 years
237	2008	7629.00	Lake of the Woods	UL	Y	7.00	Acres	GEN	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101	4	L	> 10 years
238	2016	7132.00	Lake Paho	L3	Y	273.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Mercer	10280102		L	> 10 years
239	2020	7312.00	Lake Springfield	L3	Y	293.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Greene	11010002	1	L	> 10 years
240	2014	7055.00	Lake Ste. Louise	L3	Y	71.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	St. Charles	07110009		L	> 10 years
241	2020	7054.00	Lake St. Louis	L3	Y	444.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	St. Charles	07110009	1	L	> 10 years
242	2016	7035.00	Lake Tom Sawyer	L3	Y	4.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Monroe	07110006		L	> 10 years
243	2020	7341.00	Lake Tywappity	L3	Y	43.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Scott	08020204	1	L	> 10 years
244	2020	7336.00	Lake Wappapello	L2	Y	7827.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Wayne	08020202	1	L	> 10 years
245	2010	7212.00	Lake Winnebago	L3	Y	272.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cass	10290108		L	> 10 years
246	2006	0847.00	Lamine R.	P	Y	64.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Morgan/Cooper	10300103		H	2023
247	2018	3105.00	Lateral #2 Main Ditch	P	Y	11.50	Miles	AQL	Ammonia, Total (W)	Source Unknown	Stoddard	08020204		L	> 10 years
248	2006	3105.00	Lateral #2 Main Ditch	P	Y	11.50	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Stoddard	08020204		M	2026 - 2030
249	2014	1529.00	L. Beaver Cr.	C	Y	3.50	Miles	WBC A	Escherichia coli (W)	Source Unknown	Phelps	10290203		M	2026 - 2030

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250	2008	1529.00	L. Beaver Cr.	C	Y	3.50	Miles	AQL	Sedimentation/Siltation (S)	Smith Sand and Gravel	Phelps	10290203		M	2026 - 2030
251	2012	0422.00	L. Blue R.	P	Y	35.10	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
252	2018	0422.00	L. Blue R.	P	Y	35.10	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
253	2012	1003.00	L. Bonne Femme Cr.	P	Y	9.00	Miles	WBC B	Escherichia coli (W)	Source Unknown	Boone	10300102		M	2026 - 2030
254	2006	1863.00	L. Dry Fk.	P	N (1)	5.20	Miles	AQL	Oxygen, Dissolved (W)	Rolla SE WWTP	Phelps	07140102		M	2026 - 2030
255	2006	1864.00	L. Dry Fk.	C	N (0.6)	4.70	Miles	AQL	Oxygen, Dissolved (W)	Rolla SE WWTP	Phelps	07140102		M	2026 - 2030
256	2008	1864.00	L. Dry Fk.	C	Y	4.70	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Phelps	07140102		M	2026 - 2030
257	2006	1325.00	L. Dry Wood Cr.	P	Y	20.50	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon	10290104		M	2026 - 2030
258	2010	1326.00	L. Dry Wood Cr.	C	Y	15.60	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Barton/Vernon	10290104		M	2026 - 2030
259	2012	3137.00	Lee Rowe Ditch	C	Y	6.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Mississippi	08020201		M	2026 - 2030
260	2018	7346.00	Lewis Lake	L3	Y	6.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Stoddard	08020204		L	> 10 years
261	2002	7020.00	Lewistown Lake	L1	Y	35.00	Acres	DWS	Atrazine (W)	Rural NPS	Lewis	07110002	2	M	2026 - 2030
262	2012	3575.00	Line Cr.	C	Y	7.00	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Platte	10240011		H	2023
263	2018	4107.00	Little Blue River tributary	C	Y	5.50	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		L	> 10 years
264	2020	7180.00	Little Dixie Lake	L3	Y	176.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Callaway	10300102	1	L	> 10 years
265	2010	3279.00	L. Lost Cr.	P	Y	5.80	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070206		H	2023
266	2006	0606.00	Locust Cr.	P	N (37.7)	91.70	Miles	WBC B	Escherichia coli (W)	Rural NPS	Putnam/Sullivan	10280103	2	H	2025
267	2012	2763.00	Logan Cr.	P	N (6.1)	36.00	Miles	AQL	Lead (S)	Sweetwater Lead Mine/Mill	Reynolds	11010007		M	2026 - 2030
268	2006	0696.00	Long Branch Cr.	C	N (1.8)	14.80	Miles	AQL	Oxygen, Dissolved (W)	Atlanta WWTP	Macon	10280203		M	2026 - 2030
269	2002	7097.00	Longview Lake	L2	Y	953.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101		L	> 10 years
270	2008	3652.00	L. Osage R.	C	Y	23.60	Miles	WBC B	Escherichia coli (W)	Rural NPS	Vernon	10290103		M	2026 - 2030
271	2006	3278.00	Lost Cr.	P	Y	8.50	Miles	WBC A	Escherichia coli (W)	Rural NPS	Newton	11070206		H	2021
272	2014	2854.00	L. St. Francis R.	P	N (24.2)	32.40	Miles	AQL	Lead (S)	Catherine Lead Mine, pos. Mine La Motte	Madison	08020202	2	H	2024
273	2006	2814.00	Main Ditch	C	Y	13.00	Miles	AQL	pH (W)	Poplar Bluff WWTP	Butler	11010007		M	2026 - 2030
274	2006	2814.00	Main Ditch	C	Y	13.00	Miles	AQL	Temperature, water (W)	Channelization	Butler	11010007		L	> 10 years
275	2012	3839.00	Maline Cr.	C	Y	0.50	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis City	07140101		M	2026 - 2030
276	2016	3839.00	Maline Cr.	C	Y	0.50	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis City	07140101		M	2026 - 2030
277	2016	7398.00	Maple Leaf Lake	L3	Y	127.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Lafayette	10300104		L	> 10 years
278	2002	7033.00	Mark Twain Lake	L2	Y	18132.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ralls	07110005	2	L	> 10 years
279	2018	4109.00	Martigney Creek	C	Y	1.60	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
280	2018	4109.00	Martigney Creek	C	Y	1.60	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
281	2014	3596.00	Mattese Cr.	P	Y	1.10	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140102		M	2026 - 2030
282	2016	1786.00	McClanahan Cr.	C	Y	2.50	Miles	SCR	Escherichia coli (W)	Source Unknown	Perry	07140105		M	2026 - 2030
283	2016	1786.00	McClanahan Cr.	C	Y	2.50	Miles	WBC B	Escherichia coli (W)	Source Unknown	Perry	07140105		M	2026 - 2030
284	2008	2183.00	Meramec R.	P	Y	22.80	Miles	AQL	Lead (S)	Old Lead belt tailings	St. Louis	07140102	2	M	2026 - 2030
285	2010	0123.00	M. Fk. Salt R.	C	N (11.4)	25.40	Miles	AQL	Oxygen, Dissolved (W)	Macon WWTP	Macon	07110006		M	2026 - 2030
286	2008	1299.00	Miami Cr.	P	Y	19.60	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Bates	10290102		M	2026 - 2030
287	2006	0468.00	Middle Fk. Grand R.	P	Y	27.50	Miles	WBC A	Escherichia coli (W)	Rural NPS	Worth/Gentry	10280101		H	2023
288	2010	3262.00	Middle Indian Cr.	C	Y	3.50	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Newton	11070208	5	M	2026 - 2030
289	2010	3263.00	Middle Indian Cr.	P	Y	2.20	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Newton	11070208	5	M	2026 - 2030

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290	2008	3263.00	Middle Indian Cr.	P	Y	2.20	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070208		H	2021
291	2016	4066.00	Mill Creek	C	Y	3.40	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
292	2016	4066.00	Mill Creek	C	Y	3.40	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
293	2016	4066.00	Mill Creek	C	Y	3.40	Miles	AQL	Oxygen, Dissolved (W)	Urban Runoff/Storm Sewers	Jackson	10300101		M	2026 - 2030
294	2008	1604.00	Missouri R.	P	N (33.9)	104.50	Miles	WBC B	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	St. Charles/St. Louis	10300200	2	L	> 10 years
295	2010	0226.00	Missouri R.	P	Y	184.50	Miles	WBC B	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	Atchison/Jackson	10240011	2	L	> 10 years
296	2012	0356.00	Missouri R.	P	Y	129.00	Miles	WBC B	Escherichia coli (W)	Municipal Point Source Discharges, Nonpoint Source	Jackson/Chariton	10300101	2	L	> 10 years
297	2020	7031.00	Monroe City Lake	L1	Y	94.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Ralls	07110007	1 2	L	> 10 years
298	2014	7031.00	Monroe City Lake	L1	Y	94.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ralls	07110007	2	L	> 10 years
299	2020	7034.00	Monroe City Lake B	L1	Y	55.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Monroe	07110007	1 2	L	> 10 years
300	2018	7301.00	Monsanto Lake	L3	Y	18.00	Acres	AQL	Chlorophyll-a (W)	Source Unknown	St. Francois	07140104	1 3 7	L	> 10 years
301	2016	7301.00	Monsanto Lake	L3	Y	18.00	Acres	AQL	Nitrogen, Total (W)	Source Unknown	St. Francois	07140104	1 3 7	L	> 10 years
302	2018	7301.00	Monsanto Lake	L3	Y	18.00	Acres	AQL	Phosphorus, Total (W)	Source Unknown	St. Francois	07140104	1 3 7	L	> 10 years
303	2020	7402.00	Mozingo Lake	L1	Y	998.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Nodaway	10240013	1 2	L	> 10 years
304	2010	7402.00	Mozingo Lake	L1	Y	998.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Nodaway	10240013	2	L	> 10 years
305	2018	0853.00	Muddy Cr.	P	Y	62.20	Miles	WBC B	Escherichia coli (W)	Rural NPS	Pettis	10300103		M	2026 - 2030
306	2020	7136.00	New Marceline City Lake	L1	Y	160.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Chariton	10280103	1 2	L	> 10 years
307	2016	0158.00	N. Fk. Cuivre R.	P	Y	25.10	Miles	WBC A	Escherichia coli (W)	Rural NPS	Pike/Lincoln	07110008		H	2020
308	2018	0110.00	N. Fk. Salt R.	P	Y	84.90	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Shelby/Monroe	07110005	2	L	> 10 years
309	2008	3186.00	N. Fk. Spring R.	P	Y	17.40	Miles	WBC B	Escherichia coli (W)	Rural NPS	Jasper	11070207	9	L	> 10 years
310	2008	3188.00	N. Fk. Spring R.	C	Y	55.90	Miles	WBC B	Escherichia coli (W)	Rural NPS	Dade/Jasper	11070207	9	L	> 10 years
311	2006	3188.00	N. Fk. Spring R.	C	Y	55.90	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Dade/Jasper	11070207		M	2026 - 2030
312	2012	3260.00	N. Indian Cr.	P	Y	5.20	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Newton	11070208	5	M	2026 - 2030
313	2008	3260.00	N. Indian Cr.	P	Y	5.20	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070208		H	2021
314	2014	0227.00	Nishnabotna R.	P	Y	10.20	Miles	WBC B	Escherichia coli (W)	Rural NPS	Atchison	10240004	2	M	2026 - 2030
315	2018	0227.00	Nishnabotna R.	P	Y	10.20	Miles	SCR	Escherichia coli (W)	Rural NPS	Atchison	10240004	2	M	2026 - 2030
316	2014	7316.00	Noblett Lake	L3	Y	26.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Douglas	11010006	1 7	L	> 10 years
317	2002	7316.00	Noblett Lake	L3	Y	26.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Douglas	11010006	7	L	> 10 years
318	2014	7316.00	Noblett Lake	L3	Y	26.00	Acres	AQL	Phosphorus, Total (W)	Nonpoint Source	Douglas	11010006	1 7	L	> 10 years
319	2006	0550.00	No Cr.	P	Y	28.70	Miles	WBC B	Escherichia coli (W)	Rural NPS	Grundy/Livingston	10280102		M	2026 - 2030
320	2010	0550.00	No Cr.	P	Y	28.70	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Grundy/Livingston	10280102		M	2026 - 2030
321	2020	7076.00	Nodaway Lake	L3	Y	73.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Nodaway	10240013	1	L	> 10 years
322	2010	0279.00	Nodaway R.	P	Y	59.30	Miles	WBC B	Escherichia coli (W)	Rural NPS	Nodaway/Andrew	10240010		H	2020
323	2016	7317.00	Norfolk Lake	L2	Y	1000.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ozark	11010006		L	> 10 years
324	2010	7109.00	North Bethany City Reservoir	L3	Y	78.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Harrison	10280101		L	> 10 years
325	2014	3811.00	North Branch Wilsons Cr.	P	Y	3.80	Miles	AQL	Zinc (S)	Urban NPS	Greene	11010002		M	2026 - 2030
326	2020	7218.00	North Lake	L3	Y	19.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1	L	> 10 years
327	2016	1794.00	Omete Cr.	C	Y	1.20	Miles	SCR	Escherichia coli (W)	Source Unknown	Perry	07140105		M	2026 - 2030
328	2016	1794.00	Omete Cr.	C	Y	1.20	Miles	WBC B	Escherichia coli (W)	Source Unknown	Perry	07140105		M	2026 - 2030
329	2018	3190.00	Opossum Cr.	C	Y	6.40	Miles	WBC B	Escherichia coli (W)	Rural NPS	Jasper	11070207	9	L	> 10 years
330	2016	1293.00	Osage R.	P	Y	50.70	Miles	WBC A	Escherichia coli (W)	Source Unknown	Vernon/St. Clair	10290105		H	2020
331	2006	1373.00	Panther Cr.	C	Y	9.70	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Polk/St. Clair	10290106		M	2026 - 2030

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332	2008	2373.00	Pearson Cr.	P	Y	8.00	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	Greene	11010002	5	L	2031
333	2006	2373.00	Pearson Cr.	P	Y	8.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Greene	11010002		L	2031
334	2016	0099.00	Peno Cr.	C	Y	14.40	Miles	AQL	Oxygen, Dissolved (W)	Northeast Correctional Center WWTP	Pike	07110007		M	2026 - 2030
335	2020	7273.00	Perry County Community Lake	L3	Y	89.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Perry	07140105	1	L	> 10 years
336	2008	7628.00	Perry Phillips Lake	UL	Y	32.00	Acres	GEN	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Boone	10300102	4	L	> 10 years
337	2002	0218.00	Peraque Cr.	C	Y	10.90	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Nonpoint Source	Warren/St. Charles	07110009	5	M	2026 - 2030
338	2012	0215.00	Peraque Cr.	P1	Y	9.60	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	St. Charles	07110009		M	2026 - 2030
339	2016	0218.00	Peraque Cr.	C	Y	10.90	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Warren/St. Charles	07110009		M	2026 - 2030
340	2018	0785.00	Petite Saline Cr.	P	Y	21.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Cooper/Moniteau	10300102		L	> 10 years
341	2010	2815.00	Pike Cr.	C	Y	6.00	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Butler	11010007		M	2026 - 2030
342	2010	0312.00	Platte R.	P	Y	142.40	Miles	WBC B	Escherichia coli (W)	Rural NPS	Worth/Platte	10240012	2	H	2020
343	2012	1327.00	Pleasant Run Cr.	C	Y	7.60	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon	10290104		M	2026 - 2030
344	2006	3120.00	Pole Cat Slough	P	Y	12.60	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Dunklin	08020204		M	2026 - 2030
345	2014	3120.00	Pole Cat Slough	P	Y	12.60	Miles	AQL	Temperature, water (W)	Source Unknown	Dunklin	08020204		M	2026 - 2030
346	2020	7238.00	Pomme de Terre Lake	L2	Y	7820.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Hickory/Polk	10290107	1	L	> 10 years
347	2020	7213.00	Raintree Lake	L3	Y	248.10	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Cass	10290108	1	L	> 10 years
348	2020	7083.00	Ray County Community Lake	L3	Y	23.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Ray	10300101	1	L	> 10 years
349	2018	0743.00	Renfro Cr.	C	Y	1.50	Miles	AQL	Oxygen, Dissolved (W)	Abandoned Mine Lands and Rural NPS	Callaway/Boone	10300102		L	> 10 years
350	2016	7204.00	Rinquelin Trail Community Lake	L3	Y	27.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Maries	10290111		L	> 10 years
351	2006	1710.00	River des Peres	P	Y	2.60	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis City	07140101		H	2025
352	2006	3972.00	River des Peres	C	Y	13.60	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		H	2025
353	2012	1710.00	River des Peres	P	Y	2.60	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis City	07140101		M	2026 - 2030
354	2016	3972.00	River des Peres	C	Y	13.60	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
355	2016	3972.00	River des Peres	C	Y	13.60	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
356	2018	4111.00	River des Peres tributary	C	Y	1.80	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
357	2018	4111.00	River des Peres tributary	C	Y	1.80	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
358	2018	4111.00	River des Peres tributary	C	Y	1.80	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
359	2018	4106.00	Rock Creek	C	Y	6.20	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson/Clay	10300101		H	2023
360	2018	4106.00	Rock Creek	C	Y	6.20	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson/Clay	10300101		H	2023
361	2020	7086.00	Rocky Hollow Lake	L3	Y	20.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Clay	10300101	1	L	> 10 years
362	2020	7164.00	Rothwell Lake	L3	Y	27.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Randolph	10280203	1	L	> 10 years
363	2018	3577.00	Sadler Br.	C	Y	0.80	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Polk	10290106		L	> 10 years
364	2010	0594.00	Salt Cr.	C	Y	14.90	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Chariton	10280103		M	2026 - 2030
365	2014	0893.00	Salt Fk.	P	Y	26.70	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Saline	10300104		M	2026 - 2030
366	2012	2113.00	Salt Pine Cr.	C	Y	1.20	Miles	AQL	Lead (S)	Barite tailings pond	Washington	07140104		M	2026 - 2030
367	2012	2113.00	Salt Pine Cr.	C	Y	1.20	Miles	AQL	Zinc (S)	Barite tailings pond	Washington	07140104		M	2026 - 2030
368	2012	0103.00	Salt R.	P1	Y	9.30	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Ralls	07110007	2	L	> 10 years
369	2008	0091.00	Salt R.	P	Y	29.00	Miles	AQL	Oxygen, Dissolved (W)	Mark Twain Lake re-regulation dam	Ralls/Pike	07110007	2	L	> 10 years
370	2014	0103.00	Salt R.	P1	Y	9.30	Miles	AQL	Oxygen, Dissolved (W)	Cannon Dam	Ralls	07110007	2	L	> 10 years
371	2006	0655.00	S. Blackbird Cr.	C	Y	13.00	Miles	AQL	Ammonia, Total (W)	Source Unknown	Putnam	10280201		M	2026 - 2030
372	2006	0142.00	S. Fk. Salt R.	C	N (20.1)	40.10	Miles	AQL	Oxygen, Dissolved (W)	Mexico WWTP, Rural Nonpoint Source	Callaway/Audrain	07110006		M	2026 - 2030

Row #	Year	WBID	Waterbody	Class	Entire WB Imprd	WB Size	Units	IU	Pollutant	Source	County Up/Down	HUC 8	Comment	TMDL Priority	TMDL Schedule Year
373	2020	0141.00	S. Fk. Salt R.	P	Y	9.30	Miles	AQL	pH (W)	Nonpoint Source	Monroe	07110006		L	> 10 years
374	2006	1249.00	S. Grand R.	P	Y	66.80	Miles	WBC B	Escherichia coli (W)	Rural NPS	Cass/Henry	10290108		H	2020
375	2020	2865.00	Shays Cr.	C	Y	1.70	Miles	AQL	Lead (S)	Mine La Motte	Madison	08020202		L	> 10 years
376	2020	7042.00	Shelbina Lake	L1	Y	45.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Shelby	07110005	1 2	L	> 10 years
377	2014	3222.00	Shoal Cr.	P	N (3.8)	50.50	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070207	2	M	2026 - 2030
378	2014	3981.00	Shoal Creek tributary	C	Y	1.90	Miles	GEN	Cadmium (W)	Tanyard Hollow Pits	Jasper/Newton	11070207	4	M	2026 - 2030
379	2020	3982.00	Shoal Creek tributary	C	Y	2.20	Miles	AQL	Cadmium (W)	Mill Tailings	Jasper	11070207		M	2026 - 2030
380	2014	3981.00	Shoal Creek tributary	C	Y	1.90	Miles	GEN	Zinc (W)	Tanyard Hollow Pits	Jasper/Newton	11070207	4	M	2026 - 2030
381	2014	3982.00	Shoal Creek tributary	C	Y	2.20	Miles	AQL	Zinc (W)	Mill Tailings	Jasper	11070207		M	2026 - 2030
382	2018	3244.00	Silver Cr.	P	Y	1.90	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070207		M	2026 - 2030
383	2012	3259.00	S. Indian Cr.	P	Y	8.70	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Source Unknown	McDonald/Newton	11070208	5	M	2026 - 2030
384	2008	3259.00	S. Indian Cr.	P	Y	8.70	Miles	WBC B	Escherichia coli (W)	Rural NPS	McDonald/Newton	11070208		H	2021
385	2014	3754.00	Slater Br.	C	Y	3.70	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Jasper	11070207	9	L	> 10 years
386	2006	0399.00	Sni-a-bar Cr.	P	Y	36.60	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Jackson/Lafayette	10300101		M	2026 - 2030
387	2012	0224.00	Spencer Cr.	C	Y	1.50	Miles	AQL	Chloride (W)	Road/Bridge Runoff, Non-construction	St. Charles	07110009		M	2026 - 2030
388	2016	5007.00	Spring Branch	C	N (1.4)	3.10	Miles	WBC B	Escherichia coli (W)	Source Unknown	St. Louis	07140102		H	2024
389	2018	5004.00	Spring Branch	C	Y	6.70	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
390	2018	5004.00	Spring Branch	C	Y	6.70	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jackson	10300101		H	2024
391	2006	3160.00	Spring R.	P	Y	61.70	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence/Jasper	11070207	9	L	> 10 years
392	2010	3164.00	Spring R.	P	Y	8.80	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
393	2010	3165.00	Spring R.	P	Y	11.90	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
394	2018	4112.00	Spring River tributary	C	Y	4.00	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Jasper	11070207	9	L	> 10 years
395	2018	2677.00	Spring Valley Cr.	P	Y	10.80	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Shannon	11010008		L	> 10 years
396	2006	3135.00	Stevenson Bayou	C	Y	6.40	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Mississippi	08020201		M	2026 - 2030
397	2012	2835.00	St. Francis R.	P	N (8.4)	93.10	Miles	CLF	Temperature, water (W)	Source Unknown	St. Francois	08020202		M	2026 - 2030
398	2006	3138.00	St. Johns Ditch	P	Y	15.30	Miles	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	New Madrid	08020201		L	> 10 years
399	2006	0959.00	Straight Fk.	C	Y	6.00	Miles	AQL	Oxygen, Dissolved (W)	Versailles WWTP	Morgan	10300102		H	2025
400	2006	0686.00	Sugar Cr.	P	Y	6.80	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Randolph	10280203		M	2026 - 2030
401	2018	0686.00	Sugar Cr.	P	Y	6.80	Miles	AQL	Sulfate + Chloride (W)	Source Unknown	Randolph	10280203		L	> 10 years
402	2018	4108.00	Sugar Creek	C	Y	1.80	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
403	2018	4108.00	Sugar Creek	C	Y	1.80	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
404	2014	7166.00	Sugar Creek Lake	L1	Y	308.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Randolph	10280203	2	L	> 10 years
405	2006	7399.00	Sunset Lake	L3	Y	6.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Cole	10300102		L	> 10 years
406	2002	7313.00	Table Rock Lake	L2	Y	41747.00	Acres	AQL	Chlorophyll-a (W)	Municipal Point Source Discharges, Nonpoint Source	Stone	11010001	1 7	H	2025
407	2002	7313.00	Table Rock Lake	L2	Y	41747.00	Acres	AQL	Nitrogen, Total (W)	Municipal Point Source Discharges, Nonpoint Source	Stone	11010001	1 7	H	2025
408	2002	7313.00	Table Rock Lake	L2	Y	41747.00	Acres	AQL	Nutrient/Eutrophication Biol. Indicators (W)	Municipal Point Source Discharges, Nonpoint Source	Stone	11010001	1 7	H	2025
409	2016	7352.00	Thirtyfour Corner Blue Hole	L3	Y	9.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Mississippi	08010100		L	> 10 years
410	2008	0549.00	Thompson R.	P	N (5.2)	70.60	Miles	WBC B	Escherichia coli (W)	Rural NPS	Harrison	10280102	2	H	2021
411	2012	3243.00	Thurman Cr.	P	Y	3.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070207	9	L	> 10 years
412	2018	2114.00	Trib. Old Mines Cr.	C	Y	1.50	Miles	AQL	Lead (S)	Barite tailings pond	Washington	07140104		M	2026 - 2030
413	2010	2114.00	Trib. Old Mines Cr.	C	Y	1.50	Miles	AQL	Sedimentation/Siltation (S)	Barite tailings pond	Washington	07140104		M	2026 - 2030
414	2018	2114.00	Trib. Old Mines Cr.	C	Y	1.50	Miles	AQL	Zinc (S)	Barite tailings pond	Washington	07140104		M	2026 - 2030

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415	2010	1420.00	Trib. to Goose Cr.	C	Y	3.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence	10290106		H	2021
416	2006	3490.00	Trib. to L. Muddy Cr.	C	Y	1.00	Miles	AQL	Chloride (W)	Tyson Foods	Petit	10300103		L	> 10 years
417	2006	3589.00	Trib. to Wolf Cr.	C	Y	1.50	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	St. Francois	08020202		M	2026 - 2030
418	2006	0074.00	Troublesome Cr.	C	N (6.1)	41.30	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Knox	07110003		M	2026 - 2030
419	2012	0074.00	Troublesome Cr.	C	Y	41.30	Miles	AQL	Sedimentation/Siltation (S)	Habitat Mod. - other than Hydromod.	Knox/Marion	07110003		L	> 10 years
420	2012	3175.00	Truitt Cr.	C	Y	6.40	Miles	SCR	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
421	2016	3174.00	Truitt Cr.	P	Y	1.50	Miles	WBC B	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
422	2018	2985.00	Turkey Cr.	C	N (2.3)	3.10	Miles	AQL	Ammonia, Total (W)	Puxico WWTF	Stoddard	08020203		L	> 10 years
423	2006	3216.00	Turkey Cr.	P	Y	7.70	Miles	AQL	Cadmium (S)	Tri-State Mining District	Jasper	11070207		H	2021
424	2006	3217.00	Turkey Cr.	P	Y	6.10	Miles	AQL	Cadmium (S)	Tri-State Mining District	Jasper	11070207		H	2021
425	2016	3282.00	Turkey Cr.	P	Y	2.40	Miles	AQL	Cadmium (S)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
426	2006	3216.00	Turkey Cr.	P	Y	7.70	Miles	AQL	Cadmium (W)	Tri-State Mining District	Jasper	11070207		H	2021
427	2006	3282.00	Turkey Cr.	P	Y	2.40	Miles	AQL	Cadmium (W)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
428	2016	3282.00	Turkey Cr.	P	Y	2.40	Miles	AQL	Copper (S)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
429	2006	3216.00	Turkey Cr.	P	N (4.5)	7.70	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jasper	11070207	9	L	> 10 years
430	2006	3217.00	Turkey Cr.	P	Y	6.10	Miles	WBC A	Escherichia coli (W)	Urban Runoff/Storm Sewers	Jasper	11070207	9	L	> 10 years
431	2012	0751.00	Turkey Cr.	C	Y	6.30	Miles	WBC A	Escherichia coli (W)	Source Unknown	Boone	10300102		H	2023
432	2006	3217.00	Turkey Cr.	P	Y	6.10	Miles	AQL	Lead (S)	Tri-State Mining District	Jasper	11070207		H	2021
433	2008	3216.00	Turkey Cr.	P	Y	7.70	Miles	AQL	Lead (S)	Tri-State Mining District	Jasper	11070207		H	2021
434	2016	3282.00	Turkey Cr.	P	Y	2.40	Miles	AQL	Lead (S)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
435	2006	3282.00	Turkey Cr.	P	Y	2.40	Miles	AQL	Lead (W)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
436	2016	3282.00	Turkey Cr.	P	Y	2.40	Miles	AQL	Nickel (S)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
437	2018	2985.00	Turkey Cr.	C	N (2.3)	3.10	Miles	AQL	Oxygen, Dissolved (W)	Puxico WWTF	Stoddard	08020203		L	> 10 years
438	2006	3216.00	Turkey Cr.	P	Y	7.70	Miles	AQL	Zinc (S)	Tri-State Mining District	Jasper	11070207		H	2021
439	2006	3217.00	Turkey Cr.	P	Y	6.10	Miles	AQL	Zinc (S)	Tri-State Mining District	Jasper	11070207		H	2021
440	2016	3282.00	Turkey Cr.	P	Y	2.40	Miles	AQL	Zinc (S)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
441	2006	3282.00	Turkey Cr.	P	N (1.2)	2.40	Miles	AQL	Zinc (W)	Bonne Terre chat pile	St. Francois	07140104		M	2026 - 2030
442	2014	3983.00	Turkey Creek tributary	C	Y	2.90	Miles	GEN	Cadmium (S)	Abandoned Smelter Site	Jasper	11070207	4	H	2021
443	2016	3983.00	Turkey Creek tributary	C	Y	2.90	Miles	GEN	Cadmium (W)	Abandoned Smelter Site	Jasper	11070207	4	H	2021
444	2016	3984.00	Turkey Creek tributary	C	Y	2.20	Miles	GEN	Cadmium (W)	Mill Tailings	Jasper	11070207	4	H	2021
445	2014	3983.00	Turkey Creek tributary	C	Y	2.90	Miles	GEN	Lead (S)	Abandoned Smelter Site	Jasper	11070207	4	H	2021
446	2014	3983.00	Turkey Creek tributary	C	Y	2.90	Miles	GEN	Zinc (S)	Abandoned Smelter Site	Jasper	11070207	4	H	2021
447	2014	3983.00	Turkey Creek tributary	C	Y	2.90	Miles	GEN	Zinc (W)	Abandoned Smelter Site	Jasper	11070207	4	H	2021
448	2014	3984.00	Turkey Creek tributary	C	Y	2.20	Miles	GEN	Zinc (W)	Leadwood Hollow pits	Jasper	11070207	4	H	2021
449	2014	3985.00	Turkey Creek tributary	C	Y	1.60	Miles	GEN	Zinc (W)	Chitwood Hollow pits	Jasper	11070207	4	H	2021
450	2010	1414.00	Turnback Cr.	P	Y	19.90	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence/Dade	10290106		H	2021
451	2016	4079.00	Twomile Creek	C	Y	5.60	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		M	2026 - 2030
452	2016	7099.00	Unity Village Lake #2	L1	Y	26.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Jackson	10300101	2	L	> 10 years
453	2020	7051.00	Vandalia Community Lake	L3	Y	35.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Audrain	07110008	1	L	> 10 years
454	2020	7032.00	Vandalia Reservoir	L1	Y	28.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	Pike	07110007	1 2	L	> 10 years
455	2006	1708.00	Watkins Creek	C	Y	6.40	Miles	AQL	Chloride (W)	Urban Runoff/Storm Sewers	St. Louis/St. Louis City	07140101		H	2025
456	2016	4097.00	Watkins Creek tributary	C	Y	1.20	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
457	2016	4097.00	Watkins Creek tributary	C	Y	1.20	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years

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458	2016	4098.00	Watkins Creek tributary	C	Y	1.20	Miles	SCR	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
459	2016	4098.00	Watkins Creek tributary	C	Y	1.20	Miles	WBC B	Escherichia coli (W)	Urban Runoff/Storm Sewers	St. Louis	07140101		L	> 10 years
460	2020	7072.00	Waukomis Lake	L3	Y	76.00	Acres	AQL	Phosphorus, Total (W)	Nonpoint Source	Platte	10240011	17	L	> 10 years
461	2012	7071.00	Weatherby Lake	L3	Y	185.00	Acres	AQL	Chlorophyll-a (W)	Urban Runoff/Storm Sewers	Platte	10240011	17	L	> 10 years
462	2012	7071.00	Weatherby Lake	L3	Y	185.00	Acres	HHP	Mercury in Fish Tissue (T)	Atmospheric Deposition - Toxics	Platte	10240011	7	L	> 10 years
463	2010	7071.00	Weatherby Lake	L3	Y	185.00	Acres	AQL	Nitrogen, Total (W)	Urban Runoff/Storm Sewers	Platte	10240011	17	L	> 10 years
464	2014	7071.00	Weatherby Lake	L3	Y	185.00	Acres	AQL	Phosphorus, Total (W)	Urban Runoff/Storm Sewers	Platte	10240011	17	L	> 10 years
465	2006	0560.00	Weldon R.	P	Y	43.40	Miles	WBC B	Escherichia coli (W)	Rural NPS	Mercer/Grundy	10280102		H	2021
466	2006	1317.00	W. Fk. Dry Wood Cr.	C	Y	8.10	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Vernon	10290104		M	2026 - 2030
467	2008	1504.00	Whetstone Cr.	P	Y	12.20	Miles	AQL	Oxygen, Dissolved (W)	Rural NPS	Wright	10290201		H	2024
468	2010	3182.00	White Oak Cr.	C	Y	18.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence/Jasper	11070207	9	L	> 10 years
469	2012	1700.00	Wildhorse Cr.	C	Y	3.90	Miles	WBC B	Escherichia coli (W)	Rural, Residential Areas	St. Louis	10300200		M	2026 - 2030
470	2010	3171.00	Williams Cr.	P	Y	1.00	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
471	2010	3172.00	Williams Cr.	P	Y	8.50	Miles	WBC A	Escherichia coli (W)	Rural NPS	Lawrence	11070207	9	L	> 10 years
472	2012	3594.00	Williams Cr.	P	Y	1.00	Miles	WBC B	Escherichia coli (W)	Rural NPS	St. Louis	07140102		M	2026 - 2030
473	2014	3280.00	Willow Br.	P	Y	2.20	Miles	AQL	Cadmium (S)	Mill Tailings	Newton	11070206		M	2026 - 2030
474	2010	3280.00	Willow Br.	P	Y	2.20	Miles	WBC B	Escherichia coli (W)	Rural NPS	Newton	11070206		H	2021
475	2014	3280.00	Willow Br.	P	Y	2.20	Miles	AQL	Zinc (S)	Mill Tailings	Newton	11070206		M	2026 - 2030
476	2020	7438.00	Willow Brook Lake	L1	Y	53.00	Acres	AQL	Chlorophyll-a (W)	Nonpoint Source	DeKalb	10280101	12	L	> 10 years
477	2006	0955.00	Willow Fk.	C	Y	6.80	Miles	AQL	Oxygen, Dissolved (W)	Tipton WWTP and Unknown Sources	Moniteau	10300102		H	2025
478	2006	0956.00	Willow Fork tributary	C	Y	0.50	Miles	AQL	Oxygen, Dissolved (W)	Source Unknown	Moniteau	10300102		M	2026 - 2030
479	1998	2375.00	Wilson Cr.	P	Y	14.00	Miles	AQL	Aquatic Macroinvertebrate Bioassessments/ Unknown (W)	Nonpoint Source	Greene	11010002	5	L	2031
480	2006	2375.00	Wilson Cr.	P	N (7.4)	14.00	Miles	WBC B	Escherichia coli (W)	Nonpoint Source	Greene	11010002		L	2031
481	2014	2429.00	Woods Fk.	C	Y	5.50	Miles	AQL	Fishes Bioassessments/ Unknown (W)	Source Unknown	Christian	11010003	5	M	2026 - 2030

Key To List:

Bolded rows are new listings for the 2020 listing cycle

Row #: Row number that is not unique to any water, but is simply a count of the rows (listings)

Year: Year this waterbody/pollutant pair was added to the 303(d) List

WBID: Unique waterbody identification number. Clicking the link will bring up a WQA Public Search webpage with the available data for that WBID

Waterbody: Name of the waterbody.

Class: Waterbody Classification in Missouri State Water Quality Standards: P - Permanently Flowing Waters, C - Intermittently Flowing Waters, L1 - Drinking Water Reservoirs, L2 - Large Multi-purpose Lakes,

L3 - Other Recreational Lakes, US - Unclassified Stream, UL - Unclassified Lake

Entire WB Imprd: Y= Yes the entire waterbody is considered impaired; N= No the entire waterbody is not considered impaired.

WB Size: Size of entire waterbody segment

IU: Impaired Use

AQL - Protection of Warm Water Aquatic Life ; CLF - Cool-Water Fishery ; CLD - Cold-Water Fishery ; DWS - Drinking Water Supply ; GEN - General Criteria ; HHP - Human-Health Protection (Fish Consumption) ;

SCR - Secondary Contact Recreation ; WBC A - Whole Body Contact Recreation A (Designated Public Swimming Areas) ; WBC B - Whole Body Contact Recreation B (Those areas not considered WBC A)

Pollutant: The reason/cause the water is impaired

Media Indicators: (W) - The pollutant is in the water ; (S) - The pollutant is in the sediment ; (T) - The pollutant is in the tissue of an organism ; If no media indicator is shown the pollutant is in the water

Source: The source of the pollutant causing the impairment

County Up/Down: The county of the upstream end and downstream end of the segment that is impaired. Clicking the link will bring up a map viewer displaying the location of the impaired portion of the waterbody.

Comment:

1 - Nutrient related impairment

2 - Water is a Public Drinking Water Supply

3 - Monsanto Lake is part of the group of lakes known as the St. Joe State Park Lakes

4 - General Use pertaining to Aquatic Life

5 - This water is listed for either "Aquatic Macroinvertebrate Bioassessment/Unknown (W)" or "Fishes Bioassessment/Unknown (W)". This water lacks the necessary information

to point to a discrete pollutant and does not show signs of habitat impairment. Since the Department currently cannot point to a specific pollutant as the cause, the water is being listed for the observed effect as the reason the water is impaired.

6 - Only Lac Capri of the Terre Du Lac Lakes is impaired

7 - Lake is impaired for site specific criteria

8 - Trend analysis shows this water will exceed WQS within 5 years. See the 2020 Listing Methodology Document and Nutrient Implementation Plan for more information.

9 - This water is being prioritized as low for TMDL development due to 319 watershed management plans being implemented in the watershed.

Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

<http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm>

APPENDIX C - LAKE NUTRIENT TREND DATA

Appendix C - Lake Nutrient Trends

Chlorophyll-a Trends

Lake Name	WBID	Years of Data	Year of Potential Chl-a	Parametric Trend Analysis		Non-Parametric Trend Analysis		Category	Ecoregion
				Slope	p-value	Slope	p-value		
Brookfield Lake	7138	4	1865	↓ -0.156	0.550	↓ -0.203	0.734	2A	Plains
Henry Sever Lake	7024	7	2044	↑ 0.451	0.376	↓ -0.106	1.000	2A	Plains
L. Prairie Comm. Lake	7287	5	2026	↑ 0.341	0.459	↑ 0.348	0.086	2A	Ozark Highlands
Lake of the Ozarks	7205	7	2020	↑ 0.596	0.286	↑ 0.278	0.764	2A	Ozark Highlands
Long Branch Lake	7171	14	2216	↑ 0.074	0.770	↓ -0.005	1.000	2A	Plains
Stockton Lake	7235	8	2032	↑ 0.343	0.256	↑ 0.202	0.266	2A	Ozark Highlands
Bilby Ranch Lake	7368	4	2012	↑ 0.594	0.443	↑ 0.377	0.734	2B	Plains
HS Truman Lake	7207	5	2016	↑ 1.288	0.337	↑ 0.544	0.462	2B	Plains
Smithville Lake	7077	19	2046	↑ 0.392	0.078	↑ 0.331	0.093	2B	Plains
Manito Lake	7198	5	2020	↑ 0.688	0.239	↑ 0.576	0.807	3A	Ozark Border
Atkinson Lake	7234	5	2020	↓ -0.248	0.747	↓ -0.466	0.865	3B	Plains
Watkins Mill	7087	4	1975	↓ -0.315	0.573	↓ -0.272	0.734	3B	Plains
<i>Blind Pony Lake</i>	<i>7189</i>	<i>4</i>	<i>1995</i>	<i>↑ 1.594</i>	<i>0.541</i>	<i>↑ 1.025</i>	<i>0.734</i>	<i>Impaired</i>	<i>Plains</i>
<i>Deer Ridge Community Lake</i>	<i>7015</i>	<i>7</i>	<i>2017</i>	<i>↑ 1.327</i>	<i>0.168</i>	<i>↑ 0.845</i>	<i>0.764</i>	<i>Impaired</i>	<i>Plains</i>
<i>DiSalvo Lake</i>	<i>7331</i>	<i>5</i>	<i>2005</i>	<i>↑ 6.918</i>	<i>0.002</i>	<i>↑ 6.219</i>	<i>0.086</i>	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Fellow Lake</i>	<i>7237</i>	<i>12</i>	<i>1881</i>	<i>↓ -0.084</i>	<i>0.368</i>	<i>↓ -0.086</i>	<i>0.193</i>	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Harrison County Lake</i>	<i>7386</i>	<i>4</i>	<i>3500</i>	<i>↓ -0.002</i>	<i>0.999</i>	<i>↓ -0.860</i>	<i>0.734</i>	<i>Impaired</i>	<i>Plains</i>
<i>Hazel Hill Lake</i>	<i>7387</i>	<i>5</i>	<i>1998</i>	<i>↑ 1.211</i>	<i>0.020</i>	<i>↑ 1.398</i>	<i>0.086</i>	<i>Impaired</i>	<i>Plains</i>
<i>Higginsville Reservoir (South)</i>	<i>7190</i>	<i>5</i>	<i>2004</i>	<i>↑ 1.591</i>	<i>0.358</i>	<i>↑ 0.606</i>	<i>0.807</i>	<i>Impaired</i>	<i>Plains</i>
<i>Hunnell Lake</i>	<i>7029</i>	<i>9</i>	<i>2018</i>	<i>↑ 0.784</i>	<i>0.207</i>	<i>↑ 0.738</i>	<i>0.755</i>	<i>Impaired</i>	<i>Plains</i>
<i>Lake Wappapello</i>	<i>7336</i>	<i>12</i>	<i>2026</i>	<i>↓ -0.343</i>	<i>0.665</i>	<i>↓ -0.871</i>	<i>0.304</i>	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Lamar Lake</i>	<i>7356</i>	<i>6</i>	<i>2024</i>	<i>↓ -1.371</i>	<i>0.354</i>	<i>↓ -2.094</i>	<i>0.707</i>	<i>Impaired</i>	<i>Plains</i>
<i>Little Dixie Lake</i>	<i>7180</i>	<i>10</i>	<i>2052</i>	<i>↓ -0.077</i>	<i>0.892</i>	<i>↓ -0.161</i>	<i>0.858</i>	<i>Impaired</i>	<i>Plains</i>
<i>Mark Twain Lake</i>	<i>7033</i>	<i>13</i>	<i>2058</i>	<i>↑ 0.294</i>	<i>0.360</i>	<i>↑ 0.217</i>	<i>0.428</i>	<i>Impaired</i>	<i>Plains</i>
<i>Mozingo Lake</i>	<i>7402</i>	<i>4</i>	<i>2025</i>	<i>↑ 0.789</i>	<i>0.247</i>	<i>↑ 0.679</i>	<i>0.734</i>	<i>Impaired</i>	<i>Plains</i>
<i>Nodaway lake</i>	<i>7076</i>	<i>4</i>	<i>2010</i>	<i>↑ 2.116</i>	<i>0.266</i>	<i>↑ 1.306</i>	<i>0.734</i>	<i>Impaired</i>	<i>Plains</i>
<i>North Lake</i>	<i>7218</i>	<i>5</i>	<i>1991</i>	<i>↑ 1.864</i>	<i>0.271</i>	<i>↑ 2.099</i>	<i>0.462</i>	<i>Impaired</i>	<i>Plains</i>
<i>Pomme de Terre lake</i>	<i>7238</i>	<i>14</i>	<i>2000</i>	<i>↑ 0.065</i>	<i>0.859</i>	<i>↑ 0.252</i>	<i>0.743</i>	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Raintree Lake</i>	<i>7213</i>	<i>4</i>	<i>2019</i>	<i>↑ 1.160</i>	<i>0.293</i>	<i>↑ 0.650</i>	<i>0.308</i>	<i>Impaired</i>	<i>Plains</i>
<i>McDaniel Lake</i>	<i>7236</i>	<i>4</i>	<i>2025</i>	<i>↓ -0.080</i>	<i>0.854</i>	<i>↓ -0.246</i>	<i>1.000</i>	<i>TMDL</i>	<i>Ozark Highlands</i>
<i>Spring Fork Lake</i>	<i>7187</i>	<i>3</i>	<i>1985</i>	<i>↑ 0.802</i>	<i>0.804</i>	<i>NA</i>	<i>NA</i>	<i>TMDL</i>	<i>Plains</i>

* Year of potential exceedance come from projecting the trend line to the appropriate ecoregional chlorophyll-a criterion. Years with strikethrough appeared erroneous and should be ignored. Year of potential exceedance for lakes that do not have statistically significant trends (statistically significant means a p-value <0.05) should not be used for descion making. Lakes with italicized text are either listed as

Secchi Depth Trends

Lake Name	WBID	Years of Data		Parametric Trend Analysis		Non-Parametric Trend Analysis		Category	Ecoregion
				Slope	p-value	Slope	p-value		
Brookfield Lake	7138	4		↓ -0.010	0.350	↓ -0.008	0.734	2A	Plains
Henry Sever Lake	7024	7		↑ 0.028	0.125	↑ 0.019	0.230	2A	Plains
L. Prairie Comm. Lake	7287	5		↑ 0.019	0.249	↑ 0.021	0.462	2A	Ozark Highlands
Lake of the Ozarks	7205	7		↓ -0.061	0.146	↓ -0.059	0.548	2A	Ozark Highlands
Long Branch Lake	7171	14		↓ -0.004	0.614	↓ -0.005	0.743	2A	Plains
Stockton Lake	7235	8		↓ -0.049	0.152	↓ -0.041	0.536	2A	Ozark Highlands
Bilby Ranch Lake	7368	4		↓ -0.043	0.058	↓ -0.047	0.089	2B	Plains
HS Truman Lake	7207	5		↓ -0.016	0.618	↓ -0.017	1.000	2B	Plains
Smithville Lake	7077	19		↓ -0.013	0.012	↓ -0.014	0.021	2B	Plains
Manito Lake	7198	5		↑ 0.022	0.205	↑ 0.025	0.221	3A	Ozark Border
Atkinson Lake	7234	5		↑ 0.009	0.012	↑ 0.009	0.027	3B	Plains
Watkins Mill	7087	4		↑ 0.027	0.397	↑ 0.020	0.734	3B	Plains
<i>Blind Pony Lake</i>	<i>7189</i>	<i>4</i>	Secchi Depth Trend	↓ -0.013	0.524	↓ -0.017	0.734	<i>Impaired</i>	<i>Plains</i>
<i>Deer Ridge Community Lake</i>	<i>7015</i>	<i>7</i>		↓ -0.057	0.138	↓ -0.055	0.548	<i>Impaired</i>	<i>Plains</i>
<i>DiSalvo Lake</i>	<i>7331</i>	<i>5</i>		↓ -0.107	0.014	↓ -0.108	0.027	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Fellow Lake</i>	<i>7237</i>	<i>12</i>		↓ -0.027	0.207	↓ -0.030	0.193	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Harrison County Lake</i>	<i>7386</i>	<i>4</i>		↓ -0.031	0.137	↓ -0.030	0.308	<i>Impaired</i>	<i>Plains</i>
<i>Hazel Hill Lake</i>	<i>7387</i>	<i>5</i>		↓ -0.010	0.217	↓ -0.008	0.221	<i>Impaired</i>	<i>Plains</i>
<i>Higginsville Reservoir (South)</i>	<i>7190</i>	<i>5</i>		↓ -0.008	0.315	↓ -0.010	0.462	<i>Impaired</i>	<i>Plains</i>
<i>Hunnewell Lake</i>	<i>7029</i>	<i>9</i>		↓ -0.007	0.647	↓ -0.012	0.602	<i>Impaired</i>	<i>Plains</i>
<i>Lake Wappapello</i>	<i>7336</i>	<i>12</i>		↑ 0.080	0.502	↑ 0.010	0.837	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Lamar Lake</i>	<i>7356</i>	<i>6</i>		↑ 0.000	0.806	↓ -0.009	0.707	<i>Impaired</i>	<i>Plains</i>
<i>Little Dixie Lake</i>	<i>7180</i>	<i>10</i>		↓ -0.003	0.657	↓ -0.007	0.371	<i>Impaired</i>	<i>Plains</i>
<i>Mark Twain Lake</i>	<i>7033</i>	<i>13</i>		↓ -0.007	0.676	↓ -0.006	0.951	<i>Impaired</i>	<i>Plains</i>
<i>Mozingo Lake</i>	<i>7402</i>	<i>4</i>		↓ -0.047	0.008	↓ -0.048	0.089	<i>Impaired</i>	<i>Plains</i>
<i>Nodaway lake</i>	<i>7076</i>	<i>4</i>		↓ -0.009	0.100	↓ -0.008	0.089	<i>Impaired</i>	<i>Plains</i>
<i>North Lake</i>	<i>7218</i>	<i>5</i>		↓ -0.004	0.122	↓ -0.004	0.462	<i>Impaired</i>	<i>Plains</i>
<i>Pomme de Terre lake</i>	<i>7238</i>	<i>14</i>		↓ -0.022	0.445	↓ -0.022	0.511	<i>Impaired</i>	<i>Ozark Highlands</i>
<i>Raintree Lake</i>	<i>7213</i>	<i>4</i>		↑ 0.018	0.415	↑ 0.022	0.308	<i>Impaired</i>	<i>Plains</i>
<i>McDaniel Lake</i>	<i>7236</i>	<i>4</i>		↓ -0.031	0.747	↓ -0.027	0.089	<i>TMDL</i>	<i>Ozark Highlands</i>
<i>Spring Fork Lake</i>	<i>7187</i>	<i>3</i>		↑ 0.004	0.788	NA	NA	<i>TMDL</i>	<i>Plains</i>

Total Suspended Solids (TSS) Trends

Lake Name	WBID	Years of Data		Parametric Trend		Non-Parametric		Category	Ecoregion
				Slope	p-value	Slope	p-value		
Brookfield Lake	7138	4		↑ 0.210	0.440	↑ 0.081	0.734	2A	Plains
Henry Sever Lake	7024	7		↑ 0.149	0.511	↓ -0.174	0.764	2A	Plains
L. Prairie Comm. Lake	7287	5		↑ 0.052	0.590	↓ -0.031	0.807	2A	Ozark Highlands
Lake of the Ozarks	7205	7		↑ 0.168	0.183	↑ 0.146	0.133	2A	Ozark Highlands
Long Branch Lake	7171	14		↓ -0.025	0.799	↓ -0.038	0.511	2A	Plains
Stockton Lake	7235	8		↑ 0.076	0.210	↑ 0.095	0.174	2A	Ozark Highlands
Bilby Ranch Lake	7368	4		↑ 0.425	0.336	↑ 0.163	0.308	2B	Plains
HS Truman Lake	7207	5		↑ 0.090	0.588	↑ 0.110	0.462	2B	Plains
Smithville Lake	7077	19		↓ -0.059	0.520	↓ -0.056	0.576	2B	Plains
Manito Lake	7198	5		↑ 0.246	0.448	↑ 0.066	1.000	3A	Ozark Border
Atkinson Lake	7234	5		↓ -0.047	0.891	↑ 0.152	0.807	3B	Plains
Watkins Mill	7087	4		↓ -0.179	0.473	↓ -0.126	0.734	3B	Plains
<i>Blind Pony Lake</i>	7189	4	TSS Trend	↑ 0.678	0.355	↑ 0.634	0.734	Impaired	Plains
<i>Deer Ridge Community Lake</i>	7015	7		↑ 0.463	0.084	↑ 0.276	0.368	Impaired	Plains
<i>DiSalvo Lake</i>	7331	5		↑ 1.368	0.051	↑ 0.899	0.086	Impaired	Ozark Highlands
<i>Fellow Lake</i>	7237	12		↑ 0.031	0.195	↑ 0.033	0.373	Impaired	Ozark Highlands
<i>Harrison County Lake</i>	7386	4		↑ 0.857	0.348	↑ 0.484	0.308	Impaired	Plains
<i>Hazel Hill Lake</i>	7387	5		↑ 0.409	0.133	↑ 0.304	0.462	Impaired	Plains
<i>Higginsville Reservoir (South)</i>	7190	5		↑ 0.498	0.256	↑ 0.471	0.462	Impaired	Plains
<i>Hunnewell Lake</i>	7029	9		↑ 0.253	0.129	↑ 0.337	0.252	Impaired	Plains
<i>Lake Wappapello</i>	7336	12		↑ 0.014	0.933	↑ 0.106	0.537	Impaired	Ozark Highlands
<i>Lamar Lake</i>	7356	6		↓ -0.026	0.901	↓ -0.098	0.707	Impaired	Plains
<i>Little Dixie Lake</i>	7180	10		↑ 0.184	0.240	↑ 0.107	0.371	Impaired	Plains
<i>Mark Twain Lake</i>	7033	13		↑ 0.123	0.311	↑ 0.152	0.300	Impaired	Plains
<i>Mozingo Lake</i>	7402	4		↑ 0.350	0.288	↑ 0.260	0.734	Impaired	Plains
<i>Nodaway lake</i>	7076	4		↑ 0.498	0.498	↑ 0.023	0.734	Impaired	Plains
<i>North Lake</i>	7218	5		↑ 0.420	0.306	↓ -0.069	0.807	Impaired	Plains
<i>Pomme de Terre lake</i>	7238	14		↑ 0.039	0.584	↑ 0.066	0.661	Impaired	Ozark Highlands
<i>Raintree Lake</i>	7213	4		↑ 0.031	0.947	↓ -0.121	1.000	Impaired	Plains
<i>McDaniel Lake</i>	7236	4		↑ 0.060	0.449	↑ 0.037	1.000	TMDL	Ozark Highlands
<i>Spring Fork Lake</i>	7187	3		↓ -0.216	0.701	NA	NA	TMDL	Plains

APPENDIX D - LAKE SPECIFIC TROPHIC DATA

List of Lakes, Data, Trophic Status, and Ecoregion

Total Chlorophyll (ChlT), Secchi Depth (Secchi), Total Nitrogen (TN), Total Phosphorus (TP), Non-volatile Suspended Solids (NVSS), and Volatile Suspended Solids values are reported as geometric means.

WBID	Site Name	Acres	# of Years	ChlT (µg/l)	Secchi (m)	TN (µg/l)	TP (µg/l)	NVSS (mg/l)	VSS (mg/l)	Trophic Status	Ecoregion
7255	Creve Coeur Lake	327	22	47.18	0.41	856	121	15.79	8.24	Hypereutrophic	Big River Floodplain
7064	Lake Contrary	291	5	223.44	0.18	3291	393	17.15	30.91	Hypereutrophic	Big River Floodplain
7067	Lewis & Clark Lake	403	5	161.30	0.18	2432	341	36.25	22.42	Hypereutrophic	Big River Floodplain
1703	Mallard Lake	56	4	51.16	0.51	942	103	6.77	6.92	Hypereutrophic	Big River Floodplain
1615	Alpine Lake	233	11	1.88	3.72	305	6	0.98	1.12	Oligotrophic	Ozark Border
1828	Bella Vista Lake	43	10	8.07	1.54	517	23	1.43	2.07	Mesotrophic	Ozark Border
755	Bennett Lake	47	4	10.59	1.33	600	22	1.05	2.16	Mesotrophic	Ozark Border
7251	Big Lake of Whetstone Ck CA	62	3	10.00	1.13	597	22	2.70	2.15	Eutrophic	Ozark Border
7185	Binder Lake	127	29	30.46	0.84	844	59	2.84	5.30	Eutrophic	Ozark Border
1615	Castlenovo Lake	10	10	5.07	1.76	459	25	2.25	1.83	Mesotrophic	Ozark Border
1003	Cedar Lake	21	3	27.53	0.81	1157	70	1.25	6.33	Eutrophic	Ozark Border
7182	D C Rogers Lake	195	13	8.54	0.97	555	35	3.51	2.06	Eutrophic	Ozark Border
7177	Glover Spring Lake	23	7	15.34	1.12	876	59	3.70	4.43	Eutrophic	Ozark Border
7265	Goose Creek Lake	308	11	3.20	2.38	391	14	1.33	1.14	Mesotrophic	Ozark Border
1615	Innsbrook Lake	37	11	8.96	1.21	566	31	3.07	2.65	Eutrophic	Ozark Border
1709	Jennings Lake	5	15	27.93	0.92	1040	263	3.98	6.92	Eutrophic	Ozark Border
7659	Lake Boutin	20	11	9.53	1.44	617	24	1.47	2.49	Mesotrophic	Ozark Border
7267	Lake Forest	81	11	16.35	1.36	642	40	1.46	3.19	Eutrophic	Ozark Border
7311	Lake Girardeau	144	12	33.06	0.89	812	46	1.49	6.42	Eutrophic	Ozark Border
7248	Lake Lucern	41	13	8.48	1.23	588	28	2.25	2.44	Eutrophic	Ozark Border
7247	Lake Sherwood	120	10	6.86	1.87	527	17	1.05	2.91	Mesotrophic	Ozark Border
7307	Lake Tishomingo	115	19	7.80	1.68	545	20	1.36	1.97	Mesotrophic	Ozark Border
7341	Lake Tywappity	43	11	45.97	0.63	1134	58	1.63	7.66	Eutrophic	Ozark Border
7266	Lake Wanda Lee	97	10	16.27	1.57	566	43	2.19	3.15	Eutrophic	Ozark Border
7258	Lake Wauwanoka	93	19	2.84	2.88	441	16	1.44	1.43	Oligotrophic	Ozark Border
7198	Manito Lake	77	18	15.22	0.61	985	90	4.85	2.94	Eutrophic	Ozark Border
7273	Perry County Community Lake	89	13	50.46	0.48	1123	110	4.49	7.97	Hypereutrophic	Ozark Border
7183	Peters Lake	62	10	18.72	0.71	795	48	4.88	4.17	Eutrophic	Ozark Border
7249	Pinnacle Lake	115	5	3.65	2.41	455	18	1.48	1.34	Mesotrophic	Ozark Border
7444	Prairie Home CA Lake #2	20	5	7.38	1.32	567	26	1.14	2.36	Mesotrophic	Ozark Border
1007	Quarry Heights Lake	1	10	16.69	1.88	508	40	0.97	4.07	Eutrophic	Ozark Border
1008	Stephens Lake	10	8	9.17	1.20	591	38	2.40	3.21	Eutrophic	Ozark Border
1030	UMC Dairy Lake No. 3	6	4	56.23	0.50	1740	363	3.58	6.46	Hypereutrophic	Ozark Border
1030	UMC Dairy Lake No.1	14	10	79.60	0.48	1877	157	3.02	10.58	Hypereutrophic	Ozark Border
1632	Wellsville Lake	17	4	2.00	3.71	375	10	0.38	1.09	Oligotrophic	Ozark Border
3960	Whitecliff Park Lake	1	9	17.51	1.67	773	37	1.02	4.54	Eutrophic	Ozark Border
7203	Winegar Lake	8	3	10.22	1.51	568	22	0.98	2.66	Mesotrophic	Ozark Border
7239	Austin Community Lake	21	13	9.05	1.32	629	25	1.06	2.81	Eutrophic	Ozark Highland
7186	Ben Branch Lake	37	8	11.95	1.56	672	21	0.83	3.02	Mesotrophic	Ozark Highland
7315	Bull Shoals Lake	9000	16	5.08	2.84	342	10	1.73	4.71	Mesotrophic	Ozark Highland
7326	Clearwater Lake	1635	30	6.02	1.54	225	16	2.54	1.53	Mesotrophic	Ozark Highland
7299	Council Bluff Lake	423	29	2.26	3.34	225	8	0.70	0.72	Oligotrophic	Ozark Highland
7334	Crane Lake	109	9	3.84	1.41	223	12	1.88	1.48	Mesotrophic	Ozark Highland
7331	DiSalvo Lake	210	18	22.73	0.97	717	57	1.96	4.86	Eutrophic	Ozark Highland
7237	Fellows Lake	800	31	4.99	2.69	368	19	0.92	1.70	Mesotrophic	Ozark Highland
7324	Fourche Lake	49	13	2.45	3.00	259	9	0.73	1.09	Oligotrophic	Ozark Highland
7288	Indian Lake	279	15	15.31	1.04	615	34	2.29	3.09	Eutrophic	Ozark Highland
7287	L. Prairie Comm. Lake	95	31	7.90	1.49	479	24	2.33	1.78	Mesotrophic	Ozark Highland
7297	Lac Carmel	106	14	1.91	3.02	314	8	0.69	0.69	Oligotrophic	Ozark Highland
2080	Lac Lafitte	36	3	1.93	3.83	347	6	0.70	0.88	Oligotrophic	Ozark Highland
7332	Lake Killarney	61	8	26.87	0.78	601	53	3.05	4.47	Eutrophic	Ozark Highland
7206	Lake Niangua	256	3	10.96	0.45	650	47	9.24	3.56	Eutrophic	Ozark Highland
7243	Lake Northwood	77	13	3.83	1.43	441	21	2.58	1.43	Mesotrophic	Ozark Highland
7205	Lake of the Ozarks	59520	28	13.28	1.72	580	35	1.93	2.42	Eutrophic	Ozark Highland
7312	Lake Springfield	293	16	23.90	0.62	1019	49	9.82	4.17	Eutrophic	Ozark Highland
7314	Lake Taneycomo	2119	21	5.66	1.77	700	22	12.28		Mesotrophic	Ozark Highland
7336	Lake Wappapello	7827	32	24.35	1.03	615	72	4.08	5.44	Eutrophic	Ozark Highland
7322	Loggers Lake	21	8	2.69	3.17	207	8	0.49	0.94	Oligotrophic	Ozark Highland
7325	Lower Taum Sauk Lake	200	13	4.37	1.68	209	14	2.44	1.47	Mesotrophic	Ozark Highland
7282	Mac Lake - Ziske	28	12	10.75	1.56	545	27	1.18	2.51	Eutrophic	Ozark Highland
7319	McCormack Lake	9	3	0.71	3.30	96	5	0.37	0.37	Oligotrophic	Ozark Highland
7236	McDaniel Lake	218	25	14.38	1.45	462	37	1.52	3.07	Eutrophic	Ozark Highland
7301	Monsanto Lake	18	13	2.21	1.79	360	10	1.34	1.08	Mesotrophic	Ozark Highland
7316	Noblett Lake	26	11	2.21	2.46	178	11	0.63	0.82	Mesotrophic	Ozark Highland
7317	Norfolk Lake	1000	6	3.54	1.76	625	22	3.27	1.53	Mesotrophic	Ozark Highland
7241	Peaceful Valley Lake	158	14	18.60	1.38	769	33	1.41	3.33	Eutrophic	Ozark Highland
7406	Pinewoods Lake	22	11	11.00	1.28	590	27	0.68	3.45	Eutrophic	Ozark Highland
7238	Pomme de Terre Lake	7820	33	14.23	1.66	657	36	1.08	2.59	Eutrophic	Ozark Highland
7323	Ripley Lake	18	11	8.33	1.81	571	20	0.77	2.89	Mesotrophic	Ozark Highland
7245	Roby Lake	10	11	3.27	2.00	406	15	0.81	1.27	Mesotrophic	Ozark Highland
7281	Shawnee Lake - Turner	15	11	7.96	1.51	456	20	0.98	1.93	Mesotrophic	Ozark Highland
7333	Shepard Mountain Lake	21	5	12.45	1.24	364	25	1.19	2.51	Eutrophic	Ozark Highland
7321	Sims Valley Community Lake	42	14	8.85	1.53	420	20	1.06	2.49	Mesotrophic	Ozark Highland
7235	Stockton Lake	23680	32	6.69	2.70	427	17	1.23	1.72	Mesotrophic	Ozark Highland
7294	Sunnen Lake	206	14	3.26	2.49	297	12	1.22	0.86	Mesotrophic	Ozark Highland
7313	Table Rock Lake	41747	35	5.07	3.24	473	11	0.70	1.50	Mesotrophic	Ozark Highland
7304	Timberline Lakes	51	12	1.41	4.04	283	9	0.59	0.51	Oligotrophic	Ozark Highland
7225	Adrian Reservoir	45	4	24.71	0.39	839	56	9.34	5.08	Eutrophic	Plains
7360	Amarugia Lake	39	10	10.07	0.99	646	45	4.71	2.46	Eutrophic	Plains
746	Ashland Lake	5	11	39.21	0.54	1409	120	5.28	6.70	Eutrophic	Plains
1615	Aspen Lake	132	11	7.45	1.58	510	23	1.94	2.05	Mesotrophic	Plains
7234	Atkinson Lake	434	29	33.58	0.51	1060	71	7.77	5.91	Eutrophic	Plains
7019	Baring Country Club Lake	81	9	14.11	1.17	927	27	2.64	3.50	Eutrophic	Plains
7365	Belcher Branch Lake	42	7	13.92	1.04	569	37	3.21	2.50	Eutrophic	Plains
7368	Bilby Ranch Lake	95	18	28.05	0.99	860	48	2.60	4.55	Eutrophic	Plains
7189	Blind Pony Lake	96	22	35.47	0.52	1291	83	5.56	5.79	Eutrophic	Plains
7358	Blue Springs Lake	642	27	16.71	1.12	594	46	3.29	3.73	Eutrophic	Plains

WBID	Site Name	Acres	# of Years	ChlT (µg/l)	Secchi (m)	TN (µg/l)	TP (µg/l)	NVSS (mg/l)	VSS (mg/l)	Trophic Status	Ecoregion
7003	Bowling Green Lake - Old	7	12	7.03	0.95	948	70	1.79	2.53	Eutrophic	Plains
7004	Bowling Green Reservoir	41	30	6.51	1.64	513	27	1.60	1.77	Mesotrophic	Plains
7123	Breckenridge Lake	13	4	10.18	1.03	645	44	1.83	3.27	Eutrophic	Plains
7138	Brookfield Lake	120	27	6.66	1.26	598	22	3.50	2.00	Mesotrophic	Plains
7159	Bucklin Lake	17	3	24.62	0.53	1814	121	6.90	6.23	Eutrophic	Plains
7056	Busch W.A.- Kraut Run Lake	164	25	63.08	0.47	1151	102	5.66	8.98	Hypereutrophic	Plains
7232	Bushwacker Lake	148	8	11.75	1.12	595	28	2.16	2.63	Eutrophic	Plains
7229	Butler Lake	71	8	38.44	0.62	1047	75	4.56	5.79	Eutrophic	Plains
7120	Cameron Lake #1	25	3	26.00	0.37	1454	184	15.68	6.85	Hypereutrophic	Plains
7121	Cameron Lake #2	31	3	24.65	0.73	1197	76	7.45	4.45	Eutrophic	Plains
7119	Cameron Lake #3	92	18	26.66	0.52	1153	105	10.64	4.89	Eutrophic	Plains
7384	Cameron Lake #4 (Grindstone Reservoir)	173	16	29.39	0.48	1943	143	11.01	5.65	Eutrophic	Plains
7374	Cutclaw Lake	42	5	25.22	0.39	1201	108	10.48	7.66	Hypereutrophic	Plains
7058	Charity Lake	9	3	15.95	1.39	598	38	1.21	2.60	Eutrophic	Plains
7378	Coot Lake	20	5	29.64	0.50	1160	57	4.48	7.01	Eutrophic	Plains
7379	Cottontail Lake	22	6	21.47	0.42	833	85	11.98	5.59	Eutrophic	Plains
7085	Crystal Lake	122	4	25.52	0.54	957	78	10.75	5.69	Eutrophic	Plains
7015	Deer Ridge Community Lake	39	30	16.36	1.14	812	44	2.44	4.08	Eutrophic	Plains
7230	Drexel City Reservoir South	51	3	29.21	0.91	1146	51	1.90	4.63	Eutrophic	Plains
7228	Drexel Lake	28	3	33.79	0.68	1659	81	3.32	4.28	Eutrophic	Plains
7026	Edina Reservoir	51	12	26.01	0.55	1264	68	6.98	4.33	Eutrophic	Plains
7192	Edwin A Pape Lake	273	12	32.24	0.57	1035	68	6.87	4.13	Eutrophic	Plains
7011	Ella Ewing Community Lake	15	10	27.03	0.60	1259	82	6.23	4.06	Eutrophic	Plains
7146	Elmwood City Lake	197	13	17.69	0.72	765	55	4.41	3.22	Eutrophic	Plains
7151	Forest Lake	580	26	5.90	1.13	461	34	4.13	1.72	Eutrophic	Plains
7147	Fountain Grove Lakes	1366	4	35.40	0.81	1094	69	1.76	5.69	Eutrophic	Plains
7008	Fox Valley Lake	89	18	10.54	1.66	721	29	1.41	2.59	Eutrophic	Plains
1615	Foxtail Lake in Inmsbrook, Mo	3	9	18.54	0.73	776	60	3.64	3.87	Eutrophic	Plains
7426	Garden City New Lake	39	4	24.51	0.73	941	54	3.54	4.19	Eutrophic	Plains
7383	Gopher Lake	38	7	30.14	0.47	831	86	6.60	5.88	Eutrophic	Plains
7161	Green City Lake	57	10	29.64	0.53	1139	78	5.54	5.98	Eutrophic	Plains
7124	Hamilton Lake	80	15	15.01	0.80	946	57	5.03	3.34	Eutrophic	Plains
7385	Harmony Mission Lake	96	11	22.32	0.91	778	48	2.99	3.06	Eutrophic	Plains
7386	Harrison County Lake	280	18	34.85	0.58	1044	74	5.64	5.43	Eutrophic	Plains
7214	Harrisonville City Lake	419	11	18.94	0.80	881	48	5.46	4.17	Eutrophic	Plains
7152	Hazel Creek Lake	518	22	11.26	1.05	634	30	4.11	2.63	Eutrophic	Plains
7387	Hazel Hill Lake	62	18	33.49	0.69	1036	52	3.84	5.70	Eutrophic	Plains
7024	Henry Sever Lake	153	28	14.63	0.90	955	55	3.21	3.27	Eutrophic	Plains
765	Higbee City Lake	16	3	14.26	1.02	699	41	1.78	3.68	Eutrophic	Plains
7197	Higbee Lake	13	3	8.02	1.41	640	27	2.21	2.26	Mesotrophic	Plains
7190	Higginsville Reservoir (South)	147	27	30.97	0.52	1264	94	8.48	4.95	Eutrophic	Plains
7193	Holden City Lake	290	12	15.21	0.67	864	45	6.64	3.47	Eutrophic	Plains
7207	HS Truman Lake	55600	29	16.72	1.26	754	45	2.98	2.58	Eutrophic	Plains
7029	Hunnewell Lake	228	29	21.09	1.01	838	46	3.02	4.12	Eutrophic	Plains
7389	Indian Creek Community Lake	185	7	14.69	1.50	653	25	1.18	3.11	Mesotrophic	Plains
7391	Jackrabbit Lake	25	5	22.66	0.59	914	98	6.40	5.35	Eutrophic	Plains
7104	Jamesport City Lake	16	4	49.84	0.65	1311	99	2.17	8.52	Eutrophic	Plains
7105	Jamesport Community Lake	27	3	111.37	0.43	1868	135	2.72	12.83	Hypereutrophic	Plains
7114	King City New Reservoir	25	4	28.72	0.64	1039	88	6.03	5.93	Eutrophic	Plains
7112	King Lake	204	7	17.90	0.20	1618	200	28.02	6.13	Hypereutrophic	Plains
7196	Knob Noster St. Park Lakes	24	7	16.82	0.92	702	43	2.38	4.70	Eutrophic	Plains
7039	La Plata Lake - New	81	7	15.83	1.03	824	31	3.23	3.54	Eutrophic	Plains
7023	Labelle Lake #2	98	11	44.17	0.81	1275	70	2.03	6.84	Eutrophic	Plains
7627	Lake 37, Busch CA	30	3	7.84	1.17	471	26	3.21	1.94	Eutrophic	Plains
7453	Lake Allaman	6	8	11.84	1.13	609	38	3.00	3.45	Eutrophic	Plains
7469	Lake Buteo	7	8	6.17	1.18	563	32	2.43	2.58	Eutrophic	Plains
7101	Lake Jacomo	998	24	15.02	1.35	513	40	2.26	3.10	Eutrophic	Plains
1615	Lake Konstanz	18	11	1.81	2.75	354	11	1.49	1.29	Oligotrophic	Plains
7049	Lake Lincoln	88	29	4.92	2.05	417	18	1.37	1.75	Mesotrophic	Plains
7091	Lake Lotawana	487	19	14.53	1.34	563	38	1.75	2.29	Eutrophic	Plains
7131	Lake Marie	60	11	3.47	2.73	449	16	1.74	1.41	Mesotrophic	Plains
7158	Lake Nehai Tonkayea	228	11	2.51	1.91	395	14	2.52	1.10	Mesotrophic	Plains
7403	Lake Nell	24	4	28.81	0.51	1187	88	6.94	5.70	Eutrophic	Plains
7629	Lake of the Woods-KC	7	8	45.58	0.46	991	113	7.89	6.63	Hypereutrophic	Plains
7132	Lake Paho	273	12	12.72	0.76	825	45	5.62	2.90	Eutrophic	Plains
7014	Lake Showme	214	5	11.94	1.68	787	29	0.94	3.33	Eutrophic	Plains
7054	Lake St. Louis	444	23	26.54	0.53	1057	76	9.77	5.25	Eutrophic	Plains
7055	Lake Ste. Louise	71	17	9.59	1.17	516	35	3.53	2.41	Eutrophic	Plains
7103	Lake Tapawingo	83	18	22.17	1.02	682	38	2.22	4.77	Eutrophic	Plains
7153	Lake Thunderhead	859	12	14.71	0.64	947	49	6.49	2.87	Eutrophic	Plains
7122	Lake Viking	552	25	8.60	1.40	511	30	3.20	1.83	Mesotrophic	Plains
7212	Lake Winnebago	272	8	18.87	0.87	794	47	4.99	2.83	Eutrophic	Plains
7100	Lakewood Lake	279	5	16.13	1.24	586	34	2.96	2.80	Eutrophic	Plains
7356	Lamar Lake	148	24	41.33	0.79	1117	81	2.27	5.82	Eutrophic	Plains
7018	Lancaster City Lake - New	56	8	31.82	0.70	951	72	3.13	5.59	Eutrophic	Plains
7082	Lawson City Lake	25	6	20.46	0.89	912	34	3.11	4.61	Eutrophic	Plains
7111	Limpp Community State Lake	27	3	70.49	0.35	1592	115	11.43	15.89	Hypereutrophic	Plains
7180	Little Dixie Lake	176	27	26.85	0.64	927	59	4.15	4.75	Eutrophic	Plains
7209	Lone Jack Lake	31	3	15.27	1.62	646	28	1.01	2.81	Eutrophic	Plains
7171	Long Branch Lake	2686	29	13.73	0.68	913	51	5.83	3.26	Eutrophic	Plains
7097	Longview Lake	953	29	10.42	0.95	691	36	5.71	2.86	Eutrophic	Plains
7168	Macon Lake	189	13	23.86	0.78	878	50	4.22	3.90	Eutrophic	Plains
7398	Maple Leaf Lake	127	10	19.46	1.06	818	38	2.75	3.23	Eutrophic	Plains
7136	Marceline City Lake (New)	160	15	32.78	0.85	1047	73	4.39	5.74	Eutrophic	Plains
7160	Marceline Reservoir	68	6	24.14	0.68	1183	93	5.42	4.57	Eutrophic	Plains
7033	Mark Twain Lake	18132	29	5.03	0.86	0	87		2.53	Eutrophic	Plains
7115	Maysville Lake	27	12	37.43	0.62	1243	154	4.54	5.95	Eutrophic	Plains
7013	Memphis Reservoir	39	14	28.66	0.70	1055	64	5.26	6.21	Eutrophic	Plains
7439	Milan Lake South	37	14	13.55	0.98	717	45	2.64	3.16	Eutrophic	Plains
7031	Monroe City Lake	94	3	37.58	0.54	1289	107	4.31	5.86	Eutrophic	Plains
7034	Monroe City Lake B	55	16	34.19	0.52	1186	85	7.29	5.99	Eutrophic	Plains

WBID	Site Name	Acres	# of Years	ChlT (µg/l)	Secchi (m)	TN (µg/l)	TP (µg/l)	NVSS (mg/l)	VSS (mg/l)	Trophic Status	Ecoregion
7208	Montrose Lake	1444	11	57.69	0.29	1265	189	43.02	12.12	Hypereutrophic	Plains
7402	Mozingo Lake	998	18	17.61	1.28	699	36	2.53	2.63	Eutrophic	Plains
7076	Nodaway Lake	73	20	27.05	0.82	1082	49	3.87	5.29	Eutrophic	Plains
7109	North Bethany City Reservoir	78	13	7.40	1.52	662	27	2.93	2.32	Mesotrophic	Plains
7218	North Lake	19	31	45.03	0.65	1118	113	4.82	6.82	Hypereutrophic	Plains
7093	Odessa Lake	87	7	22.59	1.00	880	44	2.06	4.34	Eutrophic	Plains
7106	Old Bethany City Reservoir	18	5	6.12	1.76	592	24	1.22	2.07	Mesotrophic	Plains
226	Penn Valley Park Lake	2	8	35.90	0.54	1029	95	13.06	9.20	Eutrophic	Plains
7628	Phillips Lake	32	8	11.13	0.86	633	37	4.08	3.44	Eutrophic	Plains
7443	Pike Lake	17	4	14.12	1.55	656	26	1.07	2.58	Eutrophic	Plains
7118	Pony Express Lake	240	15	27.06	0.71	1017	60	4.23	4.69	Eutrophic	Plains
7102	Prairie Lee Lake	144	16	20.27	0.84	868	51	4.66	3.90	Eutrophic	Plains
7213	Raintree Lake	248	27	15.96	0.65	835	56	6.27	3.91	Eutrophic	Plains
7083	Ray County Community Lake	23	6	111.75	0.39	1936	164	4.71	13.11	Hypereutrophic	Plains
1615	Red Fox Lake	2	9	11.91	0.80	761	51	2.77	2.39	Eutrophic	Plains
278	Riss Lake in Parkville	127	6	4.02	1.81	366	13	2.29	1.98	Mesotrophic	Plains
7200	Rocky Fork Lake	60	8	5.69	1.68	474	18	1.63	1.70	Mesotrophic	Plains
7086	Rocky Hollow Lake	20	11	30.08	0.54	932	80	7.72	5.02	Eutrophic	Plains
7164	Rothwell Lake	27	17	23.34	1.10	887	55	2.42	4.88	Eutrophic	Plains
115	Santa Fe Lake	27	4	17.95	1.20	890	36	1.20	3.67	Eutrophic	Plains
7061	Savannah City Reservoir	20	4	23.30	0.99	898	47	3.58	4.27	Eutrophic	Plains
7145	Sears Community Lake	32	3	5.91	1.19	624	33	3.00	1.71	Eutrophic	Plains
7042	Shelbina Lake	45	14	38.51	0.57	1096	94	6.12	6.56	Eutrophic	Plains
7077	Smithville Lake	7190	22	11.73	0.99	874	67	3.24	10.73	Eutrophic	Plains
7187	Spring Fork Lake	178	21	45.36	0.52	1323	164	5.41	6.30	Hypereutrophic	Plains
7150	Spring Lake	87	9	7.21	1.05	557	34	4.14	2.07	Eutrophic	Plains
7149	Sterling Price Community Lake	23	8	62.55	0.56	1454	101	4.16	10.37	Hypereutrophic	Plains
7166	Sugar Creek Lake	308	28	19.88	0.79	834	53	5.75	4.27	Eutrophic	Plains
7173	Thomas Hill Reservoir	4400	14	13.79	0.51	761	51	7.54	2.49	Eutrophic	Plains
7624	Tri City Lake	27	23	25.90	0.78	1007	61	4.25	4.71	Eutrophic	Plains
226	Troost Lake	3	5	32.49	0.46	1446	90	3.87	5.35	Eutrophic	Plains
7154	Unionville Reservoir	74	20	31.43	0.49	1229	106	7.61	5.36	Eutrophic	Plains
7051	Vandalia Community Lake	35	13	28.57	0.81	1058	68	2.35	4.93	Eutrophic	Plains
7032	Vandalia Reservoir	28	6	16.63	0.79	1426	118	4.57	5.46	Eutrophic	Plains
7002	Wakonda Lake	78	6	49.19	0.71	1114	88	3.49	7.91	Eutrophic	Plains
1615	Wanderfern Lake	40	11	7.61	1.63	506	22	1.95	2.30	Mesotrophic	Plains
7165	Water Works Lake	22	15	21.65	1.03	848	54	2.86	4.65	Eutrophic	Plains
7087	Watkins Mill Lake	87	28	18.38	0.88	652	40	4.31	3.51	Eutrophic	Plains
7072	Waukomis Lake	76	24	8.31	1.59	559	24	2.23	2.27	Mesotrophic	Plains
7071	Weatherby Lake	185	20	6.17	2.20	428	21	1.67	2.68	Mesotrophic	Plains
1615	Whippoorwill Lake	7	10	3.92	1.69	491	22	1.63	1.69	Mesotrophic	Plains
7050	Whiteside Lake	28	6	9.61	1.79	703	23	0.73	2.58	Mesotrophic	Plains
7438	Willow Brook Lake	53	6	34.59	0.59	1198	87	7.40	5.93	Eutrophic	Plains
7110	Worth County Community Lake	17	4	37.61	0.58	1336	75	3.64	7.23	Eutrophic	Plains

APPENDIX E - OTHER WATERS RATED AS IMPAIRED AND BELIEVED TO BE IMPAIRED

**Appendix E - Other Waters Rated as Impaired and Believed to be Impaired
Category 4A, 4B, & 4C Waters**

WBID	Waterbody Name	Size	Cause of Impairment	Potential Source	Category
4083.00	Barker Creek tributary	1.20	pH	Source Unknown	4A
4083.00	Barker Creek tributary	1.20	Sulfates	Source Unknown	4A
1746.00	Big Bottom Cr.	1.50	Ammonia, Total	Municipal Point Source Discharges	4A
1746.00	Big Bottom Cr.	1.50	Oxygen, Dissolved	Municipal Point Source Discharges	4A
2916.00	Big Cr.	34.10	Cadmium	Ind./Comm. Site Strmwtr Disch, Permitted	4A
2074.00	Big R.	55.60	Lead	Mill Tailings	4A
2080.00	Big R.	81.30	Lead	Mill Tailings	4A
2080.00	Big R.	81.30	Lead	Mine Tailings	4A
2080.00	Big R.	81.30	Sedimentation/Siltation	Mill Tailings	4A
0111.00	Black Cr.	19.40	Escherichia coli	Municipal Point Source Discharges	4A
3825.00	Black Creek	5.60	Escherichia coli	Urban Runoff/Storm Sewers	4A
0417.00	Blue R.	4.40	Chlordane in Fish Tissue	Nonpoint Source	4A
3941.00	Cave Spring Br.	0.40	Nitrogen, Total	Industrial Point Source Discharge	4A
3203.00	Center Cr.	26.80	Zinc	Mill Tailings	4A
0640.00	Chariton R.	111.00	Escherichia coli	Agriculture	4A
3168.00	Chat Cr.	2.10	Zinc	Subsurface, Hardrock, Mining	4A
1706.00	Coldwater Cr.	6.90	Escherichia coli	Urban Runoff/Storm Sewers	4A
1703.00	Creve Coeur Cr.	3.80	Escherichia coli	Urban Runoff/Storm Sewers	4A
3826.00	Deer Creek	1.60	Escherichia coli	Urban Runoff/Storm Sewers	4A
2186.00	Fishpot Cr.	3.50	Escherichia coli	Urban Runoff/Storm Sewers	4A
2168.00	Flat River Cr.	10.00	Lead	Mill Tailings	4A
2168.00	Flat River Cr.	10.00	Lead	Mine Tailings	4A
2168.00	Flat River Cr.	10.00	Sedimentation/Siltation	Mill Tailings	4A
2168.00	Flat River Cr.	10.00	Zinc	Mill Tailings	4A
0593.00	Grand R.	56.00	Fishes Bioassessments	Channelization	4A
1712.00	Gravois Creek	2.30	Escherichia coli	Urban Runoff/Storm Sewers	4A
1713.00	Gravois Creek	10.70	Escherichia coli	Urban Runoff/Storm Sewers	4A
1007.00	Hinkson Cr.	7.60	Cause Unknown	Urban Runoff/Storm Sewers	4A
1008.00	Hinkson Cr.	18.80	Cause Unknown	Urban Runoff/Storm Sewers	4A
1251.00	Honey Cr.	8.50	Sulfates	Coal Mining	4A
2681.00	Jacks Fk.	61.60	Escherichia coli	Municipal Point Source Discharges	4A
2681.00	Jacks Fk.	61.60	Escherichia coli	Other Recreational Pollution Sources	4A
3233.00	Joyce Cr.	4.50	Escherichia coli	Nonpoint Source	4A
0623.00	L. Medicine Cr.	39.80	Escherichia coli	Nonpoint Source	4A
3652.00	L. Osage R.	23.60	Oxygen, Dissolved	Source Unknown	4A
1381.00	L. Sac R.	37.00	Escherichia coli	Agriculture	4A
1381.00	L. Sac R.	37.00	Escherichia coli	Nonpoint Source	4A
7314.00	Lake Taneycomo	2,118.60	Dissolved oxygen saturation	Dam or Impoundment	4A
7356.00	Lamar Lake	148.00	Nutrient/Eutrophication Biol. Indicators	Nonpoint Source	4A
3105.00	Lateral #2 Main Ditch	11.50	Sedimentation/Siltation	Nonpoint Source	4A
0606.00	Locust Cr.	91.70	Fishes Bioassessments	Channelization	4A
0857.00	Long Br.	6.00	Cause Unknown	Source Unknown	4A
2814.00	Main Ditch	13.00	Ammonia, Un-ionized	Municipal Point Source Discharges	4A
2814.00	Main Ditch	13.00	Oxygen, Dissolved	Source Unknown	4A
1709.00	Maline Creek	7.20	Escherichia coli	Urban Runoff/Storm Sewers	4A
1308.00	Marmaton R.	35.70	Oxygen, Dissolved	Nonpoint Source	4A
7236.00	McDaniel Lake	218.00	Chlorophyll-a	Nonpoint Source	4A
2787.00	McKenzie Cr.	4.70	pH	Municipal Point Source Discharges	4A
2787.00	McKenzie Cr.	4.70	pH	Source Unknown	4A
0619.00	Medicine Cr.	43.80	Escherichia coli	Nonpoint Source	4A
1284.00	Middle Fk. Tebo Cr.	7.50	Total Dissolved Solids	Coal Mining	4A
1707.03	Mississippi R.	44.60	Lead	Industrial Point Source Discharge	4A
1707.03	Mississippi R.	44.60	Zinc	Industrial Point Source Discharge	4A
1234.00	Monegaw Cr.	18.40	Sulfates	Coal Mining	4A
1300.00	Mound Br.	8.90	Dissolved oxygen saturation	Source Unknown	4A
0674.00	Mussel Fk.	29.00	Escherichia coli	Nonpoint Source	4A
0942.00	N. Moreau Cr.	47.90	Oxygen, Dissolved	Source Unknown	4A
1170.00	Niangua R.	56.00	Escherichia coli	Nonpoint Source	4A
1444.00	Piper Cr.	5.30	Aquatic Macroinvertebrate Bioassessments	Source Unknown	4A
3232.00	Pogue Cr.	2.50	Escherichia coli	Nonpoint Source	4A
2128.00	Pond Cr.	1.00	Sedimentation/Siltation	Mill Tailings	4A
2128.00	Pond Cr.	1.00	Zinc	Mill Tailings	4A

WBID	Waterbody Name	Size	Cause of Impairment	Potential Source	Category
2859.00	Saline Cr.	5.80	Nickel	Mine Tailings	4A
2170.00	Shaw Br.	1.20	Lead	Mill Tailings	4A
2119.00	Shibboleth Br.	1.00	Lead	Mill Tailings	4A
2119.00	Shibboleth Br.	1.00	Zinc	Mill Tailings	4A
2120.00	Shibboleth Br.	3.00	Lead	Mill Tailings	4A
2120.00	Shibboleth Br.	3.00	Zinc	Mill Tailings	4A
3230.00	Shoal Cr.	15.70	Escherichia coli	Nonpoint Source	4A
3231.00	Shoal Cr.	5.00	Escherichia coli	Nonpoint Source	4A
1870.00	Spring Cr.	18.00	Oxygen, Dissolved	Municipal Point Source Discharges	4A
1870.00	Spring Cr.	18.00	Solids, Suspended/Bedload	Municipal Point Source Discharges	4A
7187.00	Spring Fork Lake	178.00	Chlorophyll-a	Nonpoint Source	4A
2835.00	St. Francis R.	93.10	Oxygen, Dissolved	Municipal Point Source Discharges	4A
0710.00	Stinson Cr.	11.90	Oxygen, Dissolved	Municipal Point Source Discharges	4A
0710.00	Stinson Cr.	11.90	Oxygen, Dissolved	Natural Conditions, UAA Needed	4A
0959.00	Straight Fk.	6.00	Chloride	Municipal Point Source Discharges	4A
0686.00	Sugar Cr.	6.80	pH	Coal Mining, Subsurface	4A
3822.00	Town Br.	2.50	Cause Unknown	Source Unknown	4A
3822.00	Town Br.	2.50	Total Suspended Solids - TSS	Municipal Point Source Discharges	4A
3822.00	Town Br.	2.50	Total Suspended Solids - TSS	Source Unknown	4A
2850.00	Trace Cr.	6.20	pH	Natural Sources	4A
1288.00	Trib. M. Fk. Tebo Cr.	3.10	pH	Coal Mining	4A
1288.00	Trib. M. Fk. Tebo Cr.	3.10	Total Dissolved Solids	Coal Mining	4A
3940.00	Trib. to Big Cr.	1.60	Cadmium	Ind./Comm. Site Strmwtr Disch, Permitted	4A
3940.00	Trib. to Big Cr.	1.60	Zinc	Ind./Comm. Site Strmwtr Disch, Permitted	4A
1225.00	Trib. to Big Otter Cr.	1.00	pH	Coal Mining	4A
3663.00	Trib. to Indian Cr.	0.30	Lead	Subsurface, Hardrock, Mining	4A
3490.00	Trib. to L. Muddy Cr.	1.00	Temperature, water	Industrial Point Source Discharge	4A
3216.00	Turkey Cr.	7.70	Zinc	Mill Tailings	4A
3282.00	Turkey Cr.	2.40	Oxygen, Dissolved	Source Unknown	4A
2863.00	Village Cr.	1.90	Sedimentation/Siltation	Mill Tailings	4A
0400.00	W. Fk. Sni-a-bar Cr.	9.00	Oxygen, Dissolved	Municipal Point Source Discharges	4A
0400.00	W. Fk. Sni-a-bar Cr.	9.00	Oxygen, Dissolved	Source Unknown	4A
1708.00	Watkins Creek	6.40	Escherichia coli	Urban Runoff/Storm Sewers	4A
7009.00	Wyaonda Lake	9.00	Atrazine	Crop Production,Crop Land or Dry Land	4A
1145.00	Dry Auglaize Cr.	7.60	Cause Unknown	Source Unknown	4B
1145.00	Dry Auglaize Cr.	7.60	Oxygen, Dissolved	Source Unknown	4B
0811.00	E. Brush Cr.	9.00	Oxygen, Dissolved	Municipal Point Source Discharges	4B
0883.00	Gabriel Cr.	13.60	Oxygen, Dissolved	Municipal Point Source Discharges	4B
1438.00	L. Lindley Cr.	3.70	Aquatic Macroinvertebrate Bioassessments	Source Unknown	4B
2786.00	McKenzie Cr.	6.30	Oxygen, Dissolved	Municipal Point Source Discharges	4B
1842.00	Fox Cr.	7.20	Aquatic Macroinvertebrate Bioassessments	Source Unknown	4C
2660.00	Gladden Cr.	2.50	Oxygen, Dissolved	Natural Conditions, UAA Needed	4C
0430.00	Grand R.	127.50	Fishes Bioassessments	Channelization	4C
0056.00	N. Fabius R.	92.00	Habitat Assessment, Streams	Channelization	4C
1031.00	Osage R.	81.90	Aquatic Macroinvertebrate Bioassessments	Dam or Impoundment	4C
1387.00	Pea Ridge Cr.	1.50	Aquatic Macroinvertebrate Bioassessments	Source Unknown	4C
0216.00	Peruque Cr.	10.30	Cause Unknown	Dam or Impoundment	4C
0071.00	S. Fabius R.	80.60	Fishes Bioassessments	Channelization	4C
2755.00	W. Fk. Black R.	32.30	Physical substrate habitat alterations	Habitat Mod. - other than Hydromod.	4C

APPENDIX F - POTENTIALLY IMPAIRED WATERS

**Appendix F - Potentially Impaired Waters
Category 2B and 3B Waters**

WBID	Waterbody Name	Category	Concern
7225.00	Adrian Reservoir	3B	Turbidity
0334.00	Agee Cr.	3B	Aquatic Habitat
2093.00	Allen Br.	3B	Fish Community
1799.00	Apple Cr.	2B	Invertebrate Community
0282.00	Arapahoe Cr.	3B	Aquatic Habitat
7234.00	Atkinson Lake	3B	Nutrients
2880.00	Back Cr.	3B	Low Dissolved Oxygen
1209.00	Barker Cr.	3B	pH
7068.00	Bean Lake	3B	Nutrients, Mercury in Fish Tissue
0115.00	Bear Cr.	3B	Low Dissolved Oxygen
0272.00	Bear Cr.	3B	Aquatic Habitat
0416.00	Bear Cr.	3B	Aquatic Habitat
1015.00	Bear Cr.	3B	Fish Community
1220.00	Bear Cr.	3B	High Specific Conductivity
3265.00	Beaver Br.	3B	Invertebrate Community, Zinc in Sediment
3266.00	Beaver Br.	3B	Invertebrate Community
3267.00	Beaver Br.	3B	Invertebrate Community
1509.00	Beaver Cr.	3B	Fish Community
0273.00	Bee Cr.	3B	Aquatic Habitat
2760.00	Bee Fk.	2B	Heavy Metals
3966.00	Bee Fk.	2B	Heavy Metals
0220.00	Belleau Cr.	3B	Failed Toxicity Tests, High Specific Conductivity
1250.00	Big Cr.	2B	Low Dissolved Oxygen
1608.00	Bigelow's Cr.	3B	Low Dissolved Oxygen
7368.00	Bilby Ranch Lake	2B	Nutrients
0891.00	Blackwater R.	2B	Aquatic Habitat
0421.00	Blue R.	2B	Bacteria
0993.00	Blythes Cr.	3B	Ammonia
0032.00	Bobs Cr.	2B	Nutrients
1782.00	Bois Brule Ditch	3B	Low Dissolved Oxygen, pH
1983.00	Brazil Cr.	3B	Invertebrate Community
0276.00	Brush Cr.	3B	Aquatic Habitat
0408.00	Brush Cr.	3B	Aquatic Habitat
2056.00	Brush Cr.	3B	Fish Community
0336.00	Brushy Cr.	3B	Aquatic Habitat
0377.00	Brushy Cr.	3B	Aquatic Habitat
0395.00	Brushy Cr.	3B	Aquatic Habitat
7159.00	Bucklin Lake	2B	Nutrients
2422.00	Bull Cr.	2B	Temperature
3264.00	Bullskin Cr.	2B	Fish Community
0363.00	Burr Oak Cr.	3B	Aquatic Habitat
7232.00	Bushwacker Lake	2B	Nutrients
7120.00	Cameron Lake #1	2B	Nutrients, Mercury in Fish Tissue

WBID	Waterbody Name	Category	Concern
7121.00	Cameron Lake #2	2B	Nutrients
7119.00	Cameron Lake #3	2B	Nutrients
2431.00	Camp Cr.	3B	Fish Community
2833.00	Cane Cr.	3B	Low Dissolved Oxygen
2560.00	Caney Cr.	3B	Fish Community
0389.00	Carroll Cr.	3B	Aquatic Habitat
0322.00	Castile Cr.	2B	Low Dissolved Oxygen
3225.00	Cedar Cr.	2B	Sediment
7048.00	City Lake #2 - Perry	3B	Atrazine
0292.00	Clear Cr.	3B	Aquatic Habitat
0388.00	Clear Cr.	3B	Aquatic Habitat
0390.00	Clear Cr.	3B	Aquatic Habitat
1336.00	Clear Cr.	2B	Low Dissolved Oxygen
2082.00	Clear Cr.	3B	Fish Community
0225.00	Cole Cr.	3B	Chloride, Aquatic Habitat
0269.00	Contrary Cr.	3B	Mercury in Fish Tissue
1459.00	Contrary Cr.	3B	Fish Community
0132.00	Coon Cr.	2B	Low Dissolved Oxygen
2177.00	Coonville Cr.	2B	Lead
0410.00	Cottonwood Cr.	3B	Aquatic Habitat
1943.00	Courtois Cr.	2B	Lead in Sediment
1947.00	Courtois Cr.	3B	Invertebrate Community
0247.00	Cow Br.	3B	Aquatic Habitat
0330.00	Crooked Cr.	3B	Aquatic Habitat
0333.00	Crooked Cr.	3B	Aquatic Habitat
1928.00	Crooked Creek	2B	Cadmium, Lead
0371.00	Crooked R.	3B	Aquatic Habitat
0376.00	Crooked R.	3B	Aquatic Habitat
2616.00	Cypress Ditch #1	3B	Invertebrate Community
0144.00	Davis Cr.	3B	Low Dissolved Oxygen
0255.00	Davis Cr.	3B	Aquatic Habitat
0253.00	Davis Cr. Ditch	3B	Aquatic Habitat
0320.00	Dicks Cr.	3B	Aquatic Habitat
0268.00	Dillon Cr.	3B	Invertebrate Community
3813.00	Ditch #16	3B	Low Dissolved Oxygen, Ammonia
2617.00	Ditch #2	3B	Low Dissolved Oxygen
2077.00	Ditch Cr.	3B	Fish Community
2776.00	Ditch to Black R.	3B	Aquatic Habitat
7230.00	Drexel City Reservoir South	2B	Nutrients
3418.00	Dry Cr.	3B	Fish Community
1862.00	Dry Fk.	3B	Invertebrate Community
1314.00	Dry Wood Cr.	2B	Sulfate
0288.00	E. Br. Elkhorn Cr.	3B	Aquatic Habitat
0257.00	E. Br. Squaw Cr.	3B	Aquatic Habitat
3107.00	E. Ditch #1	3B	Low Dissolved Oxygen
0373.00	E. Fk. Crooked R.	3B	Aquatic Habitat

WBID	Waterbody Name	Category	Concern
0386.00	E. Fk. Fishing R.	3B	Invertebrate Community
0249.00	E. Fk. L. Tarkio Cr.	3B	Aquatic Habitat
0932.00	E. Fk. Postoak Cr.	3B	Aquatic Habitat
0398.00	E. Fk. Shoal Cr.	2B	Aquatic Habitat, Bacteria
0402.00	E. Fk. Sni-a-bar Cr.	3B	Aquatic Habitat, Low Dissolved Oxygen
1265.00	East Cr.	2B	High Specific Conductivity, Low Dissolved Oxygen
2085.00	Ebo Cr.	3B	Fish Community
0414.00	Edmondson Cr.	3B	Aquatic Habitat
0287.00	Elkhorn Cr.	3B	Invertebrate Community
0331.00	Elm Grove Br.	3B	Aquatic Habitat
3370.00	Fassnight Cr.	3B	Invertebrate Community
1705.00	Fee Fee Cr. (old)	3B	Bacteria, Chloride
1607.00	Femme Osage Cr.	3B	Fish Community
4119.00	Fenton Creek tributary	2B	Bacteria
4120.00	Fenton Creek tributary	2B	Bacteria
7201.00	Finger Lakes	2B	Fish Community
0375.00	Fire Br.	3B	Aquatic Habitat
0318.00	First Cr.	3B	Bacteria
0394.00	Fishing R.	2B	Bacteria
1885.00	Fishwater Cr.	3B	Low Dissolved Oxygen
0289.00	Florida Cr.	3B	Aquatic Habitat
3942.00	Foster Br.	3B	Low Dissolved Oxygen
7147.00	Fountain Grove Lakes	2B	Nutrients
3757.00	Galligher Cr.	3B	Low Dissolved oxygen, Flow
3373.00	Galloway Cr.	3B	Invertebrate Community, pH
0407.00	Garrison Fk.	3B	Aquatic Habitat
1496.00	Gasconade R.	3B	Fish Community
7383.00	Gopher Lake	2B	Nutrients
0233.00	Greys Lake	3B	Aquatic Habitat
0321.00	Grove Cr.	3B	Aquatic Habitat
3204.00	Grove Cr.	2B	Fish and Invertebrate Community
7124.00	Hamilton Lake	2B	Nutrients
0285.00	Hayzlett Br.	3B	Aquatic Habitat
2181.00	Heads Cr.	3B	Fish Community
0596.00	Hickory Br.	2B	Nutrients, Low Dissolved Oxygen
0266.00	Hickory Cr	3B	Aquatic Habitat
0308.00	Hickory Cr.	3B	Aquatic Habitat
0335.00	Hickory Cr.	3B	Aquatic Habitat
0229.00	High Cr.	3B	Aquatic Habitat
0228.00	High Cr. Ditch	3B	Aquatic Habitat
0307.00	Highly Cr.	3B	Aquatic Habitat
0350.00	Holland Br.	3B	Aquatic Habitat
0351.00	Holtzclaw Cr.	3B	Aquatic Habitat
0338.00	Honey Cr.	3B	Aquatic Habitat
0919.00	Honey Cr.	3B	Aquatic Habitat
0354.00	Horse Fk.	3B	Atrazine

WBID	Waterbody Name	Category	Concern
7207.00	HS Truman Lake	2B	Nutrients
0306.00	Huff Cr.	3B	Aquatic Habitat
0212.00	Indian Camp Cr.	2B	Sedimentation
1946.00	Indian Cr.	2B	Lead, Zinc
3256.00	Indian Cr.	2B	Nutrients
7288.00	Indian Lake	3B	Nutrients, Mercury in Fish Tissue
0234.00	Iowa Ditch	3B	Aquatic Habitat
7391.00	Jackrabbit Lake	3B	Nutrients
7104.00	Jamesport City Lake	2B	Nutrients
7105.00	Jamesport Community Lake	2B	Nutrients
0286.00	Jenkins Cr.	3B	Aquatic Habitat
1719.00	Joachim Cr.	2B	Lead
3968.00	Jones Br.	3B	Sediment Contamination
0974.00	Jones Cr.	3B	Fish and Invertebrate Community
0275.00	Jordan Br.	3B	Aquatic Habitat
0329.00	Jordan Cr.	3B	Aquatic Habitat
0384.00	Keeney Cr.	3B	Aquatic Habitat
0262.00	Kimsey Cr.	3B	Aquatic Habitat
0263.00	Kimsey Cr.	3B	Aquatic Habitat
0264.00	Kimsey Cr.	3B	Aquatic Habitat
7114.00	King City New Reservoir	2B	Nutrients
7113.00	King City Old Reservoir	3B	Nutrients
7112.00	King Lake	3B	Nutrients
1334.00	Kitten Cr.	3B	Low Dissolved oxygen, Flow
1656.00	L. Berger Cr.	3B	Invertebrate Community
0424.00	L. Blue R.	3B	Aquatic Habitat
3591.00	L. Fox Cr.	3B	Fish Community
0403.00	L. Sni-a-bar Cr.	3B	Aquatic Habitat
0404.00	L. Sni-a-bar Cr.	3B	Aquatic Habitat
0409.00	L. Tabo Cr.	3B	Aquatic Habitat
0250.00	L. Tarkio Cr.	3B	Aquatic Habitat
0251.00	L. Tarkio Ditch	3B	Aquatic Habitat
0328.00	L. Third Fk. Platte R.	3B	Aquatic Habitat
7064.00	Lake Contrary	3B	Nutrients, Mercury in Fish Tissue
0359.00	Lake Cr.	3B	Aquatic Habitat
7403.00	Lake Nell	3B	Nutrients
7206.00	Lake Niangua	3B	Nutrients
7153.00	Lake Thunderhead	2B	Atrazine
7018.00	Lancaster City Lake - New	2B	Nutrients
7111.00	Limpp Community State Lake	2B	Nutrients, Mercury in Fish Tissue
0280.00	Lincoln Cr.	3B	Aquatic Habitat
7143.00	Linneus Lake	2B	Nutrients
0243.00	Long Br.	3B	Aquatic Habitat
3531.00	Long Grove Br.	3B	Low Dissolved Oxygen
1617.00	Lost Cr.	3B	Fish Community
7325.00	Lower Taum Sauk Lake	2B	Nutrients

WBID	Waterbody Name	Category	Concern
0425.00	Lumpkin Cr.	3B	Aquatic Habitat
0691.00	M. Fk. Little Chariton R.	2B	Aquatic Habitat
0267.00	Mace Cr.	3B	Aquatic Habitat
7160.00	Marceline Reservoir	3B	Nutrients
3277.00	Mason Springs Valley	3B	Bacteria
1338.00	McCarty Cr.	3B	Aquatic Habitat, pH
7319.00	McCormack Lake	3B	Mercury in Fish Tissue
0213.00	McCoy Cr.	2B	Nutrients
0231.00	McElroy Cr.	3B	Aquatic Habitat
0324.00	McGuire Br.	3B	Aquatic Habitat
1321.00	McKill Cr.	3B	Sulfate, pH
1324.00	McKill Cr.	3B	Sulfate, pH
0031.00	McLean Cr.	3B	Nutrients
7013.00	Memphis Reservoir	2B	Nutrients
2185.00	Meramec R.	2B	Lead
3415.00	Middle Big Cr.	3B	Low Dissolved Oxygen
0258.00	Middle Br. Squaw Cr.	3B	Aquatic Habitat
2744.00	Middle Fk. Black R.	2B	Fish Community
0245.00	Middle Tarkio Cr.	3B	Aquatic Habitat
0159.00	Mill Cr.	3B	Sedimentation, Invertebrate Community
0265.00	Mill Cr.	3B	Aquatic Habitat
0301.00	Mill Cr.	3B	Aquatic Habitat
1757.00	Mill Cr.	3B	Invertebrate Community
2118.00	Mill Cr.	2B	Lead, Zinc
0740.00	Millers Cr.	3B	Invertebrate Community
1707.02	Mississippi R.	2B	Bacteria
0755.00	Moniteau Cr.	3B	Sulfate, pH
7208.00	Montrose Lake	2B	Nutrients
1315.00	Moores Br.	3B	High Specific Conductivity
0302.00	Moss Br.	3B	Aquatic Habitat
0369.00	Moss Cr.	3B	Aquatic Habitat
0426.00	Mouse Cr.	2B	Low Dissolved Oxygen
0343.00	Mozingo Cr.	3B	Aquatic Habitat
0291.00	Muddy Cr.	3B	Aquatic Habitat
0391.00	Muddy Fk.	3B	Invertebrate Community
0049.00	N. Wyaconda R.	3B	Aquatic Habitat
0277.00	Naylor Cr.	3B	Aquatic Habitat
2752.00	Neals Cr.	2B	Lead, Nickel, Zinc
0392.00	New Hope Cr.	3B	Aquatic Habitat
0309.00	Nichols Cr.	3B	Aquatic Habitat
0344.00	Norvey Cr.	3B	Aquatic Habitat
0260.00	Old Ch. L. Tarkio Cr.	3B	Aquatic Habitat
0261.00	Old Ch. L. Tarkio Cr.	3B	Aquatic Habitat
0238.00	Old Ch. Nishnabotna R.	3B	Aquatic Habitat
0240.00	Old Ch. Nishnabotna R.	3B	Aquatic Habitat
0284.00	Old Chan. Nodaway R.	3B	Aquatic Habitat

WBID	Waterbody Name	Category	Concern
0294.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0295.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0297.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0298.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0299.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0300.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0304.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0305.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0311.00	Old Chan. Nodaway R.	3B	Aquatic Habitat
0325.00	Old Chan. Platte R.	3B	Aquatic Habitat
0326.00	Old Chan. Platte R.	3B	Aquatic Habitat
0332.00	Old Chan. Platte R.	3B	Aquatic Habitat
0341.00	Old Chan. Platte R.	3B	Aquatic Habitat
0348.00	Old Chan. Platte R.	3B	Aquatic Habitat
0368.00	Old Chan. Wakenda Cr.	3B	Aquatic Habitat
0026.00	Old Kings Lake Cr.	3B	Nutrients
2111.00	Old Mines Cr.	2B	Cadmium, Lead, Zinc
1472.00	Osage Fk.	2B	Bacteria
2962.00	Otter Cr.	3B	Low Dissolved Oxygen
0358.00	Palmer Cr.	3B	Aquatic Habitat
7441.00	Palmer Lake	2B	Mercury in Fish Tissue
0521.00	Panther Cr.	3B	Nutrients
7241.00	Peaceful Valley Lake	3B	Nutrients
2425.00	Peckout Hollow	3B	Fish and Invertebrate Community
0283.00	Pedlar Cr.	3B	Aquatic Habitat
1616.00	Peers Slough	3B	Fish Community
7183.00	Peters Lake	3B	Nutrients
0349.00	Pigeon Cr.	3B	Aquatic Habitat
1728.00	Plattin Cr.	2B	Ammonia
2192.00	Pomme Cr.	3B	Chloride, Low Dissolved Oxygen, Aquatic Habitat
2127.00	Pond Cr.	2B	Zinc, Sedimentation
7118.00	Pony Express Lake	2B	Nutrients
0313.00	Prairie Cr.	3B	Aquatic Habitat
2037.00	Red Oak Cr.	2B	Low Dissolved Oxygen
0136.00	Reese Fk.	3B	Low Dissolved Oxygen
0347.00	Riggin Br.	3B	Aquatic Habitat
3827.00	River des Peres	3B	Chloride, Bacteria
0355.00	Roberts Br.	3B	Atrazine
0236.00	Rock Cr.	3B	Aquatic Habitat
0237.00	Rock Cr.	3B	Low Dissolved Oxygen, Aquatic Habitat
0378.00	Rocky Fk.	3B	Aquatic Habitat
0382.00	Rollins Cr.	3B	Aquatic Habitat
0278.00	Rush Cr.	3B	Ammonia
0921.00	S. Fk. Blackwater R.	3B	Aquatic Habitat
0293.00	S. Fk. Clear Cr.	3B	Aquatic Habitat
2189.00	Saline Cr.	3B	Low Dissolved Oxygen

WBID	Waterbody Name	Category	Concern
2190.00	Saline Cr.	3B	Low Dissolved Oxygen
0413.00	Salt Br.	3B	Aquatic Habitat
0290.00	Sand Cr.	3B	Aquatic Habitat
7061.00	Savannah City Reservoir	2B	Nutrients
0952.00	Scott Br.	3B	Low Dissolved Oxygen, Ammonia
0317.00	Second Cr.	3B	Aquatic Habitat
1319.00	Second Nicolson Cr.	2B	Sulfate
7253.00	See Tal Lake	3B	Mercury in Fish Tissue
0385.00	Shackelford Br.	3B	Aquatic Habitat
0450.00	Shain Cr.	3B	Ammonia, Nutrients
0087.00	Sharpsburg Br.	3B	Nutrients
7036.00	Shelbyville Lake	2B	Nutrients
7333.00	Shepard Mountain Lake	3B	Nutrients
0396.00	Shoal Cr.	3B	Aquatic Habitat
0397.00	Shoal Cr.	2B	Low Dissolved Oxygen, Aquatic Habitat, Bacteria
1934.00	Shoal Cr.	3B	Fish Community
3229.00	Shoal Cr.	3B	Bacteria
0739.00	Smith Cr.	3B	High Specific Conductivity, pH
0353.00	Smith Fk.	3B	Aquatic Habitat
7077.00	Smithville Lake	2B	Nutrients, Atrazine
0401.00	Sni-a-bar Cr.	3B	Aquatic Habitat
3369.00	South Cr.	2B	Bacteria
0003.00	South R.	2B	Nutrients
3159.00	Spring R.	3B	Heavy Metals
3167.00	Spring R.	3B	Bacteria
0252.00	Squaw Cr.	3B	Aquatic Habitat
1486.00	Steins Cr.	3B	Fsh Community
7149.00	Sterling Price Community Lake	3B	Nutrients
2355.00	Stewart Cr.	3B	Fish Community
2751.00	Strother Cr.	2B	Invertebrate Community
3965.00	Strother Cr.	2B	Invertebrate Community
1030.00	Sugar Br.	3B	Ammonia, Low Dissolved Oxygen
0270.00	Sugar Cr.	3B	Aquatic Habitat
0271.00	Sugar Cr.	3B	Aquatic Habitat
2866.00	Sweetwater Br.	3B	Copper, Lead, Nickel
2867.00	Sweetwater Br.	3B	Lead
0405.00	Tabo Cr.	3B	Aquatic Habitat
0406.00	Tabo Cr.	3B	Aquatic Habitat
2509.00	Tabor Cr.	3B	Fish and Invertebrate Community
7045.00	Teal Lake	3B	Mercury in Fish Tissue
3130.00	Tenmile Pond	2B	Nutrients, DDT
7173.00	Thomas Hill Reservoir	2B	Nutrients
3763.00	Tiff Cr.	3B	Fish Community
7304.00	Timberline Lakes	2B	Nutrients
2759.00	Toms Cr.	3B	Cadmium
0239.00	Tr. to O. Ch. Nishnabotna R.	3B	Aquatic Habitat

WBID	Waterbody Name	Category	Concern
0241.00	Tr. to O. Ch. Nishnabotna R.	3B	Aquatic Habitat
0365.00	Trib to Crabapple Cr.	3B	Aquatic Habitat
0274.00	Trib. to Bee Cr.	3B	Aquatic Habitat
3967.00	Trib. to Bee Cr.	3B	Heavy Metals
2923.00	Trib. to Big Cr.	3B	Heavy Metals
0323.00	Trib. to Castile Cr.	3B	Aquatic Habitat
0393.00	Trib. to Clear Cr.	3B	Aquatic Habitat
0133.00	Trib. to Coon Cr.	2B	Nutrients, Low Dissolved Oxygen
0254.00	Trib. to Davis Cr.	3B	Aquatic Habitat
0374.00	Trib. to E. Fk. Crooked R.	3B	Aquatic Habitat
0429.00	Trib. to E. Fk. L. Blue R.	3B	Aquatic Habitat
0415.00	Trib. to Edmondson Cr.	3B	Aquatic Habitat
0232.00	Trib. to High Cr.	3B	Aquatic Habitat
0303.00	Trib. to Mill Cr.	3B	Aquatic Habitat
2115.00	Trib. to Mineral Fk.	2B	Lead, Zinc
0411.00	Trib. to Missouri R.	3B	Aquatic Habitat
0370.00	Trib. to Moss Cr.	3B	Aquatic Habitat
3261.00	Trib. to N. Indian Cr.	3B	Invertebrate Community
0310.00	Trib. to Nichols Cr.	3B	Aquatic Habitat
0281.00	Trib. to Nodaway R.	3B	Aquatic Habitat
0314.00	Trib. to Prairie Cr.	3B	Aquatic Habitat
2868.00	Trib. to Sweetwater Br.	3B	Lead
0361.00	Turkey Cr.	3B	Aquatic Habitat
0362.00	Turkey Cr.	3B	Aquatic Habitat
7154.00	Unionville Reservoir	3B	Nutrients
0412.00	Van Meter Ditch	3B	Aquatic Habitat
0379.00	W. Fk. Crooked R.	3B	Aquatic Habitat
0380.00	W. Fk. Crooked R.	3B	Aquatic Habitat
3310.00	W. Fk. East Cr.	2B	Low Dissolved Oxygen
0929.00	W. Fk. Post Oak Cr.	3B	Aquatic Habitat
0366.00	W. Fk. Wakenda Cr.	3B	Aquatic Habitat
0367.00	W. Fk. Wakenda Cr.	3B	Aquatic Habitat
0230.00	W. High Cr.	3B	Aquatic Habitat
0244.00	W. Tarkio Cr.	3B	Aquatic Habitat
0246.00	W. Tarkio Cr.	3B	Aquatic Habitat
0360.00	Wakenda Cr.	3B	Aquatic Habitat
0364.00	Wakenda Cr.	3B	Aquatic Habitat
2136.00	Wallen Cr.	3B	Invertebrate Community
1339.00	Walnut Cr.	2B	Nutrients, Low Dissolved Oxygen
7137.00	Walt Disney Lake	2B	Sulfate and Chloride
2374.00	Ward Br.	3B	Bacteria
7087.00	Watkins Mill Lake	3B	Nutrients
1639.00	Whetstone Cr.	2B	Fish Community
0346.00	White Cloud Cr.	3B	Aquatic Habitat
0259.00	Wildcat Cr.	3B	Aquatic Habitat
0387.00	Williams Cr.	3B	Aquatic Habitat

WBID	Waterbody Name	Category	Concern
0381.00	Willow Cr.	3B	Aquatic Habitat
7110.00	Worth County Community Lake	2B	Nutrients
0047.00	Wyaconda R.	2B	Bacteria

APPENDIX G - RESPONSIVENESS SUMMARY



2020 303(d) List
Responses to Public Comments
Received During the Public Notice Period

Public Notice Period
November 15, 2019 – February 20, 2020

Missouri Department of Natural Resources
Water Protection Program
PO Box 176
Jefferson City, MO 65102-0176
800-361-4827 / 573-751-1300

Introduction

Pursuant to 40 C.F.R. § 130.7, States, Territories, and authorized Tribes must submit biennially to the U.S. Environmental Protection Agency (EPA) a list of water-quality limited (impaired) segments, pollutants causing impairment, and the priority ranking of waters targeted for total maximum daily load (TMDL) development. The Missouri Department of Natural Resources (Department) placed the draft 2020 303(d) List of Impaired Waters on public notice from November 15, 2019, to February 20, 2020. All original comments received during this public notice period are available online on the Department's website at dnr.mo.gov/env/wpp/waterquality/303d/303d.htm. Comments were received from the following groups:

- I. LimnoTech on behalf of the Doe Run Resource Company
- II. Metropolitan St. Louis Sewer District
- III. Missouri Coalition for the Environment
- IV. City of Kansas City
- V. City of Independence
- VI. City of Springfield

This document summarizes and paraphrases the comments received, provides the Department's responses to those comments, and notes any changes made to the final proposed 2020 303(d) List of Impaired Waters or supporting documentation.

Summary of Department actions as a result of public comments

A. Waters to be added or re-added to the Proposed 2020 303(d) List

1. Mazingo Lake (water body identification (WBID) 7402) – Chlorophyll-a

B. Waters Proposed to be Delisted from the 2020 303(d) List

1. Courtois Creek (WBID 1943) – Lead in sediment
2. Indian Creek (WBID 1946) – Lead in sediment
3. Indian Creek (WBID 1946) – Zinc in sediment
4. Indian Creek (WBID 1946) – Lead in water
5. Crooked Creek (WBID 1928) – Cadmium in sediment
6. Crooked Creek (WBID 1928) – Lead in sediment
7. Crooked Creek (WBID 1928) – Cadmium in water
8. Bee Fork (WBID 2760) – Lead in water
9. West Fork Black River (WBID 2755) – Lead in sediment
10. West Fork Black River (WBID 2755) – Nickel in sediment
11. Little Antire Creek (WBID 4115) – *Escherichia coli* (*E. coli*)
12. Brush Creek (WBID 3986) – Polycyclic Aromatic Hydrocarbons (PAHs) in sediment

C. Other changes to the 2020 303(d) List

1. King Lake (WBID 7112) – Chlorophyll-a
 - i. This water will be removed from the list due to all data showing impairment being older than seven years.

Summary of Comments and Department Responses

I. LimnoTech on behalf of the Doe Run Resource Corporation (Doe Run)

LimnoTech requested the reassessment and delisting of multiple streams due to actions that Doe Run has taken in the watersheds of the streams referenced in the comment letter. LimnoTech provided recently collected data showing the effects of the actions taken by Doe Run. Streams referenced for delisting: Courtois Creek (WBID 1943), Indian Creek (WBID 1946), Crooked Creek (WBID 1928), Bee Fork (WBID 2760), and West Fork Black River (WBID 2755). LimnoTech also requested the Department withdraw the TMDLs for Indian Creek and Courtois Creek, or alternatively pursue a permit in lieu of a TMDL.

Summary of actions taken by Doe Run:

1. A treatment plant was constructed at the Doe Run Viburnum facility and began operation in October 2016. The Viburnum facility discharges into Indian Creek and then subsequently into Courtois Creek.
2. Doe Run discharges from Casteel Mine into Crooked Creek were eliminated in May 2014.
3. Doe Run discharges from Buick Resources Recycling Facility (BRRF) into Crooked Creek were eliminated in March 2016.
4. Doe Run eliminated discharges from the Fletcher Mine and Mill facility into Bee Fork.

Department Response

The Department appreciates the comments provided by LimnoTech on behalf of Doe Run. The actions taken by Doe Run have reduced or eliminated pollutant sources within the watersheds of these impaired segments, providing the Department cause to split the data record following these improvements. Therefore, only data collected after the actions taken by Doe Run will be considered as recent and relevant to assessment of designated uses on the streams listed. The data provided demonstrates that water quality standards (WQSs) are now being met; therefore, the Department proposes to delist Courtois Creek (WBID 1943) for lead in sediment, Indian Creek (WBID 1946) for lead in water, Indian Creek (WBID 1946) for lead and zinc in sediment, Crooked Creek (WBID 1928) for cadmium in water and sediment, Crooked Creek (WBID 1928) for lead in sediment, Bee Fork (WBID 2760) for lead in water, and West Fork Black River (WBID 2755) for lead and nickel in sediment. Indian Creek (WBID 1946) is not currently listed for zinc in water.

The Department will evaluate the need to take action on the TMDLs for Indian Creek or Courtois Creek upon final approval of the 2020 303(d) list by the Missouri Clean Water Commission and EPA. TMDLs are protective of water quality regardless of the status (impaired or unimpaired) of the water body or water bodies for which the TMDL is applicable.

II. Metropolitan St. Louis Sewer District (MSD)

MSD provided comments in regard to several streams:

1. Little Antire Creek (WBID 4115) – MSD provided data for 2017, 2018, and 2019 that indicate the WQS for the Whole Body Contact Recreation class B use is currently being supported.
2. The Department’s assessment of River des Peres (WBID 1710) does not reflect the 2017 and 2018 data provided by MSD.
3. The Department’s assessment of Spring Branch (WBID 5007) does not reflect the 2017 and 2018 data provided by MSD.
4. The Department’s assessment of Watkins Creek (WBID 1708) does not reflect the 2017 and 2018 data provided by MSD.
5. MSD proposed that *Escherichia coli* impairment for Gravois Creek (WBID 4051) is addressed through the TMDL for the Gravois Creek watershed.

Department Response

The Department appreciates the comments provided by MSD.

Comment 1

The Department reassessed Little Antire Creek including the data provided by MSD and agrees that data indicate that WQs are now being met. The Department proposes to delist Little Antire Creek (WBID 4115) for *E. coli*.

Comments 2 – 4

The Department apologizes for the error and will add the data to our database. As noted by MSD, the data does not change the impairment status of these streams.

Comment 5

Per federal regulations at 40 C.F.R. § 130.7(c)(1), states shall establish TMDLs for all identified water quality-limited segments. The Gravois Creek TMDL approved by EPA on January 16, 2018, calculates the *E. coli* loading capacities and associated wasteload and load allocations for two water quality-limited segments of Gravois Creek, WBIDs 1712 and 1713. Although the draft TMDL document made available for public review from March 3 to May 2, 2017, did include calculations specific to WBID 4051, this segment was removed from the final document in response to the public comments submitted by MSD. For this reason, WBID 4051 remains identified as a Category 5 impaired water. The Department recognizes that actions implemented to target the loading capacities calculated for Gravois Creek are occurring on a watershed scale and may result in pollutant reductions to the tributary of Gravois Creek. For this reason, the *E. coli* impairment for WBID 4051 has been identified on the 2020 303(d) List as a low priority for TMDL development in order to allow such pollutant reductions to occur. For more information regarding Missouri TMDLs, please contact Mike Kruse, TMDL Unit Chief, at 573-522-4901.

III. Washington University Interdisciplinary Environmental Clinic on behalf of Missouri Coalition for the Environment (MCE)

The Missouri Coalition for the Environment submitted comments that focus on the new nutrient criteria for lakes and the proposed lake listings added under such criteria. MCE identified three major concerns: 1) insufficient data collection; 2) a lack of transparency in the listing methodology and process; and 3) the reconsideration of five lakes that MCE suggests should be added to the list.

Concern 1

MCE commented that the Department’s Nutrient Criteria Implementation Plan requires a minimum of 4 samples for each year a lake is considered and provided 4 examples wherein lakes had less than 4 measurements per year. Also noted by MCE were 6 examples of lakes missing measures of Chlorophyll-a (Chl-a), total nitrogen (TN) and total phosphorus (TP), and/or Secchi depth, and 17 examples of lakes with large temporal data gaps wherein impairment thresholds were also exceeded. MCE requests that the Department prioritize data collection from lakes wherein threshold exceedances have occurred recently or at least once in the sampling record. MCE also commented that the amount of data collected on unlisted lakes is insufficient.

Concern 2

MCE requests that the Department provide Excel worksheets for all lakes of the state, whether listed as impaired or not, along with a narrative analysis to clearly explain why each lake was or was not included. MCE requests written descriptions of assessment endpoints, which should include more details on fish kills and/or excessive turbidity. MCE also requests that the Department provide a full list of lakes and water bodies by name and make improvements to the Water Quality Assessment System that would include general accessibility and the inclusion of an ecoregion field. MCE also requests that the data should be compiled into a single Excel file. Additionally, MCE asks for more description of potentially impaired lakes listed in the 305(b) report and requests Excel data and a narrative analysis to be made available for each of these lakes.

Concern 3

Additionally, MCE identified five lakes to be reconsidered for listing, along with explanations for why these lakes should be considered:

1. Jackrabbit Lake (WBID 7391)
2. Shelbyville Lake (WBID 7036)
3. Montrose Lake (WBID 7208)
4. Cameron Lake No. 1 (WBID 7120)
5. Cameron Lake No. 2 (WBID 7121)

Department Response

The Department appreciates the comments made by the Washington University Interdisciplinary Environmental Clinic on behalf of the Missouri Coalition for the Environment (MCE).

Concern 1

The requirement to calculate nutrient concentrations as the geometric mean of a minimum of four representative samples is contained in 10 CSR 7.031(5)(N)4, not the Nutrient Criteria Implementation Plan. In order to assess a lake against the numeric nutrient criteria in 10 CSR 20-7.031(5)(N)4, at least four samples must be collected between May 1 and September 30 under representative conditions. If this data requirement is not met, the lake will be placed in Category 3 of Missouri's 305(b) Report until further information can be collected. Although the Department wishes to have at least four samples for lake assessment, sample collection is often subject to circumstances outside the Department's control (e.g., unsafe weather conditions, flooding, etc.) and therefore this data requirement may not always be met. The collection of Chl-a, TN, TP, and Secchi depth are necessary for assessment, but the Department is not required to collect this data; instead, this is a data requirement for assessment against the criteria. These parameters were important to the development of the criteria, thus the Department cannot properly assess against the criteria when there is missing information.

There are no federal or state statutes or regulations that require the Department to collect water quality samples. However, the Department solicits a multitude of data every year by funding statewide efforts to collect quality-assured water quality samples at lakes. The Department has a cooperative agreement for sample collection with the University of Missouri Limnology Lab through their Statewide Lake Assessment Program (SLAP) and their Lakes of Missouri Volunteer Program (LMVP). SLAP collects samples between May 1 and September 30 from approximately 78 lakes statewide. Of those 78 lakes, 38 have been consistently sampled as part of a long-term data study for assessing water quality and conducting long-term trend analyses; the remaining 40 lakes are rotated every 3-4 years. The Department will work with SLAP to expand monitoring or add priority lakes for additional data collection needs, subject to year to year budget limitations. In addition to SLAP, a large portion of the Department's data is collected through LMVP with lake volunteers. Neither the University nor the Department can control where the public wants to volunteer their sampling efforts. The Department is very appreciative of volunteer efforts and the data they contribute.

The Lake Ecoregion Criteria in 10 CSR 20-7.031(5)(N)1.C.(I) do not explicitly require a minimum number of years of data, but the Lake Site-Specific Criteria 10 CSR 20-7.031(5)(N)1.C.(II) do require a minimum of three years of data. According to the 2020 Listing Methodology Document (LMD): "If a water body has not been listed previously and all data indicating an impairment is older than 7 years, then the water body is placed into Category 2B or 3B and prioritized for future sampling." If more recent data confirms the impairment, then older data is included in the assessment. The LMD is public noticed for every listing cycle. The Department will be accepting comments on the 2022 LMD in the near future.

At present, neither the Department nor the University of Missouri have the capacity nor budget to regularly sample every lake in the state. To the extent that the Department does not have comprehensive water quality data on Missouri lakes, this is largely due to logistical and budgetary constraints. The Department cannot change the amount or types of data collected from past sampling efforts. However, in 2019, the Department began working more closely with the University to expand monitoring to ongoing SLAP efforts. With much of the data used by the

Department to make assessments coming from the University's volunteer program, the Department welcomes the opportunity to coordinate with MCE and the University to find more volunteers to sample lakes. The Department invites MCE to inform its members of volunteer opportunities through the LMVP. Additionally, the Department is prepared to work with any organization to develop a quality assurance project plan (QAPP) to collect additional samples.

Concern 2

The Department has provided assessment worksheets for each water body listed on the 303(d) list. Each ecoregional lake nutrient assessment worksheet has been color coded, and exceedances of the criteria, thresholds, and eutrophication factors are highlighted. Included at the bottom of each assessment worksheet is an explanation of the criteria used and justification for the impairment listing. The LMD contains information on how each piece of the criteria will be assessed. The Department is open to suggestions for improving the transfer of information of interest to the public and how that appears on the assessment worksheets. If the LMD is not clear in its presentation of the information, the Department is open to suggested language to clarify the assessment process. As noted by MCE, the Department provides public access to the data used for assessments. If members of the public are interested in data for a specific water body, the Department can provide the data in spreadsheet format for that water body and explain the assessment process. The Department will look at improving the public data search web application to correct any issues. The Department is looking into newer technologies that may provide better access for the public. Water quality data can also be requested through an Open Records Request (<https://dnr.mo.gov/sunshinerequests.htm>) or by emailing Robert.Voss@dnr.mo.gov.

A shapefile containing all the lakes in Missouri that are included in the Missouri Use Designation Dataset (MUDD) can be downloaded from the Missouri Spatial Data Information Service (MSDIS), available at <https://data-msdis.opendata.arcgis.com/datasets/mo-2019-lake-numeric-nutrient-criteria-watersheds/data>. This dataset contains the WBID, size, whether or not the lake has site-specific criteria, and the percent of the lake's watershed that is in each ecoregion. For assessment purposes, the Department applied the criteria for the ecoregion comprising the majority of the watershed (e.g., if 51 percent of a lake's watershed is in the Ozark Border ecoregion and 49 percent is in the Plains ecoregion, Ozark Boarder criteria were used for assessment).

In accordance with the LMD, the Department should provide a statement on the assessment worksheet when using data more than seven years old in assessment decisions. In the case of assessment worksheets for the ecoregional lake nutrient criteria, the Department included data older than seven years when necessary to ensure three years of data that met the requirements. If all of the data was older than seven years, then the data should not have been used for impairment decisions, but may still be used to categorize the lake for future data needs. All data used for assessment, including the date of sampling, is included in the assessment worksheets. The Department will make a greater effort to include a written justification when using data older than seven years in assessment worksheets.

Lakes included as potentially impaired in the 305(b) Report are lakes that met the LMD requirements to be placed into categories 2B or 3B only. These waters mainly lack the data necessary to come to a confident assessment conclusion or do not meet the LMD definition of an impaired water, but the Department has reason to believe that water quality concerns remain. The Department can provide the water quality data for those waters upon request. The Department will prioritize collection of more data on waters that show impairment based on data that is too old to use.

Concern 3

1. Jackrabbit Lake (WBID 7391)

Jackrabbit Lake does not meet the impairment criteria. While the Chl-a values do increase over time from 2011 to 2017, there is not enough data to account for climatic variation. The Department, therefore, cannot evaluate possible bias in the current data. If data had been collected between 2011 and 2017, it is undetermined whether this data would have exceeded the Plains ecoregional criteria as well. While Jackrabbit Lake does exceed the screening thresholds for TN, TP, and Secchi depth, neither of the endpoints of Chl-a/TP ratio and inorganic suspended sediment are met, nor are algal toxin counts exceeded. Therefore, the lake does not presently meet the criteria for impairment.

2. Shelbyville Lake (WBID 7036)

The only available data for Shelbyville Lake are from 2010 and 2014, and no Chl-a data are available for 2010. These data cannot appropriately account for the climatic variability of the site. While Chl-a data in 2014 exceeds the Plains ecoregional criteria, and the screening thresholds are exceeded for inorganic suspended sediment, Secchi depth, TN, and TP, the Chl-a/TP ratio is greater than 0.15. Therefore, the site does not meet the LMD definition of an impaired water.

3. Montrose Lake (WBID 7208)

MCE is correct that Montrose Lake has exceeded the Plains ecoregion Chl-a criteria in the last three years of available data. However, the last three years of available data are from 2008, 2007, and 2005. All of these dates are older than seven years and therefore may not be representative of current lake conditions. While these data do not meet the LMD requirements for listing, the Department has prioritized this lake for additional monitoring.

4. Cameron lake No. 1 (WBID 7120)

The only available data for Cameron Lake No. 1 is from 2016 and 1996. Chl-a data from 2016 exceed the numeric nutrient criteria. Chl-a data from 1996 do not exceed the criteria, and additional data do show elevated levels of mineral turbidity. However, the Department cannot definitively say that the 1996 data represents current conditions. While these data do not meet the LMD requirements for listing, the Department has prioritized this lake for additional monitoring.

5. Cameron Lake No. 2 (WBID 7121)

Similar to Cameron Lake No. 1, the only two years of available data for Cameron Lake No. 2 are 2016 and 1996. Chl-a data from 2016 exceed the numeric nutrient criteria. Chl-a data

from 1996 do not exceed the criteria, and additional data do show elevated levels of mineral turbidity. However, the Department cannot definitively say that the 1996 data represents current conditions. While these data do not meet the LMD requirements for listing, the Department has prioritized this lake for additional monitoring.

Additionally, MCE pointed out that King Lake (WBID 7112) was listed using data that was all collected more than seven years prior to assessment. This listing was in error and does not follow the LMD, therefore the Department will remove King Lake from the proposed 303(d) list. However, the Department intends to collect additional data from this lake for use in future assessments.

IV. City of Kansas City

Kansas City Water Services provided comments regarding Brush Creek (WBID 3986) and the PAHs impairment. Kansas City Water Services commented that two of the three sites used for assessment are in Kansas, rather than Missouri. The City comments that the listing is also based on a probable effects concentration (PEC) threshold that is not a regulatory standard, but rather intended for weight of evidence to warrant further investigation. The Missouri site is indicated by the City to be below the recommended PEC values for impairment. The City therefore requests that the stream be reassessed using only data from Missouri.

Department Response

In accordance with the LMD, PAH toxicity is assessed by comparing the sum of the geometric means for all PAH compounds to 150 percent of the recommended PEC value for total PAHs. The Department has reassessed the PAHs impairment on Brush Creek (WBID 3986) and determined that the sum of the geometric means for all PAHs compounds at the Missouri site (site code 3986/5.1) is below the 100 percent recommended PEC value for total PAHs (22.8 mg/kg). Total PAH values at the Kansas sites suggest that total PAHs in the stream are decreasing as the water body flows into Missouri. The Department proposes to delist Brush Creek for PAHs in sediment based on this reassessment.

V. City of Independence

The City of Independence requests that the Department re-evaluate *E. coli* impairment for the following sites by calculating geometric means without the inclusion of storm flow samples:

1. Little Blue River (WBID 0422)
2. Little Blue River Tributary (WBID 4107)
3. Burr Oak Creek (WBID 3414)
4. Crackerneck Creek (WBID 3962)
5. Rock Creek (WBID 4106)
6. Spring Branch (WBID 5004)

The City of Independence cited a joint agreement with the United States Geological Survey (USGS) in order to obtain data during storm events. The City and USGS provided data for some

of these events, along with geometric means that were calculated with and without storm flow samples for Little Blue River, Rock Creek, and Spring Branch. Based on these calculations, the City suggests that a significant bias in *E. coli* counts is present when storm flow data is included.

Department Response

The Department appreciates the comments made by the City of Independence. Missouri's WQSs do not contain a high flow or storm flow exclusion to the recreational use criteria. The data used for assessment contained samples from both storm flow and non-storm flow conditions. The Department will not exclude data points purely on the basis of storm flow exceedance, especially when such data shows bacterial contamination issues during storm flow events. The Department maintains the listing of Little Blue River (WBID 0422), Little Blue River Tributary (WBID 4107), Burr Oak Creek (WBID 3414), Crackerneck Creek (WBID 3962), Rock Creek (WBID 4106), and Spring Branch (WBID 5004).

VI. City of Springfield

The City of Springfield provided comments on the TMDL schedule for Pearson Creek (WBID 2373) and Wilsons Creek (WBID 2375), asking the Department to lower the priority from medium to low and revise the schedule to greater than 10 years. The City also provided comments requesting the Department delist North Branch Wilsons Creek for zinc in sediment, noting that the 2020 LMD states additional biological data is needed, and this data is lacking from the assessment.

Department Response

The Department appreciates the City's efforts to improve water quality in Pearson and Wilson creeks. At this time, no specific information was provided about how the City's integrated plan will address these impairments and, as a result, no adjustment to the TMDL development schedule could be made. However, the Department would like to invite the City to meet with us in order to discuss what additional information could be provided so that the TMDL schedule could be adjusted appropriately for the 2022 303(d) listing cycle. Please contact Mike Kruse, TMDL Unit Chief, at 573-522-4901 or via email at Michael.Kruse@dnr.mo.gov to set up a time to discuss. For guidance about what specific types of information the Department considers when delaying TMDL development so that water quality improvements through other restoration actions can occur, please see the document online titled [*TMDL Alternative – Category 5-alt Components*](#).

North Branch Wilsons Creek was initially placed on the 2014 303(d) List due to levels of zinc in sediment above 150 percent of PEC. The City cites the 2020 LMD needing biological data as part of the weight of evidence to confirm the toxicity of zinc in sediment to aquatic life. While biological data is a requirement for placing any new waters on the 303(d) list for toxics in sediment, the water body has already been listed and there is no evidence to show that the zinc is not causing toxicity. In the absence of biological data or additional sediment data, the Department will maintain North Branch Wilsons Creek on the 303(d) list for zinc in sediment.

November 7, 2019

Missouri Department of Natural Resources
Attention: Robert Voss
Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
robert.voss@dnr.mo.gov

RE: Missouri Section 303(d) Impaired Waters List

Dear Mr. Voss:

On behalf of The Doe Run Company (“**Doe Run**”), LimnoTech collected water and sediment samples to inform Missouri Section 303(d) Impaired Waters List impairment determinations for streams in the Viburnum Trend. As you are aware, Doe Run has constructed water treatment plants at mine and mill facilities, leading to improved water quality. The sampling was conducted consistent with a Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) that had submitted to and approved by Missouri DNR in 2017. An Addendum to the SAP, describing proposed 2019 sampling, was provided to Missouri DNR in April 2019. Missouri DNR provided approval of the Addendum to the SAP in an email dated April 26, 2019. The sampling was conducted June 26-27 and September 4-5, 2019, and focused on stream reach segments and parameters that had previously been included as impaired on past Missouri 303(d) lists.

Attached to this letter is a sampling report presenting a summary of the data collection activities, results of field measurements and laboratory analyses, and quality control / quality assurance review. The laboratory Electronic Data Deliverable (EDD) reports are also being provided to you via email. We request that Missouri DNR include these data in assessments to develop the 2020 303(d) list, as well as future assessments.

Additionally, based on the results of these recent samples, the following impairments from the 2018 303(d) list should be removed from the forthcoming 2020 list:

- Courtois Cr. (WBID 1943): lead in sediment
 - A treatment plant has been constructed at the Doe Run Viburnum facility which discharges into Indian Creek, upstream of Courtois Cr. and began operation in October, 2016.
 - 2017-2019 data indicate lead levels in sediment are below the probable effect level (PEL), which represents 150% of the probable effects concentration (PEC) and is the value used by MDNR to assess impairment of sediments. In addition, the probable effects concentration quotient (PECO), which MDNR uses to estimate the synergistic effects of multiple metals in sediments, is below the threshold of 0.75, as shown in the table below.

Courtois Creek Lead in Sediments

Location	Date	Lead (mg/kg)	PECQ
1943/29.0	9/4/2019	12.4	0.077
1943/29.0	6/26/2019	40.6	0.146
1943/29.0	9/29/2017	66.1	0.236
Geometric mean		32.2	0.134
Probable Effect Level Threshold		192	0.75

- Indian Cr. (WBID 1946): lead and zinc in sediment.
 - As stated above, a treatment plant has been constructed at the Doe Run Viburnum facility which discharges into Indian Cr., and a previous outfall to a tributary to Indian Cr. has been eliminated. The treatment plant began operation in October, 2016.
 - 2017-2019 data indicate lead and zinc levels in sediment are below the PELs, and the PECQ for the suite of metals in sediment is below the threshold, as shown in the table below.

Indian Creek Lead and Zinc in Sediments

Location	Date	Lead (mg/kg)	Zinc (mg/kg)	PECQ
1946/0.1	9/4/2019	132	286	0.450
1946/0.1	6/26/2019	89.2	56.8	0.179
1946/0.1	9/29/2017	110	326	0.477
Geometric mean		109	174	0.312
Probable Effect Level Threshold		192	689	0.75

- Crooked Cr. (WBID 1928): cadmium and lead in sediment, copper in water
 - Doe Run previously discharged into Crooked Cr. from the Casteel Mine and BRRF. Regular discharges were eliminated in May, 2014 and March, 2016 respectively.
 - 2017-2019 data indicate cadmium and lead levels in sediment are below the PELs, and the PECQ for the suite of metals in sediment is below the threshold, as shown in the table below.

Crooked Creek Cadmium and Lead in Sediments

Location	Date	Cadmium (mg/kg)	Lead (mg/kg)	PECQ
1928/0.5	9/4/2019	2.3	33.7	0.181
1928/0.5	6/26/2019	4.2	39.8	0.258
1928/0.5	9/29/2017	4.3	62.4	0.306
Geometric mean		3.5	43.7	0.241
Probable Effect Level Threshold		7.5	192	0.75



- 2019 data indicate copper concentrations in water below the lowest calculated hardness-based water quality criterion, as shown in the table below.

Crooked Creek Copper in Water

Location	Date	Copper (µg/L)
1928/0.5	9/4/2019	0.78
1928/0.5	6/26/2019	0.77
1928/0.5	9/29/2017	0.58
1928/3.5	9/4/2019	0.75
1928/3.5	6/26/2019	1.1
1928/3.5	9/29/2017	0.75
Chronic Water Quality Criterion		11

- Bee Fk. (WBID 2760): lead in water
 - Doe Run previously discharged mine and tailings water to Bee Fork from the Fletcher Mine and Mill facility. Mine water and tailings water discharges at Fletcher have been discontinued; discharges to Bee Fork are now stormwater only.
 - 2017-2019 data indicate dissolved lead concentrations in water well below the lowest hardness-based chronic criterion, as shown in the table below.

Bee Fork Lead in Water

Location	Date	Lead (µg/L)
2760/8.6	9/5/2019	0.13
2760/8.6	6/27/2019	0.25
2760/8.6	9/26/2017	1.9
Chronic Water Quality Criterion		2.6

- West Fk. Black R. (WBID 2755): lead and nickel in sediment
 - 2017-2019 data indicate geometric mean lead and nickel levels in sediment are below the PELs, and the geometric mean PECQ for the suite of metals in sediment is below the threshold, as shown in the table below.



West Fork Black River Lead and Nickel in Sediments

Location	Date	Lead (mg/kg)	Nickel (mg/kg)	PECQ
2755/21.5	9/5/2019	136	22.4	0.332
2755/21.5	6/27/2019	8.6	4.2	0.049
2755/21.5	9/27/2017	264	34.6	0.597
2755/22.3	9/5/2019	23.7	7.8	0.093
2755/22.3	6/27/2019	96	31.1	0.356
2755/22.3	9/27/2017	1430	126	2.818
2755/22.5	9/5/2019	53.2	18.9	0.269
2755/22.5	6/27/2019	37.1	12.7	0.125
2755/22.7	9/27/2017	9.8	3.2	0.041
Geometric mean		64.5	16.2	0.205
Probable Effect Level Threshold		192	73	0.75

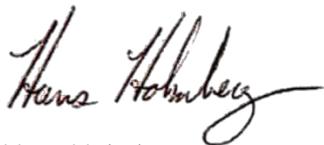
Additionally, there is a TMDL for lead and zinc in water for Indian Creek and Courtois Creek. The data collected during the 2017 and 2019 surveys show compliance with water quality standards for both lead and zinc in Indian Creek, as shown in the table below. Doe Run requests that MDNR withdraw the TMDL, or alternatively, accept the existing Viburnum permit as a permit in lieu of the TMDL.

Lead and Zinc Concentrations in Water in Indian Creek

Location	Date	Lead ($\mu\text{g/L}$)	Zinc ($\mu\text{g/L}$)
1946/0.1	9/4/2019	<0.13	4.6
1946/0.1	6/26/2019	<0.1	<10
1946/0.1	9/29/2017	0.36	16.9
Chronic water quality criterion		4.2	175

Please contact us if you have questions.

Sincerely,
LimnoTech



Hans Holmberg
Associate Vice President, Senior Engineer

Attachments:
Sampling Report
Electronic Data Deliverables submitted via email





**Metropolitan St. Louis
Sewer District**

Division of Environmental Compliance
10 East Grand Avenue
St. Louis, MO 63147-2913
314-768-6200 www.stlmsd.com

February 10, 2020

Robert Voss
Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, Missouri 65201

Dear Mr. Voss:

The Metropolitan St. Louis Sewer District has reviewed the St. Louis area streams included on the proposed 2020 Section 303(d) listings and de-listings for Missouri. We would like to take the opportunity to provide the Missouri Department of Natural Resources (MDNR) with the following comments.

303(d) List Comments

Comment #1: Little Antire Creek (WBID 4115.00) was listed as impaired by *E. coli* for WBC B in 2016. Since MDNR sent out the data solicitation request, MSD has collected additional data for this waterbody. Review of this additional data shows compliance with the water quality standard for the past three (3) years. MSD is requesting that MDNR consider the data collected during 2017, 2018 and 2019. Review of this data indicates that Little Antire Creek is attaining water quality standards and should be delisted for impairment by *E. coli*. Supporting data will be provided to the Department in an electronic format.

Comment #2: MDNR's 2020 data review worksheet for River des Peres (WBID 1710.00) does not include the 2017 or 2018 data that was submitted by MSD during the data solicitation. This data will not affect the listing status, but MSD requests that the data be added to MDNR's water quality database for future use. Data will be re-submitted to the Department in an electronic format.

Comment #3: MDNR's 2020 data review worksheet for Spring Branch (WBID 5007.00) does not include the 2017 or 2018 data that was submitted by MSD during the data solicitation. This data will not affect the listing status, but MSD requests that the data be added to MDNR's water quality database for future use. Data will be re-submitted to the Department in an electronic format.

Comment #4: MDNR's 2020 data review worksheet for Watkins Creek (WBID 1708.00) does not include the 2017 or 2018 data that was submitted by MSD during the data solicitation. This data will not affect the listing status, but MSD requests that the data be added to MDNR's water quality database for future use. Data will be re-submitted to the Department in an electronic format.

Comment #5: Gravois Creek tributary (WBID 4051.00) was listed as impaired by *E. coli* for WBC B in 2016. Since the time of the original listing, EPA has approved a Total Maximum Daily Load (TMDL) for the Gravois Creek Watershed. Implementation of this TMDL will address the water quality issues throughout the watershed, including the Gravois Creek tributary. MSD is proposing WBID 4051.00 be delisted and placed in Category 4A – TDML approved or established by EPA.

The Metropolitan St. Louis Sewer District appreciates the MDNR's commitment to transparency and the use of sound data and analysis in protecting Missouri's waterways. Thank you for the opportunity to provide comments during this process.

If you have any questions or comments, please feel free to contact me at (314) 436-8714 or Austin Nieman at (314) 436-8700.

Sincerely,

A handwritten signature in black ink, appearing to be 'JP', written over a light blue horizontal line.

Jason Peterein
Program Manager – Department of Environmental Compliance
Metropolitan St. Louis Sewer District

cc: Jay Hoskins
Austin Nieman



Interdisciplinary Environmental Clinic

February 20, 2020

Robert Voss
Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
VIA email: robert.voss@dnr.mo.gov

Re: Missouri 2020 Section 303(d) Impaired Waters List

Dear Mr. Voss,

On behalf of the Missouri Coalition for the Environment (“MCE”), the Washington University Interdisciplinary Environmental Clinic is submitting this letter to comment on the proposed Missouri 2020 Section 303(d) Impaired Waters List (“303(d) list”). Our comments specifically focus on the proposed lakes that are added under the new nutrient criteria. MCE is an environmental advocacy organization with offices in St. Louis City and Columbia. MCE has over 800 members throughout Missouri. MCE’s members have advocated since 1969 for the protection of all streams, rivers, wetlands, and floodplains throughout the State of Missouri. MCE’s members frequently pursue various activities which involve drawing drinking water from, swimming and fishing in, and floating on Missouri’s waters. Thus, MCE has a substantial interest in MDNR’s proposed 303(d) list.

Section 303(d) of the Clean Water Act requires states to develop a list of impaired waters (“303(d) list”) by April 1st of every even-numbered year that do not meet the state’s Water Quality Standards. Missouri Department of Natural Resources (“MDNR”) published the Draft 2020 Section 303(d) Impaired Waters List on November 15, 2019. While the 303(d) list covers all pollutants for all waters of the state, we have reviewed and will be commenting based only on the new nutrient criteria for lakes. We previously testified at MDNR’s public hearing on the 303(d) list draft proposal on February 13, 2020 and will expand upon our testimony in the following comments.

Lakes added under the new nutrient criteria make up over 75% of all new waterbody additions to the proposed 2020 303(d) list. For this reason, we believe MDNR should pay special attention to how it implements its nutrient criteria plan and monitors lakes for impairment. MCE’s specific concerns and recommendations for the 303(d) list focus on three major points. First, MCE has noticed deficient collections of data and recommends MDNR comply with all data collection requirements. Second, MCE recommends MDNR improve transparency in the 303(d) listing methodology and process. Finally, MCE has found five additional lakes that show sufficient impairment qualifying them for 303(d) listing. MCE asks MDNR to consider adding these lakes

to the list.

I. MISSING INFORMATION FROM DATA COLLECTION AND RECOMMENDATIONS FOR IMPROVEMENT

There is a significant amount of data that has not been collected as required. First, according to the Department's Nutrient Criteria Implementation Plan, a minimum of four samples/grabs must be taken each year considered.¹ The following lakes have missing grabs for at least one of the most recent three years of data:

- Busch W.A. Kraut Run Lake: missing 1 grab in 2015; missing 3 grabs in 2014
- Rocky Hollow Lake: missing 1 in 1996
- Cameron Lake #4: missing 2 grabs in 2018; missing 1 in 2015
- Garden City New Lake: missing 1 grab in 2018

Second, each sample must include data for Chl-a, TN, TP, and Secchi depth.² Many lakes are missing one or more of these data requirements in sample years used to analyze these lakes. Missing data includes:

- Chl-a: Busch W.A. Kraut Run Lake (2015, 2014, 2010), Coot Lake (2010), Catclaw Lake (2010), Monroe City Lake (2010), New Marceline Lake (2010)
- TN + TP: Busch W.A. Kraut Run Lake (2015, 2014)
- Secchi depth: Lake Killarney (2003)

Additionally, a general review of a sample of unlisted lakes reveals that the amount of data collected by MDNR is insufficient. There are many non-impaired lakes on MDNR's Water Quality Assessment System that only have data for specific analytes without any nutrient data or only have fish tissue analysis without any water testing data. While most of the missing data points come from grabs prior the new nutrient criteria, MDNR is still using data from these years to determine whether a lake should be placed on the list. Under the new nutrient criteria, we hope to see all required data and grabs for each lake.

Under the third requirement, MDNR must consider at least three years of data and any data over seven years old may not be used to assess impairment.³ As stated in the Implementation Plan, "a duration of three or more years is necessary to account for natural variations in nutrient levels due to climatic variability."⁴ In its Methodology for the Development of the 2020 Section 303(d) List in Missouri, DNR states that "[f]or assessing present conditions, more recent data are preferable; however, older data may be used to assess present conditions if the data remains

¹ *Nutrient Criteria Implementation Plan*, MO. DEP'T OF NAT. RES. 8 (July 27, 2018).

² *Id.*

³ *Id.*

⁴ *Id.* at 4.

representative of present conditions.”⁵ Based on the information available from DNR’s Water Quality Data Search, there are many waterbodies for which there is a significant gap in years between sample collections.⁶ Additionally, on numerous occasions after a lake exceeded an impairment or screening threshold, there was no sampling undertaken in the subsequent years.⁷ Following each lake is the three most recent years that water quality data was collected:

- Butler Lake (2017, 2015, 2006)
- Drexel Lake (2017, 2015, 2011)
- Edina Reservoir (2012, 2008, 2006)
- Edwin A. Pape Lake (2016, 2009, 2005)
- Fredericktown City Lake (2017, 2014, 2008)
- Green City Lake (2016, 2012, 2009)
- Harrisonville City Lake (2017, 2015, 2007)
- Labelle Lake #2 (2017, 2015, 2011)
- Monroe City Lake (2014, 2011, 2010)
- New Marceline City Lake (2016, 2010, 2009)
- Willow Brook Lake (2015, 2006, 2005)
- Catclaw Lake (2017, 2011, 2010)
- Ella Ewing Community Lake (2012, 2008, 2007)
- King Lake (2009, 2006, 2005)
- Lake Killarney (2018, 2007, 2005)
- Rocky Hollow Lake (2012, 2008, 2005)
- Vandalia Community Lake (2012, 2005, 2002)

A. Prioritization of Data Collection for Lakes where Recent Data Indicates Impairment

We first recommend that DNR prioritize data collection for lakes where a recent collection of data showed that screening values and/or impairment thresholds were exceeded. Understandably, MDNR is limited in its capacity to collect data due to resource constraints. While we commend MDNR for adding lakes to 303(d) even though it requires using data from years before 2011, we are concerned that through their discretion of whether or not to consider old data, other lakes are left off of the protected list because of insufficient data. For example, if a lake has “good” criteria for years 2008 and 2009, and then the lake is sampled in 2016 and exceeds the Chl-a threshold, MDNR has the authority to keep a lake off the 303(d) list simply by not testing it after 2016. Thus, to mitigate the potential for impaired lakes being left off the list due to lack of

⁵ *Methodology for the Development of the 2020 Section 303(d) List in Missouri, Mo. Dep’t of Nat. Res. 17 (Apr. 6, 2016).*

⁶ *Water Quality Assessment System, MO. DEP’T. OF NAT’L RES.,*
https://apps5.mo.gov/mocwis_public/wqa/waterbodySearch.do

⁷ MDNR considered data taken before 2011 for these lakes, 2011 representing 7 years before 2018 when is the most recent year any data was published for proposed additions to the 2020 303(d) list. Missouri Department of Natural Resources, 2020 Section 303(d) Listed Waters Proposed List for Public Notice (November 15, 2019), <https://dnr.mo.gov/env/wpp/waterquality/303d/docs/2020-303d-list-public-notice-attachments.pdf>.

sampling, MDNR should direct resources towards those lakes that have already exceeded impairment thresholds at least once.

For example, we reviewed data for Lamar Lake (Barton County) (WBID:7356.00) and found that its Chl-a data from 2018, 2017 and 2016 are 27.8, 26.5 and 28.7 respectively. These all exceeded the Chl-a screening value but failed to exceed the Impairment Response Threshold. The only assessment endpoint noted was Secchi depth data which indicated no impairment. But Secchi data alone does not verify that the lake is not impaired, and more data is needed to assess whether it should be included on the 303(d) list. Thus, there is a possibility that if more assessment endpoint data was collected, it would show that Lamar Lake is impaired and requires protection through inclusion on the 303(d) list.

B. Use of Discretion To Be Over-Inclusive In The Use Of Older Data

Additionally, we recommend that MDNR continue to use its discretion to be over-inclusive, rather than under-inclusive, when adding lakes using data older than 7 years and consider several additions to the list that rely on older data. A failure to collect an adequate amount of recent data does not justify the non-inclusion of waters that older data indicates as being impaired or trending towards being impaired.

II. RECOMMENDATIONS TO INCREASE TRANSPARENCY

MDNR's proposed 303(d) list seriously lacks transparency. The purpose of the 303(d) public hearing is to give the public the opportunity to comment on the newly added lakes, and potentially suggest new additions. But, if the public is to have any meaningful opportunity to do this, they must have access to the proper data and information.

A. Inclusion of A Narrative Justification For 303(d) Additions

Due to the complexity of the new nutrient criteria, MDNR should include a narrative for each newly proposed 303(d) waterbody addition describing why a lake was added to the list. While MDNR does provide a link to an Excel sheet with data on each lake, this data often does not provide the entire picture.⁸ Additionally, MDNR failed to provide Excel format data for the lakes that were not placed on the 303(d) list. Excel data should be provided for the lakes that MDNR decided were not impaired, along with a narrative analysis and conclusion explaining why the lake was or was not judged to be impaired. If a lake has two or more years of Chl-a data that exceeds the nutrient response impairment threshold, then the reason for its addition is apparent. For the lakes that did not exceed the response threshold but rather had three years of data that exceed one of the nutrient screening thresholds (triggering consideration of the response assessment endpoints), it is less clear whether the lake should be added to the 303(d) list. The Excel documents contain very little information about any of the response assessment endpoints, such as if there were documented fish kills or excessive turbidity. MDNR should include all

⁸ 2020 Section 303(d) Listed Waters Proposed List for Public Notice, *supra* note 7.

assessment endpoints data and a written narrative that describes MDNR's analysis and conclusion. If a lake is added to the list (or not added), the public should know exactly why it was added (or not) so that individuals have the proper knowledge to submit comments and understand the lake's condition with respect to water quality. Missouri decided not to use numeric nutrient criteria to determine impairment, and instead uses a system that requires consideration of several parameters before impairment can be demonstrated. Having chosen this system, Missouri must now explain how it is using these multiple data points when it communicates impairment decisions to the public.

B. Expansion of Access to Basic Waterbody Information

MDNR should make available basic information about Missouri lakes so that the public can monitor lakes that are not on the 303(d) list. While MDNR has the Water Quality Assessment System (WQAS), which allows the public to search a lake by name and find a list of all data taken from that lake, it does not have a list of all lakes and reservoirs under its jurisdiction in Missouri. As such, there is no list that an individual can go to and in order to determine if a particular body of water is protected by the state. In addition, if an individual does find the data on a particular lake on the WQAS, there is no definite way to know what criteria applies to that lake. Missouri has three different sets of criteria based on which region (Plains, Ozark Highlands, and Ozark Border) a lake is located. The WQAS documents on a particular lake do not contain information about which region the lake falls into and there is no map showing the boundaries of each region. So, if an individual sees that the Chl-a concentration of a particular lake averages to about 17, then it would be impaired if it were in the Ozark Highlands, but would not be at all if it were located in the Plains. Thus, with no basis to assess data against, there is no way for the public to know definitively if a particular lake should be considered impaired or at least be subject to stricter monitoring. The MDNR should do a better job of compiling data and providing information for these lakes. The data collected by the same program in the same year should be compiled into one Excel file, making it easier for the public to review.

C. Written Justification For The Use Of Older Data

MDNR should publish written justifications for using or not using data older than seven years alongside the proposed 303(d) list. As mentioned in the previous section, MDNR has discretion to use older data and according to the MDNR's own listing methodology, "If the department uses data older than seven years to make a Section 303(d) list decision, a written justification for the use of such data will be provided." Without such information, the public may assume that every lake with data showing impairment for one year or more, regardless of when the data was collected, has the potential to be added to the 303(d) list.

D. Water Quality Assessment Tool Update

MDNR should consider updating its Water Quality Assessment tool website/database. While the database is immensely helpful in accessing water quality data, it should be noted that there are frequent error messages and time periods where the data is inaccessible. If the public is to have

the ability to monitor and provide comments on MDNR's activities, they must be able to consistently access the information.

E. Written Analysis and Conclusion of Potentially Impaired Lakes

There is a list of lakes placed on the 305(b) list named as potentially impaired lakes, but there is no available Excel data provided for this list that is similar to the data provided for the lakes placed on the 303(d) List. The MDNR should include Excel data and a narrative analysis with a conclusion for these lakes. This would allow the public to know that a certain lake has indicators of impairment and that it has the potential of becoming impaired. It is also important that the public know which lakes are showing signs of impairment so that they can provide oversight of MDNR to ensure that they are conducting the extra testing that is required.

III. CURRENT UNLISTED LAKES THAT SHOULD BE INCLUDED ON 2020 303(d) LIST

A. Jackrabbit Lake (Jackson County) (WBID:7391.00)

Jackrabbit Lake's most recent data is from 2017, 2011, and 2010. In 2010, the available data indicates that the lake was below the screening threshold. Again in 2011, the available data was just slightly under the screening threshold, with a geometric mean of 16.67 for Chlorophyll-a, but showing a clear upward trend. In 2017, six years later, the geometric mean for Chlorophyll-a had increased more than three-fold to 60.23. Had data been collected within the 6-year timeframe between 2011 and 2017, it is more than likely that another year's data would have exceeded the impairment threshold and Jackrabbit Lake would have automatically been added to the 303(d) list based on the requirements of the listing methodology.

B. Shelbyville Lake (Shelby County) (WBID:7036.00)

Shelbyville Lake has data from year 2010 and 2014. In 2014, Shelbyville Lake had a Chl-a geometric mean of 73.027, which is higher than the Plains Response Impairment Threshold. And the data from 2010 only had the data of Total Chlorophyll, the geometric mean of Total Chlorophyll was 94.775. Even assuming that Total Chlorophyll is 120% of the Chl-a (which normally would not reach that high), the estimated geometric mean of Chl-a is still 78.979, still higher than the Response Impairment Threshold. Up to now the lake was still not listed on the 303(d) list.

C. Montrose Lake (Henry County) (WBID:7208.00)

Montrose Lake has data from year 2007 and 2008. In 2007, the geometric mean of Chl-a was 54.976. In 2008, the geometric mean of Chl-a was 53.496. Both years' data had exceeded the Response Impairment Threshold for the plains region. Thus, the lake should be placed on the 303(d) list.

D. Cameron Lake #1 (DeKalb County) (WBID:7120.00)

Cameron Lake #1 has data from 1998 and 2016. In 2016, the geometric mean for Cameron Lake #1's Chlorophyll-a was 49.11. The last time Cameron #1 was tested before 2016 was 1998, and the sample did not include values for Chlorophyll-a, Phosphorus, or Nitrogen. Had additional data been collected before or after 2016, it is more than likely that another year's data would have exceeded the impairment threshold and Cameron #1 would have automatically been added to the 303(d)list based on the requirements of the listing methodology.

E. Cameron Lake #2 (DeKalb County) (WBID:7121.00)

Cameron Lake #2 is similar to Cameron Lake #1 and has data from 1998 and 2016. In 2016, the geometric mean for Cameron Lake #2's Chlorophyll-a was 33.92. The last time Cameron Lake #2 was tested before 2016 was 1998, and the sample did not include values for Chlorophyll-a, Phosphorus, or Nitrogen. Had additional data been collected before or after 2016, it is more than likely that another year's data would have exceeded the impairment threshold and Cameron Lake #2 would have automatically been added to the 303(d)list based on the requirements of the listing methodology.

IV. CONCLUSION

In summation of our public testimony and written commentary, we ask MDNR to implement the following recommendations: (1) Comply with the implementation plan requirements including collecting all prescribed data and ensuring that such data is up to date; (2) Include lakes that indicate impairment even if MDNR was unable to collect two years of data from the past seven years; (3) Improve transparency by making the 303(d) list information and reasoning more publicly available. This includes adding written narratives that describe why each lake was added to the list; (4) Consider adding the lakes detailed above. In this letter, we have further supported upon and explained these recommendations. While we understand the limits of MDNR's resources, we strongly encourage MDNR to ensure that all required data is collected moving forward, to improve transparency with the public, and to consider adding the lakes detailed above. We are glad to have the opportunity to weigh in on the 2020 303(d) list and appreciate MDNR considering our comments.

Sincerely,



Elizabeth Hubertz
Clinic Attorney



KC WATER

REGULATORY COMPLIANCE DIVISION

4700 E. 63rd Street • Kansas City, MO 64130

P: 816-513-0600 • F: 816-513-0615 • www.kcwater.us

February 19, 2020

Mr. Robert Voss
Water Protection Program
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102-0176

Subject: Comments on Proposed 2020 303(d) List for Missouri

Mr. Voss,

The City of Kansas City (City) submits the following comments on the proposed 2020 303(d) List of impaired waters which the Missouri Department of Natural Resources (MDNR or Department) placed on public notice on November 15, 2019.

The 2020 303(d) List identifies Brush Creek (3986) as impaired for total polycyclic aromatic hydrocarbons (PAHs) in the sediment. This listing is based on sediment data collected from 2006 through 2015 at three monitoring locations: 1) Brush Creek upstream of Rockwell Ln (Site 3986/5.1), 2) Brush Creek at Park Road (3986/6.2), and 3) Brush Creek downstream of Tomahawk Rd (Site 3986/7.9). However, sites 3986/6.2 and 3986/7.9 are both located in the State of Kansas and are upstream of Missouri Waterbody ID (WBID) 3986.

Total PAH sediment data from Missouri site 3986/5.1 is below the probable effects concentration (PEC) used to determine the need for further evaluation. The Listing Methodology Document (LMD) for the 2020 Section 303(d) List states that "pollutant geometric means will be compared to 150% of the recommended PEC values." The geometric mean of total PAH sediment data at Missouri site 3986/5.1 is 19.2 mg/kg, which is below 150% of the PEC value of 22.8 mg/L (i.e., below 34.2 mg/kg) recommended by MacDonald et al. (2000). Furthermore, PECs are not regulatory standards and are only intended to be used as part of a weight of evidence analysis.

In summary, the draft listing of Brush Creek (3986) for total PAHs in sediment is based solely on 1) data collected upstream of the listed segment in the State of Kansas, and 2) a threshold value intended only to trigger a weight of evidence analysis. Total PAH sediment data from the only site within the listed segment does not even meet the threshold for further analysis. Therefore, the City requests the Department remove Brush Creek from the 303(d) List for total PAHs.

Thank you for considering our comments on the proposed 2018 303(d) list. Please contact me at 816-513-0601 if you have any questions or would like to discuss these issues further.

Sincerely,

Sherri Irving, Regulatory Compliance Division Manager

cc: Terry Leeds, Director
David Nelsen, Wastewater Utility Officer
Matt Bond, Deputy Director
Brent Herring, Wastewater Treatment Division Manager



INDEPENDENCE

★ WATER POLLUTION CONTROL ★

February 19, 2020

Department of Natural Resources
Water Protection Program
Attn: Mr. Robert Voss
P.O. Box 176, Jefferson City, MO 65102-0176

RE: Draft Missouri 2020 Section 303(d) Impaired Waters List Public Comment

The City of Independence (City) would like to request that the following streams listed in the Draft Missouri 2020 Section 303(d) Impaired Waters List be re-evaluated for *Escherichia coli* (E. coli):

Little Blue River, WBID 0422.00
Little Blue River Tributary, WBID 4107.00
Burr Oak Creek, WBID 3414.00
Crackerneck Creek, 3962.00
Rock Creek, WBID 4106.00
Spring Branch, WBID 5004.00

It is believed that these streams have been misclassified as impaired, based on data collected by the United States Geological Survey (USGS) through a joint founding agreement with the City of Independence, Missouri. The purpose of this agreement is to meet compliance with the City's Municipal Separate Storm Sewer System (MS4) Permit. The MS4 permit requires sampling during storm events. Results from these storm flow sampling events were included in the data set used by MDNR for the 303(d) list determination.

The Methodology for the Development of the 2020 Section 303(d) List in Missouri, states on page 49 under *Other Statistical Considerations* that "Data sets composed mainly or entirely of storm water data or data collected only during a season when water quality problems are expected could result in a biased estimate of the true exceedance frequency. In these cases, the department may use methods to estimate the true annual frequency and display these calculations whenever they result in a change in the impairment status of a water body".

At the request of the City, USGS calculated the geometric mean of E. coli for Rock Creek, Little Blue River, and Spring Branch, Attachments 1, 2, and 3 respectfully. The analysis was conducted with and without the addition of storm flow samples in the data set. Their calculations shows a significant bias in E. coli counts when storm flow samples are included.

The City respectfully requests that the Missouri Department of Natural Resources review the data used in the determination of impairment for the previously mentioned streams and calculate the E. coli geometric mean without storm flow samples included in the data set.

Thank you for the opportunity to comment on this matter and if you have any further questions regarding this comment please feel free to contact us.

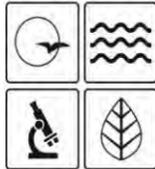
Sincerely,



Josh Eis
Environmental Compliance Supervisor
City of Independence - Water Pollution Control
jeis@indepmo.org
816.325.7054
9600 Norledge Ave.
Independence MO 64051

Attachments

- Attachment 1 - Rock Creek, WBID 4106.00
- Attachment 2 - Spring Branch, WBID 5004.00
- Attachment 3 - Little Blue River, WBID 422.00



Missouri Department of Natural Resources

Rock Creek - WBID 4106.00

US Geological Survey-WRD, Mo.

HUC 8: 10300101

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Time	Rec Season	Sample ID	Qualifier	Ecoli (#/100ml)	Stormflow sample
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2011	6	27	0400	Y	211809		54000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2011	8	19	0015	Y	211811		27000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2011	4	13	0815	Y	211806		160.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2011	9	15	0700	Y	211813		390.00	
2011 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										Sample Count = 4		
2011 Recreational Season Geometric Mean:												

*Sample is the average of two or more duplicate samples.

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2012	6	11	0415	Y	222848		88000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2012	5	22	0800	Y	222847		150.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2012	9	12	1015	Y	231704		500.00	
2012 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										Sample Count = 3		
2012 Recreational Season Geometric Mean:												

*Sample is the average of two or more duplicate samples.

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2014	4	10	1145	Y	243836		140.00		
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2014	7	22	0715	Y	243837		1000.00		
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2014	8	26	1300	Y	250811		1900.00		
2014 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										1794.72		Sample Count = 3	
2014 Recreational Season Geometric Mean:										-			

*Sample is the average of two or more duplicate samples.

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2015	4	22	0445	Y	269948		300.00			
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2015	5	18	0445	Y	269949		7600.00			
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	6	16	0800	Y	255440		21000.00			
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	6	1805	Y	255441		250000.00	X		
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	6	2020	Y	255442		100000.00	X		
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	6	2230	Y	255443		120000.00	X		
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	20	1015	Y	255444		60000.00	X		
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	8	10	0615	Y	255445		1400.00			
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	9	22	0600	Y	255446		740.00			
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	10	13	0530	Y	255447		86.00			
2015 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										7736.21		Sample Count = 10		geomean without stormwater sample: 1273.51
2015 Recreational Season Geometric Mean:										7736.21				

*Sample is the average of two or more duplicate samples.

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	4	27	0945	Y	269952		18000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	5	2	1200	Y	269953		310.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	6	15	1200	Y	269954		380.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	7	19	1230	Y	269956		440.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	8	0910	Y	269957		2000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	24	2045	Y	269959		34000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	25		Y	269961		34000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	25	0200	Y	269962		3100.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	9	7	0945	Y	269963		300.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	10	13	1200	Y	269964		380.00	X

2016 Recreational Season Geometric Mean - No Data Qualifier Adjustment:	3088.53	Sample Count = 11	geomean without stormwater sample:
2016 Recreational Season Geometric Mean:	1941.84	499.52	

*Sample is the average of two or more duplicate samples.

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	4	12	1215	Y	276106		280.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	5	22	1045	Y	276111		410.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	6	26	1200	Y	276112		420.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	7	20	1230	Y	276113		200.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	8	16	1100	Y	276118		34000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	9	21	1230	Y	276119		860.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	9	25	1400	Y	276120		360.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	10	17	1150	Y	276121		370.00	

2017 Recreational Season Geometric Mean - No Data Qualifier Adjustment:	663.50	Sample Count = 8
2017 Recreational Season Geometric Mean:	663.50	

*Sample is the average of two or more duplicate samples.

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	4	16	1045	Y	277215		460.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	5	8	0930	Y	277216		13.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	6	19	1145	Y	277217		260.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	7	16	1040	Y	277218		630.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	8	16	1110	Y	277219		200.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	8	19	1945	Y	277220		8000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	9	20	1110	Y	277221		630.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	10	16	1100	Y	277222		630.00	

2018 Recreational Season Geometric Mean - No Data Qualifier Adjustment:	397.40	Sample Count = 8	geomean without stormwater sample:
2018 Recreational Season Geometric Mean:	397.40	258.80	

*Sample is the average of two or more duplicate samples.

Summary

Year	All records	No storm
2014		
2015	7736.21	1273.51
2016	1941.84	499.52
2017	663.50	
2018	397.40	258.80

Bacteria

Rock Creek is a Class B Whole Body Contact recreational water with an E. coli standard of 206 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data. Rock Creek is also a Secondary Contact recreational water with an E. coli standard of 1134 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data.

Rock Creek has exceeded one or both criterion at least once in the last three years of available data.

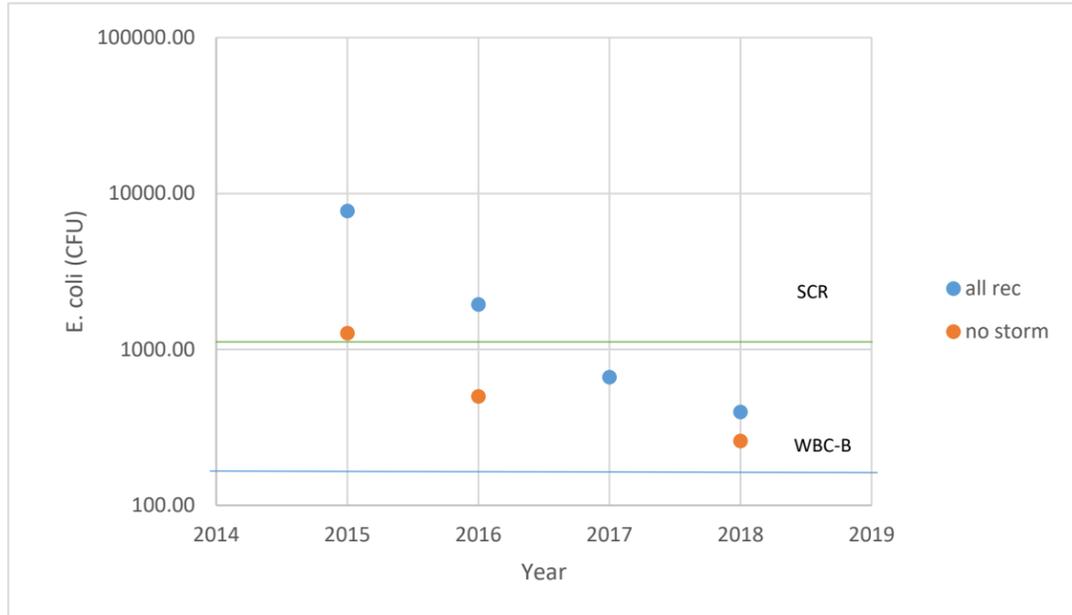
Thus Rock Creek is judged as impaired for Escherichia coli.

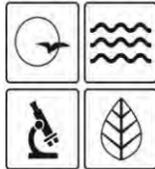
Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

<http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm>

09/19/2019 MES





Missouri Department of Natural Resources

Spring Branch - WBID 5004.00

US Geological Survey-WRD, Mo.

HUC 8: 10300101

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Time	Rec Season	Sample ID	Qualifier	Ecoli (#/100ml)	Stormflow sample
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2011	4	13	0930	Y	211949		340.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2011	8	19	0015	Y	211953		30000.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2011	9	15	0815	Y	211955		390.00	
2011 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										Sample Count = 3		
2011 Recreational Season Geometric Mean:												

*Sample is the average of two or more duplicate samples.

USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2012	5	22	1100	Y	222896		810.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2012	6	11	0845	Y	222897		28000.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2012	9	17	0930	Y	238498		410.00	
2012 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										Sample Count = 3		
2012 Recreational Season Geometric Mean:												

*Sample is the average of two or more duplicate samples.

USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2014	4	10	1100	Y	243922		77.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2014	7	22	1015	Y	243923		260.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2014	8	26	0815	Y	250904		440.00	
2014 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										Sample Count = 3		
2014 Recreational Season Geometric Mean:												

*Sample is the average of two or more duplicate samples.

USGS	5004/2.2	Spring Branch @ Holke Road	FieldDupl*	2015	7	6	1900	Y	255628		39000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	FieldDupl*	2015	7	6	1901	Y	255629		67000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	4	22	1030	Y	255625		290.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	6	16	1100	Y	255627		9000.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	7	6	2050	Y	255630		86000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	7	6	2140	Y	255631		77000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	7	20	1130	Y	255632		15000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	8	10	1030	Y	255633		520.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	9	22	0945	Y	255634		1300.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	10	13	0900	Y	255635		210.00	
2015 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										6284.96	Sample Count = 10	geomean without stormwater samples
2015 Recreational Season Geometric Mean:										6284.96	918.76	

*Sample is the average of two or more duplicate samples.

USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	4	27	0830	Y	270030		14000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	5	2	0935	Y	270031		100.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	6	15	0915	Y	270032		1100.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	7	19	0915	Y	270033		1900.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	8	0800	Y	270034		740.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	24	2130	Y	270036		20000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	24	2350	Y	270037		24000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	25	0100	Y	270038		9900.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	9	7	0745	Y	270039		630.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	10	6	0845	Y	270040		6900.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	10	13	0815	Y	270041		490.00	X

2016 Recreational Season Geometric Mean - No Data Qualifier Adjustment:	2480.93	Sample Count = 11	geomean without stormwater samples
2016 Recreational Season Geometric Mean:	2480.93		627.69

*Sample is the average of two or more duplicate samples.

USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	4	12	0915	Y	276196		370.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	5	22	0945	Y	276201		850.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	6	26	1000	Y	276202		1800.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	7	20	1115	Y	276203		2200.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	8	16	1030	Y	276208		17000.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	9	21	1100	Y	276209		630.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	9	25	1345	Y	276210		56.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	10	17	1000	Y	276211		600.00

2017 Recreational Season Geometric Mean - No Data Qualifier Adjustment:	904.55	Sample Count = 8
2017 Recreational Season Geometric Mean:	904.55	

*Sample is the average of two or more duplicate samples.

USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	4	16	1015	Y	277278		86.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	5	8	1000	Y	277279		400.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	6	19	1000	Y	277280		500.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	7	16	1010	Y	277281		2800.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	8	16	1030	Y	277282		1200.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	8	19	2115	Y	277283		9100.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	9	20	1030	Y	277284		200.00
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	10	16	1030	Y	277285		860.00

2018 Recreational Season Geometric Mean - No Data Qualifier Adjustment:	740.55	Sample Count = 8	geomean without stormwater samples
2018 Recreational Season Geometric Mean:	740.55		517.50

*Sample is the average of two or more duplicate samples.

Summary

Year	All records	no storm
2015	6284.96	918.75727
2016	2480.93	627.68783
2017	904.55	904.55
2018	740.55	517.50403

Bacteria

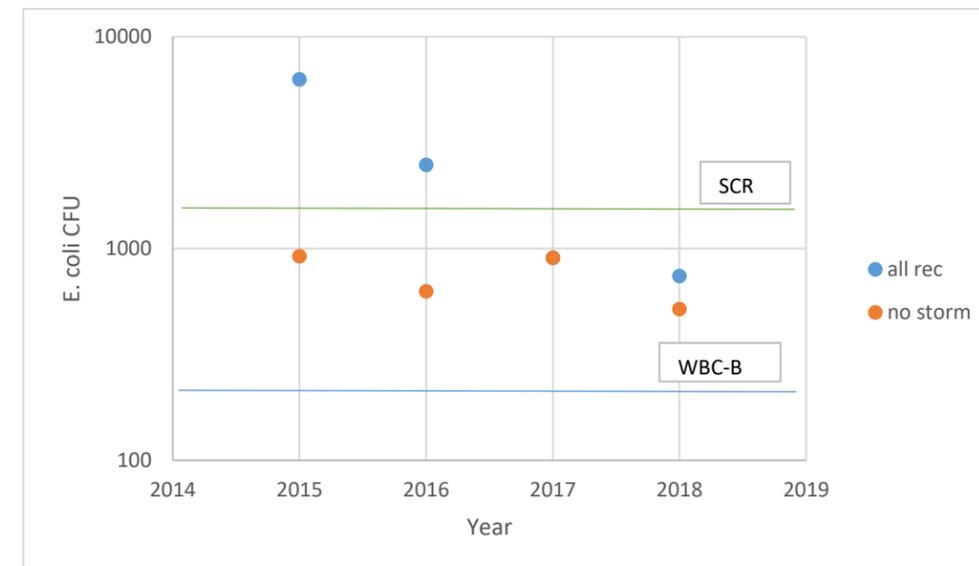
Spring Branch is a Class B Whole Body Contact recreational water with an E. coli standard of 206 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data. Spring Branch is also a Secondary Contact recreational water with an E. coli standard of 1134 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data. Spring Branch has exceeded one or both criterion at least once in the last three years of available data. Thus Spring Branch is judged as impaired for Escherichia coli.

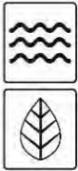
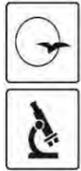
Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

<http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm>

09/19/2019 MES





Missouri Department of Natural Resources

L. Blue R. - WBID 422.00

US Environmental Protection Agency, Region VII, US Geological Survey-WRD, Mo.

HUC 8: 10300101

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Time	Rec Season	Sample ID	Qualifier	Ecoli (#/100ml)	Stormflow collection
USEPA-7	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	FieldDupl*	2011	6	2	0837	Y	244809		133.25	
USEPA-7	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2011	6	8	0821	Y	244811		23.80	
USEPA-7	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	6	2	0904	Y	244812		182.90	
USEPA-7	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	6	8	0903	Y	244813		19.50	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2011	4	13	1030	Y	211932		53.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2011	9	15	1015	Y	211938		150.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	4	13	0700	Y	211982		63.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	6	27	1115	Y	211985		11000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	9	15	1100	Y	211988		86.00	

2011 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								120.51	Sample Count = 10		geomean without stormflow samples: 68.54
2011 Recreational Season Geometric Mean:								120.51			

*Sample is the average of two or more duplicate samples.

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2012	5	22	1015	Y	222890		65.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2012	5	22	1400	Y	222907		9.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2012	6	11	1045	Y	222908		23000.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2012	9	13	0900	Y	231759		330.00	

2012 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								-	Sample Count = 4		
2012 Recreational Season Geometric Mean:								-			

*Sample is the average of two or more duplicate samples.

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2014	4	10	0900	Y	243918		31.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2014	7	22	0825	Y	243919		76.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2014	8	26	0745	Y	250899		110.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2014	4	10	1030	Y	243928		43.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2014	7	22	1145	Y	243929		230.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2014	8	26	0930	Y	250914		320.00	

2014 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								477.59	Sample Count = 6		
2014 Recreational Season Geometric Mean:								96.75			

*Sample is the average of two or more duplicate samples.

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	6	16	1120	Y	255614		5700.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	6	2145	Y	255616		490000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	7	0115	Y	255617		23000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	7	0900	Y	255618		31000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	20	1145	Y	255619		14000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	8	10	1100	Y	255620		3100.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	9	22	1030	Y	255621		310.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	10	13	0950	Y	255622		41.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	4	22	1445	Y	270013		160.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	5	18	1250	Y	270014		470.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	6	16	1310	Y	270015		2200.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	7	20	1300	Y	270016		18000.00	X
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	8	10	1325	Y	270017		100.00	X

USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	9	22	1230	Y	270018		410.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	10	13	1247	Y	270019		41.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	4	22	1250	Y	270020		130.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	5	18	1200	Y	270021		2300.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	6	16	1215	Y	270022		3800.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	7	20	1220	Y	270023		17000.00	X
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	8	10	1230	Y	270024		310.00	X
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	9	22	1155	Y	270025		200.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	10	13	1200	Y	270026		63.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	4	22	1045	Y	270043		430.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	5	18	1040	Y	270044		1700.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	6	16	1105	Y	270045		5000.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	7	20	1040	Y	270046		17000.00	X
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	8	10	1100	Y	270047		840.00	X
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	9	22	1050	Y	270048		200.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	10	13	1053	Y	270049		73.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	4	22	1300	Y	255647		170.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	5	18	1300	Y	255648		750.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	6	16	0700	Y	255649		4300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	6	2030	Y	255651		1200000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	7	0200	Y	255652		26000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	7	0830	Y	255653		24000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	20	0940	Y	255654		43000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	8	10	0840	Y	255655		9600.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	9	22	0645	Y	255656		1300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	10	13	0630	Y	255657		180.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	4	22	0945	Y	255659		330.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	5	18	1000	Y	255660		1100.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	6	16	1015	Y	255661		2400.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	7	20	0950	Y	255662		26000.00	X
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	8	10	1010	Y	255663		5000.00	X
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	9	22	1010	Y	255664		100.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	10	13	1000	Y	255665		41.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	4	22	0845	Y	270087		190.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	5	18	0845	Y	270081		2000.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	6	16	0915	Y	270082		1600.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	7	20	0900	Y	270091		24000.00	X
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	8	10	0920	Y	270083		4100.00	X
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	9	22	0920	Y	270084		200.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	10	13	0910	Y	270085		97.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	4	22	0800	Y	270086		380.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	5	18	0745	Y	270088		1400.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	6	16	0750	Y	270089		1300.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	7	20	0810	Y	270090		22000.00	X
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	8	10	0815	Y	270092		6500.00	X
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	9	22	0810	Y	270093		630.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	10	13	0810	Y	270094		140.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	4	22	1000	Y	270095		140.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	5	18	1440	Y	270096		2700.00	

USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	6	16	1445	Y	270097		5000.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	7	20	1450	Y	270098		15000.00	X
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	8	10	1415	Y	270099		200.00	X
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	9	22	1400	Y	270100		620.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	10	13	1425	Y	270101		10.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	4	22	1745	Y	270102		130.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	5	18	1340	Y	270103		2800.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	6	16	1345	Y	270104		4400.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	7	20	1400	Y	270105		16000.00	X
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	8	10	1515	Y	270106	<	100.00	X
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	9	22	1320	Y	270107		630.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	10	13	1335	Y	270108		85.00	

2015 Recreational Season Geometric Mean - No Data Qualifier Adjustment:									130.89	Sample Count = 74	geomean without stormflow samples:
2015 Recreational Season Geometric Mean:									1300.89		457.69

*Sample is the average of two or more duplicate samples.

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	4	27	0715	Y	269998		15000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	5	2	0915	Y	269999		200.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	6	15	1130	Y	270000		70.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	7	19	0945	Y	270001		86.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	8	0845	Y	270002		2000.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	24	2130	Y	270003		13000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	24	2145	Y	270004		18000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	25	0730	Y	270005		20000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	25	1100	Y	270006		12000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	9	7	0715	Y	270007		190.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	10	6	1045	Y	270008		98.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	10	13	0730	Y	270009		140.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	4	27	1315	Y	270064		9600.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	5	2	0745	Y	270065		100.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	6	15	1215	Y	270066		20.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	7	19	1100	Y	270067		110.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	8	1215	Y	270068	<	100.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	24	2215	Y	270069		3500.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	25	0500	Y	270070		45000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	25	0515	Y	270071		33000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	25	0850	Y	270072		6300.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	9	7	0815	Y	270073		120.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	10	6	1130	Y	270074		300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	10	13	1000	Y	270075		200.00	X

2016 Recreational Season Geometric Mean - No Data Qualifier Adjustment:									945.91	Sample Count = 24	geomean without stormflow samples:
2016 Recreational Season Geometric Mean:									918.99		134.65

*Sample is the average of two or more duplicate samples.

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	4	12	1130	Y	276125		65.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	5	22	0915	Y	276130		590.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	6	26	1030	Y	276131		180.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	7	20	1030	Y	276132		86.00	

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	7	27	1200	Y	276136		12000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	8	16	1000	Y	276137		200.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	9	21	1015	Y	276138		200.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	9	25	1320	Y	276139		47.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	10	17	1030	Y	276140		170.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	4	12	1030	Y	276155		100.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	5	22	0730	Y	276159		590.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	6	26	0900	Y	276160		130.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	7	20	0815	Y	276161		360.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	7	27	1435	Y	276165		17000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	8	16	0845	Y	276166		1300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	9	21	0845	Y	276167		200.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	9	25	1200	Y	276168		36.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	10	17	0800	Y	276169		93.00	
2017 Recreational Season Geometric Mean - No Data Qualifier Adjustment:				277.14				Sample Count = 18		geomean without stormflow samples:		
2017 Recreational Season Geometric Mean:				277.14						169.31		

*Sample is the average of two or more duplicate samples.

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	4	16	0945	Y	277225		25.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	5	8	1030	Y	277226		39.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	6	19	0930	Y	277227		140.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	7	16	0935	Y	277228		300.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	8	16	0925	Y	277229		400.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	8	19	2230	Y	277230		4200.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	9	20	0945	Y	277231		98.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	9	1530	Y	277232		3500.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	9	1645	Y	277233		3400.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	9	1815	Y	277234		4800.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	16	0950	Y	277235		310.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	4	16	0810	Y	277247		63.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	5	8	0830	Y	277248		91.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	6	19	0800	Y	277249		38.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	7	16	0745	Y	277250		270.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	8	16	0750	Y	277251		52.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	8	20	0100	Y	277252		3400.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	9	20	0740	Y	277253		98.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	10	16	0800	Y	277254		630.00	
2018 Recreational Season Geometric Mean - No Data Qualifier Adjustment:				293.50				Sample Count = 19		geomean without stormflow samples:		
2018 Recreational Season Geometric Mean:				293.50						117.35		

*Sample is the average of two or more duplicate samples.

Summary

Year	all records	no storm
2015	1300.88966	457.693469
2016	918.99	134.64703
2017	277.14	169.3119006
2018	293.5	117.35

Bacteria

L. Blue R. is a Class B Whole Body Contact recreational water with an E. coli standard of 206 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data. L. Blue R. is also a Secondary Contact recreational water with an E. coli standard of 1134 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data.

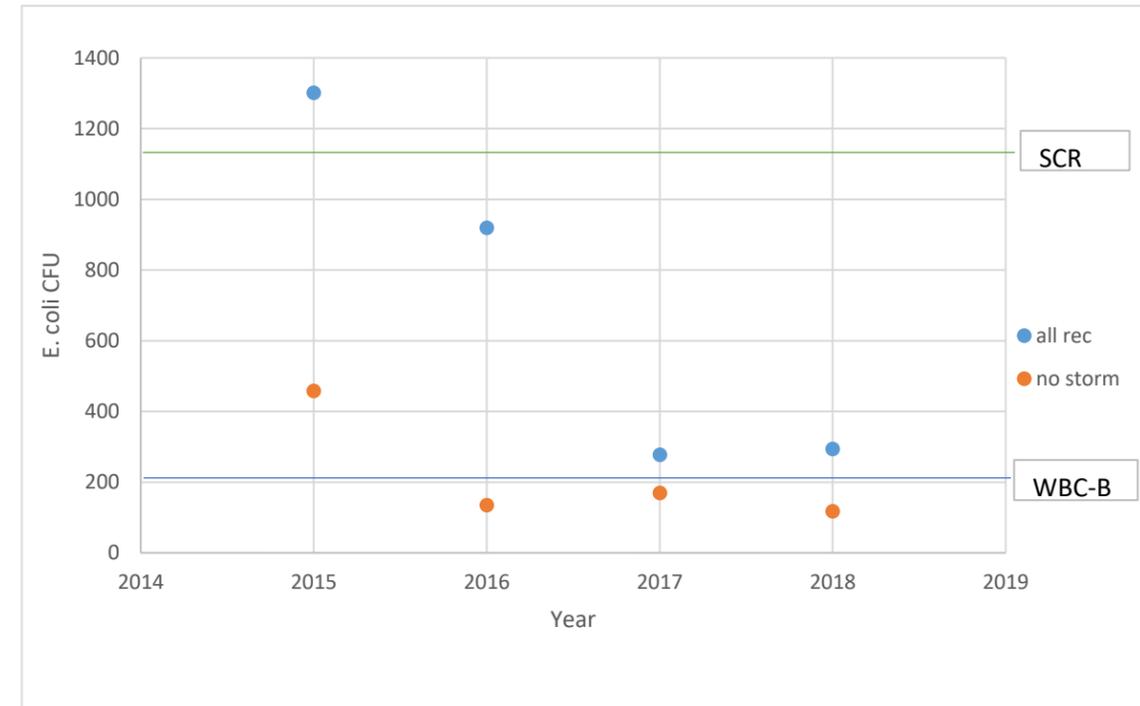
L. Blue R. has exceeded one or both criterion at least once in the last three years of available data. Thus L. Blue R. is judged as impaired for Escherichia coli.

Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

<http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm>

09/18/2019





Multiple Criteria Decision Analysis for Prioritizing Pollution Sources

Springfield-Greene County Integrated Plan

Springfield, Missouri
December 28, 2017





ACKNOWLEDGEMENTS

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Special thanks should be given to Errin Kemper, whose leadership and guidance has been key throughout this entire process. The Integrated Planning Task Force provided a deep understanding of local issues and priorities, which combined with their technical expertise has been invaluable. Special acknowledgement also goes out to Jane Clary and Jon Jones of Wright Water Engineers and Dr. Robert Pitt, who not only served on the Expert Panel, but provided excellent technical and editorial feedback on the draft report.

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1. Introduction

The City of Springfield (City), Greene County (County) and City Utilities of Springfield (CU) have developed an approach for integrated planning to best protect local environmental resources in an evolving regulatory landscape. The Integrated Plan (IP), titled “A Citizen Focused Approach,” provides a holistic plan designed to prioritize investments based on the most effective solutions to address the most pressing problems that matter most to the community. Implementation of the IP includes a four-phased approach, which is designed to be iterative:

- **Phase I** – This is the Assessment Phase which evaluates the current status of local environmental resources across air, land and water. A component of this phase is to create a large, comprehensive environmental database to enable a “Big Picture” look at local environmental resources.
- **Phase II** – The second phase is the Vision Phase and answers the question “Where do we want to be?” Success to this question is largely defined when community resources are directed towards managing environmental issues using the most effective solutions to address the most significant problems in a way that is affordable to the citizens. Additional measures of success include:
 - Local governments comply with federal and state regulations while addressing the specific needs of the community.
 - Local governments have the ability to address water, air, and solid waste issues holistically allowing both the community and the regulators to operate more efficiently.
 - There is a community culture that understands and supports the goal of high-quality environmental resources and supports these efforts through stakeholder involvement. The community has a high level of trust that resources are being used to address environmental issues efficiently and effectively.
 - The community has a clear understanding of how funding and other resources will be used to improve environmental quality.
- **Phase III** – This is the Tactical Phase and answers the question, “How will we get there?” During this phase, stakeholder groups prioritize their community’s environmental needs based on four key elements:
 - Capturing the community’s priorities,
 - Identifying and prioritizing the most significant sources of pollution,
 - Identifying and prioritizing the most effective solutions using the Sustainable Return on Investment (SROI) approach, and
 - Assessing the community’s financial capability.
- **Phase IV** – This is the Adaptive Management phase.

The focus of this report is on identifying and prioritizing the most significant sources of pollution, which is a key element of Phase III. To accomplish this task, the IP partners enlisted a team of consultants led by HDR (HDR Team) to develop a Multiple Criteria Decision Analysis (MCDA) toolset. The HDR Team included Wright Water Engineers, Dr. Robert Pitt, Black & Veatch, and Shockley Consulting. MCDA is a decision support tool for solving complex problems that are characterized as a choice among alternatives

(NRLI 2016). It is ideal for group decision making as it promotes consideration and discussion of trade-offs among alternatives. In effect, MCDA facilitates the critical thinking process in an open and transparent manner.

The five basic components of an MCDA are as follows (NRLI 2016):

1. **Goal** - The goal is defined by Element 1 of Phase III of the IP, which is to prioritize the most significant sources of pollution in the Springfield-Greene County region.
2. **Decision maker or group of decision makers with opinions** - The decision makers for the MCDA includes leaders from the City, County and CU with key input from the Environmental Priorities Task Force.
3. **Decision alternatives** – The decision alternatives are defined here by the different pollution sources. As described in greater detail within this report, an initial set of 16 pollution sources was identified for this MCDA.
4. **Evaluation criteria** – Evaluation criteria represent the interests of the decision makers. They are defined here by the community’s priorities and the pollutants or conditions that impact those priorities. For example, safe drinking water is a community priority and waterborne pathogens potentially impact that priority.
5. **Outcomes or consequences associated with alternatives** – Outcomes are defined here by the ratings and scores for each pollution source as determined by the evaluation criteria. Scores are used to prioritize the different pollution sources.

A decision framework that explicitly links the goal to the alternatives forms the basis of the MCDA model. Indicators, sometimes referred to as sub-criteria or sub-interests, are critical to the decision framework. The indicators provide an objective means of linking alternatives to the community priorities. Figure 1 illustrates the IP MCDA framework with the linkages between the community priorities, indicators, and 16 pollution sources. Once established, the framework enables decision makers to understand how the overall goal is linked to the individual alternatives and helps facilitate the scoring process.

Using the decision framework described above, alternatives are scored based on the following three sets of values: 1) priority weight, 2) indicator weight, and 3) alternative rating. For purposes of this project, priority weights reflect the Task Force findings summarized in the Community Priorities Section of this report. Indicator weights and alternative ratings were decided by a multi-disciplinary team of environmental experts and IP partners. Pollution source scores represent the sum product of the weights and ratings across all the priorities and indicators as described by the following equation:

$$\text{Pollution source score} = \sum W_P \times W_I \times R_A$$

where, W_P = community priority weight (0-1), W_I = indicator weight (0-1), and R_A = alternative rating (0-3).

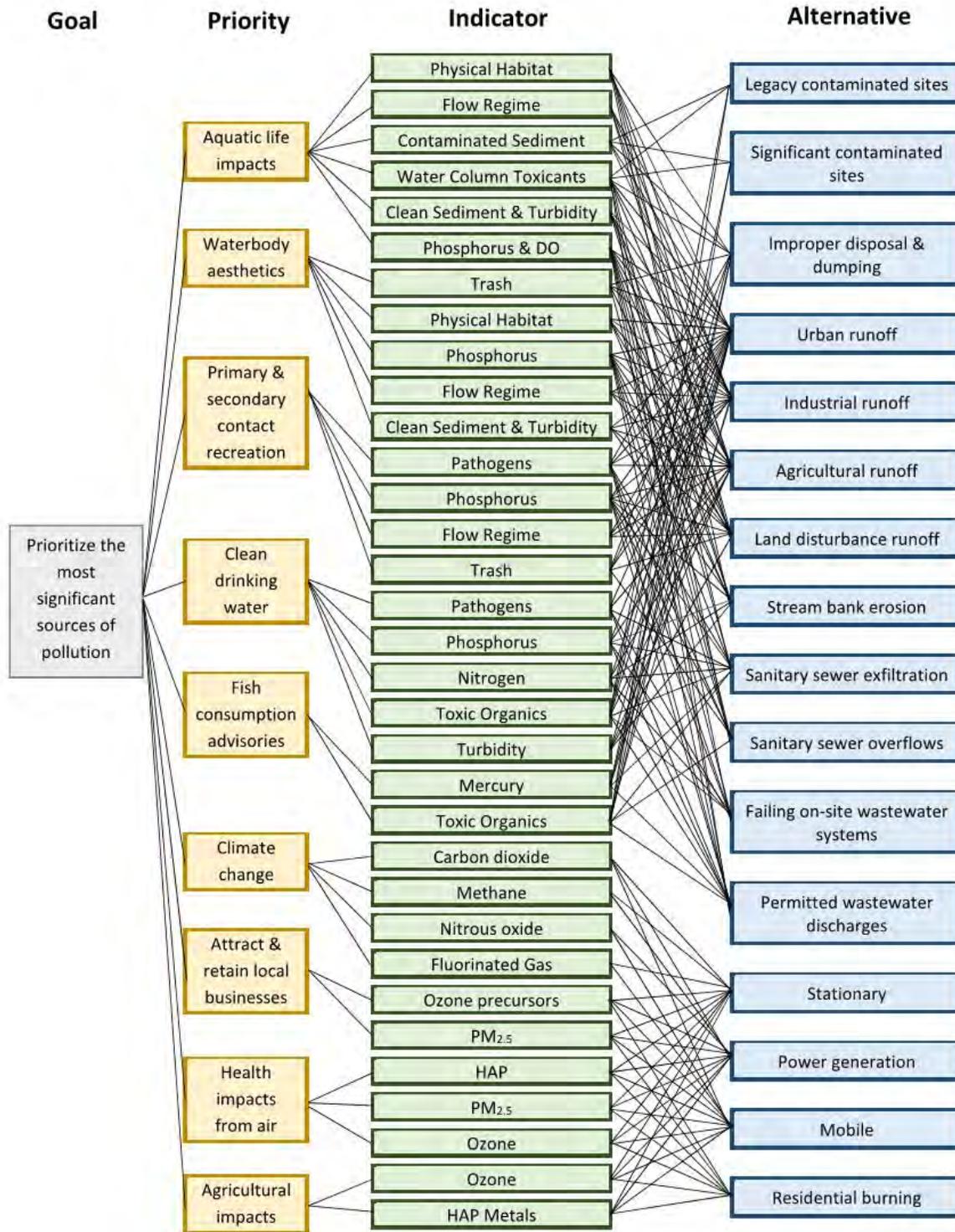


Figure 1. IP MCDA Decision Framework for Prioritizing Pollution Sources.

HDR assembled a multi-disciplinary panel of national experts to provide technical input in the selection of MCDA indicators and to assist in the scoring process. The team consisted of experts in elements of water and air pollution sources and resource impacts as detailed in the Expert Panel bios presented in Appendix A. These experts represent national knowledge leaders that were critical to drawing links between pollution sources and resource impacts. The professional judgment of the Expert Panel was also leveraged to address data gaps, where possible. The experts met with IP partner staff representing local knowledge and expertise to finalize development of the MCDA over two separate workshop events. The first workshop focused on water and land resource issues and was conducted over two days from January 17-18, 2017. The second workshop focused on air resource issues and was held on July 20, 2017. Minutes for the water and air workshops are provided for in Appendices B and C, respectively.

The purpose of this report is to document the process and results of the MCDA with respect to the identification and prioritization of the most significant sources of pollution. To this end, the report is organized as follows:

- **Section 2 - Database Development:** This section describes the development of a comprehensive environmental database. Development of this database was critical to informing the MCDA process.
- **Section 3 - Community Priorities:** This section describes how community priorities were established and weighted. This is a key element of the MCDA decision framework and scoring process.
- **Section 4 - Pollution Sources:** This section describes those pollution sources identified as alternatives for the MCDA.
- **Section 5 – Indicators:** This section describes those pollution indicators that serve as the link between the community priority and pollution sources in the MCDA decision framework.
- **Section 6 - Indicator Weights:** This section describes the process for weighting indicators and lists the final indicator weights.
- **Section 7 – Ratings:** This section describes the process for rating pollution sources and lists the final pollution source ratings.
- **Section 8 – Results:** This section presents the final MCDA scores and prioritizes the pollution sources based on those scores.
- **Section 9 - Uncertainty Analysis:** This section evaluates uncertainties associated with the MCDA ratings and its impacts on the final MCDA scores.
- **Section 10 - Data Gap Analysis:** This section discusses data gaps identified during the Expert Panel workshops.
- **Section 11 – Summary:** This section includes a summary of the MCDA and how it fits within the overall IP.

2. Database Development

Phase I of the IP represents the Assessment Phase and calls for the development of a comprehensive environmental database. Understanding existing environmental data in a holistic and comprehensive manner is essential to informing the IP process. For this reason, HDR was tasked with compiling environmental data from multiple sources into a comprehensive database for the Springfield and Greene County area. Based on discussion with the IP partners, objectives of the database include:

- Serve as a central repository of local data to support IP efforts
- Maintain data quality and comparability

- Accommodate input from multiple sources
- Provide for efficient analysis, such as trend analysis
- Easily integrate with a Geographic Information System (GIS) to allow users to view information spatially
- Key attributes – forward-looking, flexible, simple and cost-effective

HDR worked closely with the IP partners to develop a database approach that closely meets these objectives in a timely and cost-effective manner. Initial discussions focused on the pros and cons of different types of approaches ranging from simple spreadsheets through complex enterprise level geospatial databases. Recognizing that an enterprise level geospatial database is largely beyond the scope of this project but may be needed in the future, HDR ultimately recommended a two-phased approach:

- Phase 1 – Store environmental data (e.g., water quality laboratory analytical data) in an MS Access database and store geospatial information separately in a file geodatabase.
- Phase 2 – Migrate the MS Access database and geospatial data into a single enterprise geodatabase at a later date, if necessary and practicable.

Based on this recommendation, HDR developed an MS Access database and compiled relevant GIS data into a file geodatabase. As water quality data comprised the bulk of the environmental data, HDR based the database schema (structure) off of the Missouri Department of Natural Resources' MoCWIS Water Quality Assessment System. The data were spatially attributed within the database by geographic coordinates and by Task Force watershed. The Task Force watersheds were defined based on community priorities and serve as a framework for assessing water quality data. Task force watersheds include the following:

- Upper James River
- Fellows & McDaniel Lakes
- Sac River
- Wilson's Creek
- Little Sac River
- Middle James River
- Pomme de Terre River

In total, the database includes approximately 330 water quality monitoring stations and 187,000 water quality data records collected by over a dozen different entities in the Task Force watersheds (Figure 2). Air data was obtained from the U.S. Environmental Protection Agency's (USEPA) Air Quality System (AQS) and National Emissions Inventory (NEI). Since air data are fundamentally different from water quality data, these data were maintained in a separate database schema. Detailed information regarding the database was provided to the City in prior memos entitled "Database Framework Recommendation" and "Database Population Guidance".

HDR used the environmental database to compile pollutant maps, figures and tables in support of the Expert Panel workshops. Environmental data summarized for the water and air Expert Panels is provided for in Appendices D and E, respectively.

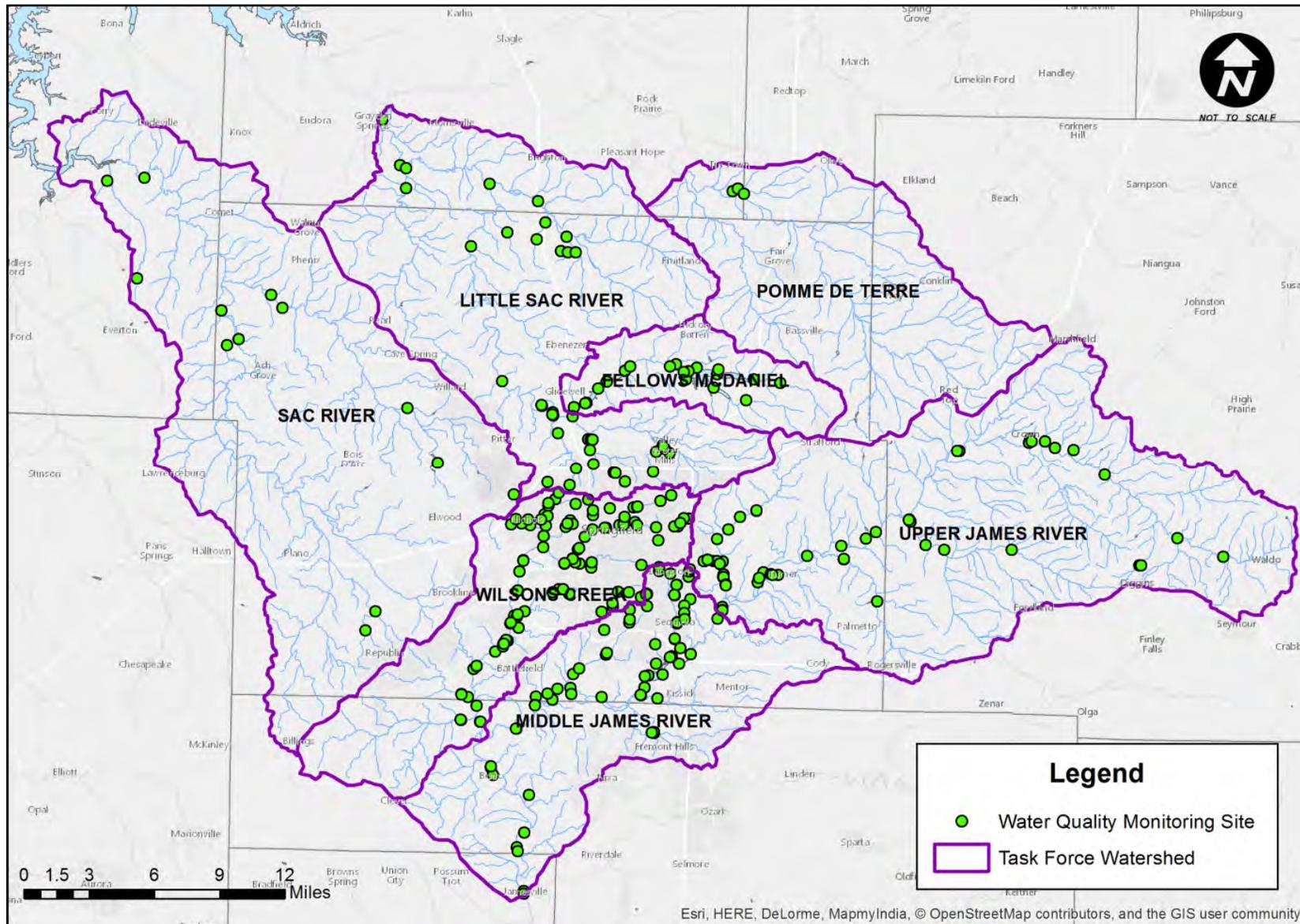


Figure 2. Task Force Watersheds and Water Quality Monitoring Stations.

3. Community Priorities

The MCDA model is designed to ensure that the decision making process reflects the community priorities. To help identify these priorities, in 2014 the Task Force met for a series of several workshops and were presented information on a variety of environmental topics. In addition, the City conducted a community survey that had 694 respondents. The survey included a variety of questions about the community’s environmental concerns. Based on the information presented, the Task Force identified, ranked, and scored a number of different community priorities into four different tiers. Results from this assessment ultimately formed the basis for the final set of community priorities and weightings identified for the MCDA (Table 1).

In two instances, community priority categories were grouped for purposes of the MCDA. Waters clean enough to swim and boat in were combined into a single category. Similarly, reduction of air quality impacts on food supply and clean water for crop irrigation, livestock and wildlife watering were re-categorized as agricultural impacts. These groupings were deemed appropriate as they are closely related and share the same indicator links to pollution sources.

Table 1. Community Priority Weights.

Community Priority	Task Force Tier	Task Force Numerical Score	MCDA Priority Weight
Clean Drinking Water	1	124	0.18
Primary and Secondary Contact Recreation	2	104	0.15
Health Impacts from Air Pollution (Air)	2	92	0.13
Climate Change (Air)	3	80	0.11
Aquatic Life Impacts	2	73	0.10
Agricultural Impacts (Air)	3	63	0.09
Ability to Attract and Retain Businesses (Air)	2	59	0.09
Fish Consumption Advisories	4	57	0.08
Waterbody Aesthetics	4	51	0.07

The nine community priorities selected for the MCDA are defined below.

3.1. Clean Drinking Water

Clean and safe water was identified as the most important priority in the Task Force report. Drinking water sources targeted for protection in the Task Force report included McDaniel Lake, Fellows Lake, Upper James River, Fulbright Spring Recharge Area, and the Upper Little Sac. CU pulls its raw water supply from these sources plus Stockton Lake and deep groundwater wells. Additionally, tens of thousands of residents in Greene County rely on groundwater for their drinking water. Potential threats to the drinking water sources identified in the Task Force report include pathogens, nutrients and increased sediment load. Toxicants from industrial sources, urban runoff and underground storage tanks also represent a potential threat to drinking water.

3.2. Primary and Secondary Contact Recreation

Streams or lakes that are clean enough to swim in (primary recreation) and boat and wade in (secondary recreation) were identified as Tier II and IV priorities, respectively, in the Task Force report. Specifically, the Task Force report prioritized protecting water from pollution in the Lower James River, Upper James River, Sac River, and Little Sac River in areas where people swim. These rivers are classified for both Whole Body Contact Recreation (WBCR) – Class A and Secondary Contact Recreation (SCR) designated use protections. WBCR Class A protections apply to waters that have been established by the property owner as public swimming areas welcoming access by the public for swimming purposes

and waters with documented existing whole body contact recreational use(s) by the public. SCR uses include fishing, wading, commercial and recreational boating, any limited contact incidental to shoreline activities, and activities in which users do not swim or float in the water. WBCR and SCR waters are protected in state regulations by *E. coli* criteria.

3.3. Health Impacts from Air Pollution (Air)

Air pollution can contribute to a variety of human health issues, affecting a number of different systems and organs. Health related issues range from minor upper respiratory irritation to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks (Kampa and Castanas 2008). To protect for health related issues, the Clean Air Act requires USEPA to set National Air Quality Standards (NAAQS) for six common air pollutants also known as “criteria pollutants”. These include particle pollution, photochemical oxidants and ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. Man-made sources of air pollutants can include emissions from automobiles, factories, power plants, construction equipment, small businesses, and open burning. The reduction in health related air quality issues was identified as a Tier II priority in the Task Force report.

3.4. Climate Change (Air)

Climate change refers to any substantial change in measures of climate lasting for an extended period of time such as major changes in temperature, precipitation, or wind patterns (USEPA 2016a). Global warming is one important aspect of climate change and refers to an average increase in the temperature of the atmosphere near the Earth’s surface. Scientists believe that increases in greenhouse gases associated with human activities are contributing to climate change and global warming. Anthropogenic sources of greenhouse gases include the burning of fossil fuels to generate electricity, heat and cool buildings, and power vehicles. The major greenhouse gases emitted into the atmosphere are carbon dioxide, methane, nitrous oxide, and fluorinated gases. The reduction of greenhouse gases was identified as a Tier III priority in the Task Force report.

3.5. Aquatic Life Impacts

Aquatic life impacts refer to the altering or impairment of fish and other aquatic life in streams, rivers, ponds and lakes due to pollutants and habitat modification. Missouri regulations at 10 CSR 20-7.031 provide for aquatic life protections through the designation of aquatic habitat uses. Warm water habitat protections apply to most all surface waters in the Springfield-Greene County region, which are defined in state regulations as waters in which naturally-occurring water quality and habitat conditions allow the maintenance of a wide variety of warm water biota. The protection of fish and other aquatic life was identified as a Tier II priority in the Task Force report.

3.6. Agricultural Impacts (Air)

Agricultural impacts refers to impacts on food supply from the reduction of air quality. These impacts may be due to climate change and ozone pollution. Both these issues were identified as a Tier III priority in the Task Force report.

3.7. Ability to Attract and Retain Local Businesses (Air)

The Task Force report identified that attainment of air quality standards to attract and retain businesses as a Tier II priority. The Task Force report noted that potential nonattainment could limit the types of businesses attracted to the region or place additional restrictions on existing businesses. The Task Force

report also included an overall goal of protecting the environment to attract/retain business and maintain a high quality of life.

3.8. Fish Consumption Advisories

Fish that are safe to eat was identified as a Tier IV priority in the Task Force report. Each year, the Missouri Department of Health and Senior Services (DHSS) create a fish consumption advisory based on an evaluation of contaminants in Missouri sport-caught fish. The advisory is based on annual fish-tissue studies by the Missouri Department of Conservation (MDC) and the Missouri Department of Natural Resources (MDNR) at various Missouri lakes, ponds, rivers, and streams (DHSS 2016). In the Springfield-Greene County region, the 2016 fish advisory includes Lake Springfield due to elevated levels of polychlorinated biphenyls (PCBs) being found in catfish and carp. There is also currently a statewide advisory for mercury.

3.9. Waterbody Aesthetics

Aesthetics of streams and lakes was identified as a Tier IV priority in the Task Force report. The Task Force report also called for improving the aesthetics of Wilsons Creek noting that there is an important trail system in this watershed and it is positioned upstream of important recreational uses. Pollutants linked to aesthetic issues in the Task Force report included sediment, trash, nutrients, and bank erosion.

4. Pollution Sources

A key task in developing the MCDA was to identify and rank sources of water, land and air pollution. Within the MCDA framework, the pollution sources define the alternatives. Pollution sources were selected in consultation with key City personnel and based on feedback from the March 28, 2016 MCDA workshop. Considerations in the selection of pollution sources included the ability to control the source, regulatory emphasis, and impact. A total of 16 pollution sources were identified, which are identified below. Fact sheets summarizing each pollution source, potential impacts and key statistics are also included in Appendix F.

4.1. Water Pollution Sources

Agricultural Runoff – Agricultural runoff is water leaving farm fields because of precipitation runoff, melted snow, or excess irrigation. As runoff moves across the land, pollutants can be mobilized and transported into streams, ponds, and lakes. Agricultural runoff can include pollution from soil erosion, feeding operations, tillage, animal waste (e.g., horses, cattle and poultry), and fertilizer. Overgrazing leads to high runoff volumes, increased erosion and water quality impacts. Livestock waste deposited in or adjacent to waterways may also lead to increased pollutant loading from agricultural runoff. Livestock with direct access to streams for watering can also degrade riparian and instream habitat.

Failing On-Site Wastewater Systems – Where central sewer services are not available, on-site (or decentralized) wastewater treatment systems are used to treat wastewater from a home or business and disperse it on the property where it is generated. Frequently referred to as septic systems, when functioning properly, on-site systems prevent human contact with sewage, and prevent contamination of surface and groundwater. Failing on-site systems allow the sewage to leave the property and may contribute bacteria and nutrient contamination to surface water and groundwater. Factors that affect the proper functioning of on-site systems include the site and soil conditions, design, installation, operation and maintenance. Surveys have shown that 70% of all septic systems in Missouri are not functioning properly (Schultheis 2001).

Urban Runoff – Stormwater runoff is surface water that originates from precipitation events such as snow, ice melt, and more commonly direct rainfall events that travels across the land rather than seeping into the ground. The runoff discharge comes from sources, such as rooftops, lawns, parking lots, roads, restaurants, golf courses, parks and driveways. Stormwater will mobilize pollutants from the land surface and contributions from land use activities and material exposure, and then transport pollutants to waterways. In addition, urbanization generally increases runoff and reduces groundwater recharge. Common urban pollutants include sediment, heavy metals, toxic organics, salts, nutrients, bacteria, herbicides, pesticides, trash, and pet waste.

Industrial Runoff – Industrial stormwater runoff comes from industrial sites regulated under the National Pollutant Discharge Elimination System (NPDES) industrial stormwater program. These sites are typically regulated due to having industrial activities and materials exposed to stormwater. Common industrial pollutants include equipment deposits (oil, grease, and metals), dust deposits, chemicals, organic waste and pollutants associated with outdoor materials storage.

Land Disturbance Runoff – As stormwater flows over a construction site, it can pick up pollutants like sediment, debris, and chemicals and transport them to nearby storm sewer systems or directly into streams, rivers, and lakes. The NPDES stormwater program requires permits for discharges from construction activities that disturb one or more acres, and discharges from smaller sites that are part of a larger common plan of development or sale.

Permitted Wastewater Discharges – Permitted direct discharges include facilities designed and operated to effectively treat municipal and industrial wastewater. Permitted direct dischargers include publicly owned wastewater treatment plants, industrial facilities and power plants. Discharges includes treated cooling, industrial and municipal wastewater. Effluent from wastewater treatment facilities is discharged to nearby streams. Treatment levels are based upon technology and water quality based requirements. Water quality based effluent limitations are set to meet water quality standards, which are established to protect designated uses such as aquatic life and swimming. Extensive pollutant removal occurs at the facilities; however, some pollutants remain within treatment plant effluent. Common pollutants that are allowed to be discharged by current USEPA rules include small amounts of metals, nutrients, bacteria, suspended solids and organics. The regulatory pollutant limits and the number of pollutants monitored change over time, typically based on federal and state recommendations informed by scientific research.

Sanitary Sewer Exfiltration – Sanitary Sewer Exfiltration occurs when untreated sewage is discharged from a leaking sanitary sewer into the surrounding geology. Exfiltration may occur due to cracks and defects in pipes, manhole defects, defective laterals and other sources within a sanitary sewer system. Exfiltration can increase during extended dry weather periods as a result of the regional groundwater table lowering. Depending on the configuration and condition of sanitary and storm sewers, exfiltrated sewage may also enter storm sewers and be transported to streams.

Sanitary Sewer Overflows – Sanitary Sewer Overflows (SSOs) occur when untreated sewage is discharged from a sanitary sewer to the ground surface or the surface water environment prior to reaching wastewater treatment facilities. The discharge comes from manholes, lift stations, emergency relief outlets, and other sources within a sanitary sewer system. SSOs are typically caused by wet weather events, blockages (e.g., tree roots), power outages and vandalism. When caused by rainfall, it is also known as a wet weather SSO.

Stream Bank Erosion – Streambank erosion refers to the removal of soil, rock and vegetation from the streambank. Streambank erosion is a natural process, but the rate at which it occurs is often increased

by human activities such as urbanization and agriculture. Acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, and habitat loss. Activities that contribute to increased streambank erosion include the urbanization of watersheds and loss of riparian forests or buffers (e.g., removal of trees or vegetation, mowing to the edge of waterway). Potential stream bank erosion resulting from livestock activities are captured within the Agricultural Runoff pollution source.

4.2. Land Pollution Sources

Improper Disposal & Dumping – Improper disposal and dumping includes discarded trash, furniture, appliances, household chemicals, yard waste, electronics, tires and other waste streams that are not recycled or disposed at a licensed facility. When discarded on land, these sources may impact water quality, wildlife, aesthetics and lead to a reduction in property values. Debris may be washed into the storm sewer system causing blockages and accumulation of trash in water quality treatment facilities or be washed into local streams and impact terrestrial and aquatic habitats. Sinkholes also are used for improper disposal, which may place pollution sources in a direct connection to groundwater.

Legacy Contaminated Sites – Legacy pollution refers to pollution that remains from historical activities. Legacy pollution is often associated with historic unlined landfills, former salvage operations, brownfields, hazardous waste dumping sites, rail yards, leaking underground storage tanks, mine tailings and former manufacturing sites. Collectively referred to as legacy contaminated sites, such areas pose environmental and health risks from a variety of pollutants (e.g., toxic organic compounds, metals, and other toxics) and exposure pathways (e.g., air, groundwater, soil).

Significant Contaminated Sites – Several significant contaminated sites are present within Springfield and Greene County. These sites are regulated by the Resource Conservation and Recovery Act (RCRA) or Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) programs. RCRA is the public law that creates the framework for the proper management of hazardous and non-hazardous solid waste. The law describes the waste management program mandated by Congress that gave USEPA authority to develop the RCRA program. CERCLA or Superfund is a federal law designed to clean up sites contaminated with hazardous substances and pollutants. The National Priorities List (NPL) is the list of hazardous waste sites eligible for long-term cleanup financed under the federal Superfund Program. There are 57 Superfund sites on the National Priorities List (NPL) in Greene County (5 active, 16 active non-NPL and 36 archived). A total of seven significant contaminated sites that may impact water quality were identified within the study area.

4.3. Air Pollution Sources

Mobile – Mobile sources include cars, trucks, buses, off-road engines, equipment and other vehicles. Mobile sources are responsible for emissions of greenhouse gases, air toxics and precursor emissions that react to form secondary pollutants. Examples of mobile source air toxics include benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, polycyclic organic matter (POM), naphthalene, and diesel particulate matter.

Residential Wood Burning – Pollutants from wood stoves and fireplaces include fine particulates, nitrogen oxides, sulfur oxides, carbon monoxide, volatile organic compounds, dioxins, and furans. Pollution from wood burning is a particular concern in the winter when cold, stagnant air and temperature inversions limit air movement. Smoke from wood burning is generated primarily by incomplete combustion, which can be caused by a number of different factors related to the wood burning device efficiency. With proper burning techniques and well-seasoned wood, emissions can be significantly reduced, even in older wood burning appliances.

Power Generation Facilities – Power generation facilities, also referred to as power plants, are industrial facilities for the generation of electric power. The primary power plants operated by City Utilities of Springfield (CU) are the James River Power Station and the John Twitty Energy Center (JTEC). Both facilities have coal burning units, but the James River Power Station recently switched to natural gas as its source of fuel. Collectively, CU power plants serve a population of approximately 249,000 with a combined capacity of 1,120 megawatts. Emissions typically associated with power generation facilities include sulfur dioxide, nitrogen oxides, particulates, carbon dioxide, and mercury.

Stationary Sources – Stationary pollution sources are defined here to mean point sources that generally require an air permit, but excludes power generation facilities. There are a variety of stationary pollution sources including the airport, landfills, hospitals, rail yards, dry cleaners, auto body shops, printers and manufacturing facilities. Stationary industrial sources are widely distributed across an area, thus tending to have some persistent (usually lower) level of impacts across the broader area. The largest producers in the county include manufacturing and automotive repair related industries. USEPA's National Air Toxics Assessments indicates hydrogen fluoride, toluene, and sulfuric acid dominate the toxic air releases in the Springfield metropolitan area. Other air pollution releases identified on USEPA's National Emissions Inventory (NEI) include fine particulates, carbon dioxide, ozone and certain other chemicals generally related to smog. Stationary sources generally not related to industrial or manufacturing such as dirt roads and residential burning are not included within this source description.

5. Pollution Indicators

Indicators are pollutants or conditions that provide the linkages between community priorities and pollution sources in the MCDA framework. For example, urban stormwater runoff (i.e., pollution source) increases nutrients and adversely impacts physical aquatic habitat (i.e., indicators), both of which can adversely impact aquatic life (i.e., community priority). Although the number of potential indicators is numerous, only the most critical indicators were selected during the Expert Panel workshops and in some instances were consolidated (e.g., water column toxicants represents metals and a variety of other pollutants). The intent of limiting the number of indicators was to avoid diluting out their impact on the community priorities. Rationale for the selection of the indicators is provided for in the workshop meeting minutes (Appendices C and D). Indicators selected for the MCDA are defined below.

5.1. Physical Aquatic Habitat

Typical physical characteristics used to assess habitat quality include epifaunal substrate, pool substrate characterization, pool variability, sediment deposition, channel flow, channel alteration, channel sinuosity, bank stability, and vegetative protection. Land disturbance activities, stream bank erosion and runoff can have a profound impact on the quality of habitat and a stream's ability to support aquatic life. Physical habitat modifications, particularly loss of the riparian corridor or stream widening, may result in elevated stream temperature due to shading loss and ultimately impact aquatic life. Physical aquatic habitat impacts may also detrimentally impact stream aesthetics (e.g., loss of riparian corridor, unstable banks, and concrete channels).

Linked Community Priorities: Aquatic Life Impacts, Waterbody Aesthetics

5.2. Flow Regime

Flow regime refers to the magnitude, frequency, duration, and rate of change of of a stream's discharge in response to precipitation and drainage basin characteristics. Changes in both low flows and high flows due to increased runoff can detrimentally impact several community priorities. Aquatic life may be impacted by scour during high flows and lack of habitat and decreased dissolved oxygen due to reduced

baseflows. Increased temperature from pavement and roof runoff during summer events may also detrimentally impact aquatic life. Stream aesthetics and recreational uses may also be impacted due to excessive high flows and decreased baseflows.

Linked Community Priorities: Aquatic Life Impacts, Waterbody Aesthetics, Primary and Secondary Contact Recreation

5.3. Contaminated Sediments

The USEPA defines contaminated sediment as “soil, sand, organic matter, or other minerals that accumulate on the bottom of a water body and contain toxic or hazardous material at levels that may adversely affect human health or the environment” (USEPA 1998). Types of contaminants found in sediment can include oil and grease, halogenated hydrocarbons or persistent organics (e.g., polychlorinated biphenyls [PCBs] and some pesticides like DDT), polycyclic aromatic hydrocarbons (PAHs), and metals (USEPA 1999). Organic matter (e.g., leaves and grass clippings) can also cause decreased oxygen levels in sediments where they can accumulate and degrade. All of these pollutants, acting independently or synergistically with multiple pollutants, may cause aquatic life toxicity. Contaminated sediment can originate from a variety of sources including stormwater runoff and atmospheric deposition (e.g., mercury). Another source is the discharge of contaminated groundwater flowing through sediments to the overlying surface water.

Linked Community Priorities: Aquatic Life Impacts

5.4. Uncontaminated Sediment & Turbidity

The USEPA lists sediment as one of the most common pollutants in rivers, streams, lakes and reservoirs.¹ It is composed of mineral particles such as clay, silt, sand, assorted-sized rocks and other non-organic materials. Sedimentation and excessive turbidity are caused by normal fluvial processes, but are greatly increased by human impacts on land. Any activity that leaves land exposed, such as agriculture and construction, can greatly increase erosion of sediment into streams. Increased sedimentation and turbidity can adversely impact aquatic life in a number of ways such as disrupting food chains, clogging fish gills, and affecting fish egg and larvae development. Excessive turbidity can impact water treatment processes and filtration by reducing effectiveness of coagulation/flocculation/sedimentation processes and could result in less effective pathogen removal.

Linked Community Priorities: Aquatic Life Impacts, Waterbody Aesthetics, Clean Drinking Water (turbidity only)

5.5. Water Column Toxicants

Water column toxicants refer to a variety of toxic elements and compounds found in the water column that can have an adverse effect on aquatic life. Such pollutants can include heavy metals, ammonia, chlorides, nitrates, pH, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, solvents, and compounds of emerging concern. Heavy metals are known for being potentially toxic and include, among others, arsenic, cadmium, lead, mercury, copper and zinc. Water column toxics can originate from many sources including mining, industry, contaminated sites, agricultural production, improper dumping, domestic effluents, atmospheric sources, and urban stormwater runoff (industrial, commercial, and residential).

¹ Based on USEPA’s Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS).

Linked Community Priorities: Aquatic Life Impacts

5.6. Toxic Organics

Toxic organics is a subset of water column toxicants and includes such compounds as pesticides, petroleum hydrocarbons, chlorinated solvents, chlorine disinfection byproducts and pharmaceuticals. Several toxic organics have been associated with adverse human health impacts such as increased carcinogenic risk and endocrine disruption. Toxic organics can potentially originate from a number of pollution sources including legacy contaminated sites, stormwater runoff, livestock production, and wastewater.

Linked Community Priorities: Clean Drinking Water, Fish Consumption Advisories

5.7. Mercury

Mercury is a toxic heavy metal, which is included on the World Health Organization's list of 10 chemicals of major concern (WHO 2017). Mercury exposure can cause neurological and developmental disorders in humans. The most common route of exposure for humans is from eating mercury contaminated fish, which tend to bioaccumulate mercury. While mercury in the environment can originate from natural processes, it largely originates from human activities. Industrial processes such as coal combustion can release mercury into the atmosphere where it can be deposited globally through precipitation. Because mercury in the atmosphere can travel great distances, it is considered a global issue. However, mercury can also enter the environment through the improper disposal of such mercury-containing products as thermometers and batteries. Therefore, municipal wastewater and urban stormwater runoff also represent potential sources of mercury.

Linked Community Priorities: Fish Consumption Advisories

5.8. Pathogens

Pathogens include a broad category of bacteria, viruses and protozoans that can cause human diseases. Many classes of pathogens excreted in feces are able to initiate waterborne infections. There are bacterial pathogens, including enteric and aquatic bacteria, enteric viruses, and enteric protozoa, which are strongly persistent in the water environment and resistant to most disinfectants. Indicator bacteria, namely *Escherichia coli* (*E. coli*), generally do not cause illness directly, but demonstrate the presence of fecal contamination. Infectious diseases caused by waterborne pathogens are the most common and widespread health risk associated with drinking water. The main route of human exposure to illness-causing pathogens in recreational waters is through direct contact with swimming, most commonly through accidental ingestion of contaminated water.

If ingested, pathogens may cause:

- Bacterial infections (e.g., gastroenteritis, cholera, salmonellosis, and shigellosis)
- Viral infections (e.g., infection hepatitis, gastroenteritis, and intestinal diseases caused by enteroviruses)
- Protozoan infections (e.g., cryptosporidiosis, amoebic dysentery, and giardiasis)

Sources of pathogens include animal and human waste from pets, wildlife, livestock, sanitary sewer overflows, improperly functioning septic systems and wastewater treatment facilities.

Linked Community Priorities: Primary and Secondary Contact Recreation, Clean Drinking Water

5.9. Aquatic Life Pathogens

Aquatic life pathogens are distinguished here from waterborne pathogens that adversely impact drinking water and primary and secondary contact recreation. Aquatic life pathogens include bacteria, viruses, protozoans, and parasites that can adversely impact the health of aquatic life or human health from fish consumption. For example, in high numbers, fish roundworms can cause illness or death in fish, but typically do not represent a risk for humans consuming fish if properly prepared. Also, parasites from crayfish can cause severe lungworm disease in people if consumed raw. The Expert Panel determined that further literature-based research is needed to determine the sources and risks associated with aquatic life pathogens with respect to both aquatic life health and fish consumption advisories. Therefore, aquatic life pathogens are included here as a potential pollution indicator, but were not factored into the final MCDA analysis.

Linked Community Priorities: Aquatic Life Impacts, Fish Consumption Advisories

5.10. Nutrients (Nitrogen and Phosphorus)

Nutrients such as nitrogen and phosphorus are ubiquitous elements in surface waters and are essential to the growth and survival of aquatic plants, algae and microbes. Nutrients occur in a variety of chemical forms in both particulate and dissolved phases. Nutrients also occur in biotic forms such as algae, which can be re-released into the aquatic environment upon decay. The availability of nutrients for uptake by aquatic organisms depends on the chemical form and the organism. Only the dissolved forms of nutrients are directly available for algae, such as ammonia, nitrate, nitrite and orthophosphate. Particulate forms of nutrients can become indirectly available as the material degrades and decomposes in the aquatic environment (including sediments).

In excess, nutrients can lead to increased production of algae and aquatic plants in freshwater systems. Reductions in dissolved oxygen caused by algal respiration and decay, unsightly algal blooms, reduced water transparency, and the production of toxins by certain algae species can all occur to varying degrees. Depending on the severity, nutrient enrichment, also known as eutrophication, can detrimentally impact aquatic life. Eutrophication may also impact drinking water supplies by increasing disinfection by-product precursors (organic carbon) and in extreme cases can lead to threats to human health by harmful algal toxins. Excessive levels of nitrate in drinking water supplies may also pose human health threats. Swimming and other recreational activities may be impaired or precluded due to reduced water clarity associated with algal growth, which can affect the attractiveness of the water body and prompt safety concerns.

Potential major sources that deliver nitrogen and phosphorus to streams and reservoirs within the Springfield-Greene County region include wastewater treatment plants and collection systems, failing on-site wastewater systems, urban runoff, stream erosion, and agriculture runoff.

Due to the complexities and various potential impacts of nutrients, the Expert Panel decided to break nutrients into three different indicator categories, depending on the community priority:

- Total Phosphorus (TP) – TP is considered the primary nutrient responsible for eutrophication related issues in Springfield area waterbodies. Based on its potential to generate unsightly algal blooms, reduced transparency, and algal toxins, phosphorus was selected as an indicator for waterbody aesthetics, primary and secondary contact recreation and drinking water.
- TP and Dissolved Oxygen (DO) – Low levels of dissolved oxygen can adversely impact aquatic life and is closely linked to eutrophication issues associated with excess nutrients such as

phosphorus. Because they are so closely linked, TP and DO are grouped as an indicator for aquatic life impacts.

- Total Nitrogen (TN) – TN, along with TP, can be a co-limiting nutrient for primary production in streams, rivers, and lakes. Although TP is typically the more limiting nutrient, TN can be a factor in driving harmful algal blooms and undesirable algal species.

Linked Community Priorities: Aquatic Life Impacts (TP and DO), Waterbody Aesthetics (TP), Primary and Secondary Contact Recreation (TP), Clean Drinking Water (TP and TN).

5.11. Trash

Trash, litter and other types of solid waste from human activities can impair the recreational value and aesthetics of a waterbody and may impact aquatic life. The most common types of litter in streams include plastic cups, plastic bags and wrapping materials, fast-food wrappers, plastic bottles, and other plastic containers. Trash can also include large objects (e.g., appliances, barrels, mattresses), floatables, and other types of debris of human origin. Sources of trash can include direct dumping and littering into waterbodies and discharges into stormwater.

Linked Community Priorities: Waterbody Aesthetics, Primary and Secondary Contact Recreation

5.12. Greenhouse Gases

Greenhouse gases are broadly defined as those gases that trap heat in the atmosphere by absorbing and emitting solar radiation. Naturally occurring levels of greenhouse gases play an important role in keeping the Earth's atmosphere warm and able to sustain life. However, greenhouse gases have increased since the industrial revolution and scientists are concerned that a buildup of these gases could cause climate impacts in the coming decades. The four principal greenhouse gases are carbon dioxide, methane, nitrous oxide and fluorinated gases.

Carbon Dioxide (CO₂)

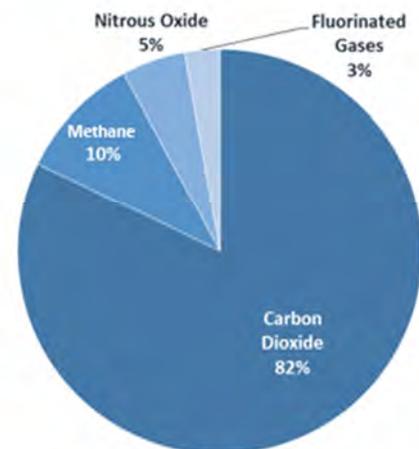
CO₂ is a major greenhouse gas emitted through the burning of fossil fuels (oil, natural gas, and coal), solid waste, and trees and wood products. While CO₂ is naturally present in the atmosphere as part of the Earth's carbon cycle, levels have been rising steadily since the start of the industrial revolution (NRC 2010). Human activities have resulted in increasing emissions of CO₂ to the atmosphere and are influencing the ability of natural sinks, like forests, to remove CO₂ from the atmosphere. USEPA's annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014* estimates that electricity and transportation represent the primary sources of CO₂ emissions in the United States at 37% and 31%, respectively (USEPA 2016b).

Linked Community Priorities: Climate Change, Agricultural Impacts

Methane (CH₄)

Methane is the primary component of natural gas, but comes from many sources, both natural and manmade. It

U.S. Greenhouse Gas Emissions in 2015



U.S. Environmental Protection Agency (2017). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015*.

is emitted during the production and transport of coal, natural gas, and oil. Emissions also originate from livestock and the decay of organic matter. Methane is more effective at absorbing heat than CO₂ but does not linger as long in the atmosphere.

Linked Community Priorities: Climate Change

Nitrous Oxide (N₂O)

Nitrous oxide is a natural part of the Earth's nitrogen cycle, but increasing levels have been attributed to human activities. It is considered the third leading contributor to climate change behind CO₂ and methane. Like methane, nitrous oxide is more effective at trapping heat than CO₂. The major anthropogenic sources of nitrous oxide emissions are agriculture, fossil fuel combustion and industrial processes.

Linked Community Priorities: Climate Change

Fluorinated Gases

Fluorinated gases are the most potent and persistent of the greenhouse gases, but only account for about three percent of the greenhouse gas emissions in the United States. Fluorinated gases are man-made gases that are emitted from a variety of industrial processes. The four types of fluorinated gases are hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride.

Linked Community Priorities: Climate Change

5.13. Ozone (O₃) and Precursors

Ozone is a gas composed of three atoms of oxygen (O₃), which occurs both in the upper atmosphere and at ground level. Ozone in the upper atmosphere occurs naturally and beneficially provides a protective barrier from the sun's harmful ultraviolet rays. Ground level ozone, however, can trigger a variety of health problems such as aggravation of asthma and permanent lung damage. It can also damage sensitive vegetation and reduce crop yield. Ground level ozone is created by chemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOC) in the presence of sunlight. NO_x is the generic term for nitric oxide (NO) and nitrogen dioxide (NO₂) and other nitrogen oxides, which are a family of poisonous, highly reactive gases. VOCs are organic compounds that are emitted from certain solids and liquids. The primary sources of NO_x and VOCs include industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents.

Linked Community Priorities: Ability to Attract and Retain Local Businesses (O₃ precursors - NO_x, VOCs), Health Impacts from Air Pollution (O₃), Agricultural Impacts (O₃)

5.14. Atmospheric Particulate Matter and Precursors

Atmospheric particulate matter (PM), also known as particle pollution, is one of six principal pollutants identified by USEPA as "criteria" air pollutants. PM represents a complex mixture of extremely small particles and liquid droplets that occur over a wide range of sizes. Particles may be emitted directly or by transformations of gaseous precursor emissions such as sulfur oxides (SO_x), NO_x, and VOCs. Sources of primary particles include agricultural operations, industrial processes, combustion of wood and fossil fuels, demolition activities, unpaved roads and construction. Precursor gases responsible for "secondary" particles can originate from distant sources. Examples include sulfates formed from sulfur dioxide emissions from power plants and industrial facilities and nitrates formed from nitrogen oxides released from power plants, mobile sources, and other combination sources.

Particle pollution is generally categorized into one of two size categories, known as PM₁₀ and PM_{2.5}. PM_{2.5}, or fine particles smaller than 2.5 micrometers in diameter, can remain airborne for long periods traveling hundreds of miles. PM₁₀, or coarse particles smaller than 10 micrometers in diameter, are typically deposited on the ground downwind of emission sources and have a smaller spatial impact than PM_{2.5}. PM_{2.5} not only impacts a larger area, but consists of secondary particles to a much greater extent than PM₁₀. If inhaled, particulate matter can cause serious health effects potentially affecting the heart and lungs. It can also cause eye, nose and throat irritation, and can serve as a carrier for toxic metals.

Linked Community Priorities: Ability to Attract and Retain Local Businesses (PM_{2.5} precursors), Health Impacts from Air Pollution (PM_{2.5})

5.15. Hazardous Air Pollutants (HAPs)

USEPA defines HAPs as toxic air pollutants that may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. Additionally, some toxic air pollutants such as mercury can be deposited onto soils or surface waters, where they can be incorporated into the food supply. There are currently 187 HAPs that USEPA is required to regulate, examples of which include benzene, perchlorethylene, and methylene. Most HAPs originate from mobile sources such as vehicles, stationary sources such as factories and power plants, and indoor sources associated with building materials and cleaning activities.

Linked Community Priorities: Health Impacts from Air Pollution, Agricultural Impacts (HAP Metals)

6. Indicator Weights

The Expert Panels were tasked with assigning weights to each of the indicators to account for relative impacts on community priorities. Weights were assigned on a scale of 0 to 1 such that the sum of the indicator weights corresponding to a community priority equaled 1. Indicator weights were assigned based on considerations provided below.

- *Watershed Scale* (water and land only) –The significance of this factor is a function of the number and importance of the community priority watersheds impacted by the indicator. It is considered of major significance if the indicator impacts all community priority watersheds. Conversely, it is considered of minor significance if it only impacts one watershed of minor importance with respect to the community priority.
- *Severity of Impact* – The significance of this factor is gaged by the severity of the impact. It is considered of major significance if the indicator severely impacts the community priority. If the impacts are only minimal, it is considered of only minor importance.
- *Likelihood of Impact* – The significance of this factor is based on the likelihood of impacts to the community priority. It is considered of major significance if there are known significant impacts from the indicator to the community priority. If impacts are highly suspected, it is considered of moderate significance. If impacts are only marginally suspected, it is considered of minor significance.
- *Frequency of Impact* – The significance of this factor is based on the frequency of impacts. It is considered of major importance if the indicator chronically impacts the community priority. Frequent acute impacts are considered moderate and infrequent acute impacts are considered minor.
- *Ability to Control* – The significance of this factor is based on the ability of the community to control the indicator. It is considered of major significance if actions by agencies or partners to control the indicator may greatly improve the community priority condition. If actions may result

in significant improvements, it is considered moderate. If actions may only result in marginal improvements it is considered minor.

Indicator weights are summarized in Table 2. Rationale for final indicator weightings is provided in the minutes from the Expert Panel workshops (Appendices C and D).

Table 2. Indicator Weights.

	Community Priority	Indicator	Weight
Water and Land	Aquatic Life Impacts	Physical Habitat	0.2
		Flow Regime	0.2
		Contaminated Sediment	0.2
		Water Column Toxicants	0.2
		Clean Sediment & Turbidity	0.1
		TP & DO	0.1
	Waterbody Aesthetics	Trash	0.3
		Physical Habitat	0.2
		TP	0.2
		Flow Regime	0.1
		Clean Sediment & Turbidity	0.2
	Primary and Secondary Contact Recreation	Pathogens	0.5
		TP	0.1
		Flow Regime	0.2
		Trash	0.2
	Clean Drinking Water	Pathogens	0.4
TP		0.3	
TN		0.1	
Toxic Organics		0.1	
Turbidity		0.1	
Fish Consumption Advisories	Mercury	0.5	
	Toxic Organics	0.5	
Air	Climate Change	CO ₂	0.76
		CH ₄	0.16
		N ₂ O	0.06
		Fluorinated Gas	0.02
	Ability to Retain and Attract Businesses	O ₃ Precursors (NO _x , VOC)	0.7
		PM _{2.5} Precursors	0.3
	Health Impacts from Air Pollution	HAPs	0.3
		PM _{2.5}	0.5
		O ₃	0.2
	Agricultural Impacts	O ₃	0.9
HAPs (Metals)		0.1	

7. Ratings

After identifying and weighting indicators, the Expert Panels were tasked with rating the link between each indicator and pollution source. Ratings were made on a scale of 0 to 3 and represent the relative impact a source has on a particular indicator, with 3 being the most impactful and 0 having no impact. As guidance, workshop participants were instructed to collectively consider the following factors when scoring pollution sources.

- Watershed Scale** (water and land only) – The significance of this factor is a function of the number and importance of the community priority watersheds impacted by the indicator. It is considered of major significance if the pollution source impacts all community priority watersheds. Conversely, it is considered of minor significance if the source only impacts one watershed of minor importance with respect to the community priority.

- *Relative Contribution* – The significance of this factor is based on the contribution of the pollution source to the pollutant species relative to other sources. If the relative contribution from the source is high, then it is considered of major significance. If the relative contribution from the source is low, then it is considered of minor significance.
- *Hydrologic Condition* (water and land only) – This factor refers to the range of hydrologic conditions under which impacts occur. If the pollution source impacts the community priority under a wide range of hydrologic conditions, it is considered of major significance. If impacts are primarily during dry weather conditions only, then it is considered of moderate significance. If impacts are primarily during wet weather conditions only, then it is considered of minor importance.
- *Risk of Pollutant* - The risk posed by the pollutants associated with the pollution source determines the significance of this factor. The source is considered of major significance if the pollutants associated with it pose a high risk to the community priority. If the pollutants only poses a low risk, then the source is considered of minor significance.

Final ratings from the Expert Panel workshop are presented in Table 3. Rationale for ratings are provided in the minutes from the Expert Panel workshops (Appendices C and D).

Table 3. Pollutant Source Ratings.

Community Priorities		Indicator		RATINGS (0-3)														
				Air				Land			Water							
		Stationary	Power Generation	Mobile	Residential Burning	Legacy Contaminated Sites	Significant Contaminated Sites	Improper Disposal & Dumping	Urban Runoff	Industrial Runoff	Agricultural Runoff	Land Disturbance Runoff	Stream Bank Erosion	Sanitary Sewer Exfiltration	Sanitary Sewer Overflows	Failing On-Site Wastewater Systems	Permitted Wastewater Discharges	
Water and Land	Aquatic life impacts	Physical Habitat						1	3	1	2	1	2					
		Flow Regime							3	1	2	1						
		Contaminated Sediment					3	3	0.5	2	2							
		Water Column Toxicants					2	2	1	2	3	1			2	1		0.5
		Clean Sediment & Turbidity								1	0.5	1.5	1	3				
	Waterbody aesthetics	TP & DO								1.5	0.5	2	1	3	3	0.5	1	3
		Trash							3	3	1		1			1		
		Physical Habitat								3	1	2	1	2				
		TP								1.5	0.5	2	1	3	3	0.5	1	3
	Primary and secondary contact recreation	Flow Regime								3	1	2	1					
		Clean Sediment & Turbidity								1	0.5	1.5	1	3				
		Pathogens							0.5	1	0.5	3			3	1.5	1	0.5
		TP								1.5	0.5	2	1	3	3	0.5	1	3
	Clean drinking water	Flow Regime								3	1	2	1					
		Trash							3	3	1		1			1		
		Pathogens								0.5		3			3		1	0.5
		TP								1		3		3	2		1	1
	Fish consumption advisories	TN								1		3		2	2		1	1
		Toxic Organics					1	3	1	1		1		2	2		0.5	0.5
		Turbidity								1		2	1.5	3				
Air	Climate Change	Mercury						2	2	1				2			0.5	
		Toxic Organics					3	1	1	2	1			1	0.5		0.5	
		CO ₂	1	3	2													
		CH ₄	1.5	0.5														
	Ability to attract and retain local businesses	N ₂ O		0.5	0.5													
		Fluorinated Gas	1		1													
	Health impacts from air pollution	O3 Precursors (NOx, VOC)	3	0.5	3	0.5												
		PM _{2.5}	3	2	2	1												
		HAP	2	1	2	3												
	Agricultural Impacts	PM _{2.5}	2	2	1	3												
O3		3	0.5	3	0.5													
HAP Metals		2	3	1	0.5													

8. Results

The objective of the MCDA is to prioritize the most significant sources of pollution in the Springfield-Greene County region. To determine significance, each of the 16 pollution sources were scored and ranked based on the sum-product of the community priority weight, indicator weight, and rating (Table 4, Figure 3). Possible scores for any individual pollution source range from 0 to 3. Final scores ranged from 0.19 for significant contaminated sites to 1.03 for agricultural runoff. Pollution sources were categorized as high, medium, or low priority based on scores as discussed below. However, such categories are only intended to convey a relative priority and do not necessarily reflect importance.

High Priority Sources

1. **Agricultural Runoff (Score = 1.03)** – Agricultural runoff impacts clean drinking water (0.49) more than any other community priority. The agricultural runoff indicator that most heavily impacts this and all community priorities is pathogens.
2. **Urban Runoff (Score = 0.97)** – Urban runoff impacts primary and secondary contact recreation (0.28) more than any other community priority. The urban runoff indicators that most heavily impact this priority are flow regime and trash. Impacts from both these indicators are equal with respect to primary and secondary contact recreation. The indicator that most heavily impacts all community priorities is trash.
3. **Stationary – Air (Score = 0.93)** – Stationary sources impact health impacts from air (0.29) more than any other community priority. The stationary indicator that most heavily impacts this community priority is PM_{2.5}. The indicator that most heavily impacts all community priorities is ozone and ozone precursors.
4. **Sanitary Sewer Exfiltration (Score = 0.90)** – Sanitary sewer exfiltration impacts clean drinking water (0.40) more than any other community priority. The sanitary sewer exfiltration indicator that most heavily impacts this and all community priorities is pathogens.
5. **Mobile – Air (Score = 0.89)** – Mobile air sources impact agricultural impacts (0.25) more than any other community priority. The mobile air sources indicators that most heavily impact this priority are HAPs and ozone. Impacts from both these indicators are equal with respect to agricultural impacts. The indicator that most heavily impacts all community priorities is ozone and ozone precursors.

Medium Priority Sources

6. **Power Generating Facilities – Air (Score = 0.60)** – Power generating facilities impact climate change (0.26) more than any other community priority. The power generating facility indicator that most heavily impacts this and all community priorities is CO₂.
7. **Stream Bank Erosion (Score = 0.51)** – Stream bank erosion impacts clean drinking water (0.25) more than any other community priority. The stream bank erosion indicator that most heavily impacts this and all community priorities is total phosphorus.
8. **Residential Burning – Air (Score = 0.43)** – Residential burning impacts health impacts from air (0.33) more than any other community priority. The residential burning indicator that most heavily impacts this and all community priorities is PM_{2.5}.

9. **Industrial Runoff (Score = 0.39)** – Industrial runoff impacts aquatic life (0.15) more than any other community priority. The industrial runoff indicator that most heavily impacts this and all community priorities is water column toxicants.
10. **Improper Disposal & Dumping (Score = 0.38)** – Improper disposal and dumping impacts primary and secondary contact recreation (0.13) more than any other community priority. The improper disposal and dumping indicator that most heavily impacts this and all community priorities is trash.
11. **Permitted Wastewater Discharges (Score = 0.32)** – Permitted wastewater discharges impact clean drinking water (0.12) more than any other community priority. The permitted wastewater discharges indicator that most heavily impacts this and all community priorities is total phosphorus.

Low Priority Sources

12. **Failing On-Site Wastewater Systems (Score = 0.27)** – Failing on-site wastewater systems impact clean drinking water (0.15) more than any other community priority. The failing on-site wastewater system indicator that most heavily impacts this and all community priorities is pathogens.
13. **Legacy Contaminated Sites (Score = 0.24)** – Legacy contaminated sites impact fish consumption advisories (0.12) more than any other community priority. The legacy contaminated site indicator that most heavily impacts this and all community priorities is toxic organics.
14. **Land Disturbance Runoff (Score = 0.23)** – Land disturbance runoff impacts primary and secondary contact recreation (0.08) more than any other community priority. The land disturbance runoff indicators that most heavily impacts this priority are flow regime and trash. Impacts from both these indicators are equal with respect to primary and secondary contact recreation. The indicator that most heavily impacts all community priorities is flow regime.
15. **Sanitary Sewer Overflows (Score = 0.22)** – Sanitary sewer overflows impact primary and secondary contact recreation (0.15) more than any other community priority. The sanitary sewer overflow indicator that most heavily impacts this and all community priorities is pathogens.
16. **Significant Contaminated Sites (Score = 0.19)** – Significant contaminated sites impact aquatic life (0.10) more than any other indicator. The significant contaminated site indicator that most heavily impacts this priority is contaminated sediment. The indicator that most heavily impacts all community priorities is toxic organics.

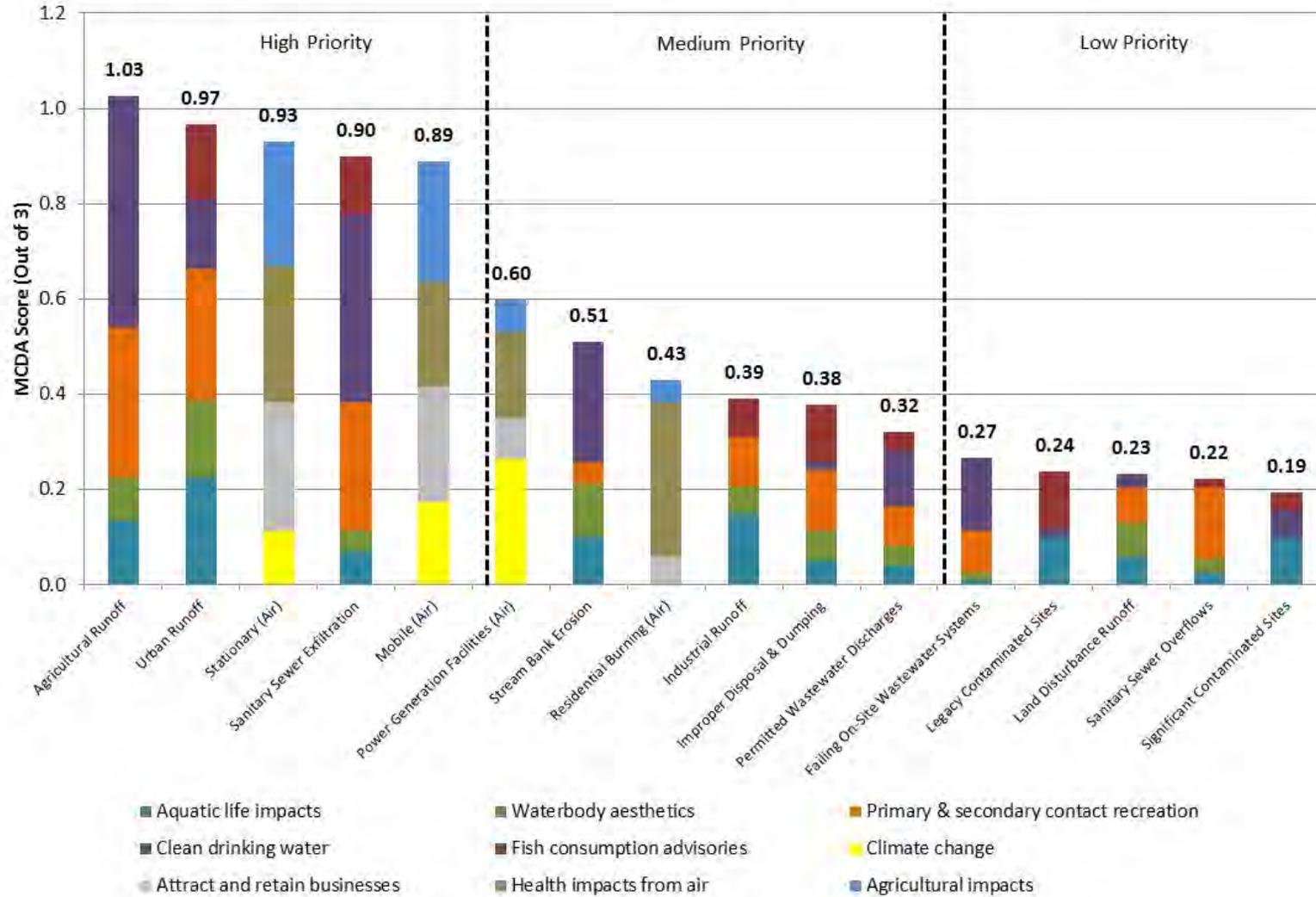


Figure 3. MCDA Scores by Community Priority.

9. Uncertainty Analysis

Uncertainty refers to a lack of data or an incomplete understanding of a decision. Uncertainty is inherent to the MCDA process. The purpose of this section is to assess uncertainty in the final MCDA scores to better understand its implications and limitations. The evaluation was conducted with a Monte Carlo simulation by randomly adjusting pollution source ratings based on a triangular distribution.

A triangular distribution is a method of describing uncertainty in variables based on a three-point estimate. The three-point estimate consists of a minimum value, maximum value, and the most likely value or mode. The three points form a continuous probability distribution shaped like a triangle, where the area under the curve is 1. The triangular distribution is typically used when there is little underlying data and is well suited for judgmental data estimates. In this case, the mode was represented by the MCDA ratings assigned during the Expert Panel workshops. The minimum and maximum were based on confidence levels ascribed to the ratings by City staff that participated in the Expert Panel workshops.

City staff assigned confidence levels ranging from 1 to 3 to all pollution source ratings. A confidence level of 1 represented a low level of confidence and a confidence level of 3 represented a high level confidence. These levels were based on the City's understanding of local pollution sources and environmental impacts coupled with the rationale used by the Expert Panel to set impact ratings. Using these confidence levels, minimum and maximum ratings adjusted anywhere from plus or minus 1/3 (high confidence) to 1 (low confidence). However, in no case were ratings set above 3 or below 0.

Having defined the minimum, maximum and mode, random x values that follow a triangular distribution were generated as part of a Monte Carlo simulation. Using this approach, boxplots were developed to provide a graphic depiction of the estimated range of uncertainty associated with the MCDA scores. The level of overlap between the interquartile range, as represented by the difference between the 25th and 75th percentile, was used as general guidance to visually assess whether differences exist between the MCDA scores. Where the median value of any one box overlapped with the interquartile range of another, the assumption was held that no difference in scores could be claimed.

9.1. Estimated Range of Pollution Source Scores

Boxplots of MCDA scores by pollution source demonstrate some uncertainty, but do not significantly alter findings presented in the Results section. This analysis suggests pollution sources categorized in the Results Section as either high, medium, or low priority are different from pollution sources in other categories. These differences appear likely as no interquartile range from one group intersects with that in another (Figure 4).

While the high, medium, and low priority categories of pollutant sources appear different from each other, differences within these categories are less clear. Within the high priority category, agriculture appears to rank highest followed by urban runoff and stationary sources. However, there does not appear to be any clear difference in scores between the mobile and sanitary sewer exfiltration sources of air and water pollution, respectively. Within the medium priority category, all sources appear to have different scores with the exception of industrial runoff and improper disposal & dumping. Within the low priority category, there is little to no distinction in scores between land disturbance runoff, legacy contaminated sites, and sanitary sewer overflows.

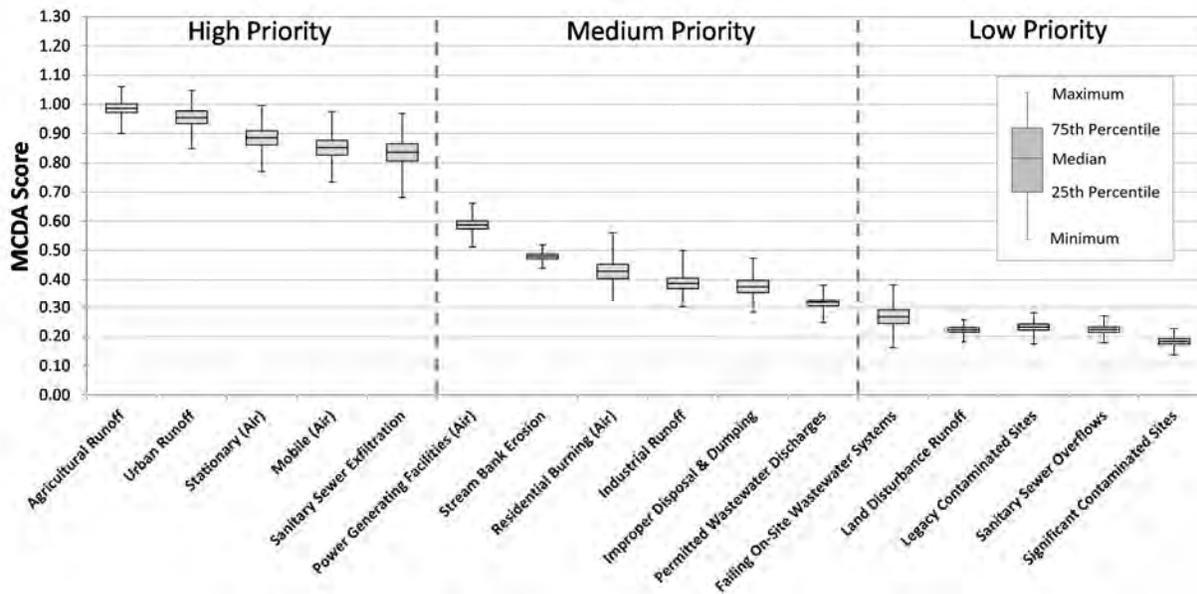


Figure 4. Estimated Range of Uncertainty for MCDA Pollution Source Scores. (Based on randomly generated values that follow a triangular distribution.)

9.2. Estimated Range of Pollution Indicator Impacts

MCDA scores were aggregated at the pollution indicator level to allow for a relative comparison of their impacts to all community priorities. The comparisons were made based on boxplots developed from a Monte Carlo simulation using the triangular distribution described above. Based on an approximate visual grouping, the most impactful indicators include pathogens, phosphorus and ozone (Figure 7). MCDA scores for all three of these indicators fall above and outside the range of all other indicators. Of these three indicators, pathogens has the highest score, followed by phosphorus and ozone. There does not appear to be any difference in scores between phosphorus and ozone due to the overlapping boxplots.

After pathogens, phosphorus and ozone, the six most impactful indicators in descending order of score are PM_{2.5}, toxic organics, CO₂, trash, flow regime, and HAPs. Indicators within this group appear to have statistically different scores based on the separation between the interquartile ranges. There is little separation in scores for the four subsequent indicators, which include physical habitat, mercury, sediment & turbidity, and water column toxics. On the low end, the five least impactful indicators in descending order of score include contaminated sediment, total nitrogen, CH₄, N₂O, and fluorinated gases.

In general, indicators with higher levels of impact had a wider distribution of scores suggestive of greater uncertainty (Figure 5). However, this pattern can largely be explained by the indicator weight, which corresponds with the magnitude and span of the scores. As the weight of an indicator increases, so does its score and the span of its boxplot. Therefore, a boxplot that spans a wider range of MCDA scores does not necessarily reflect any less confidence or understanding of the data than one that spans a tighter range. However, a high scoring indicator with a wide spanning boxplot does underscore the need for better characterization and understanding of that indicator. Based on findings presented in Figure 7, efforts to reduce uncertainty should be focused on pathogens, total phosphorus and ozone.

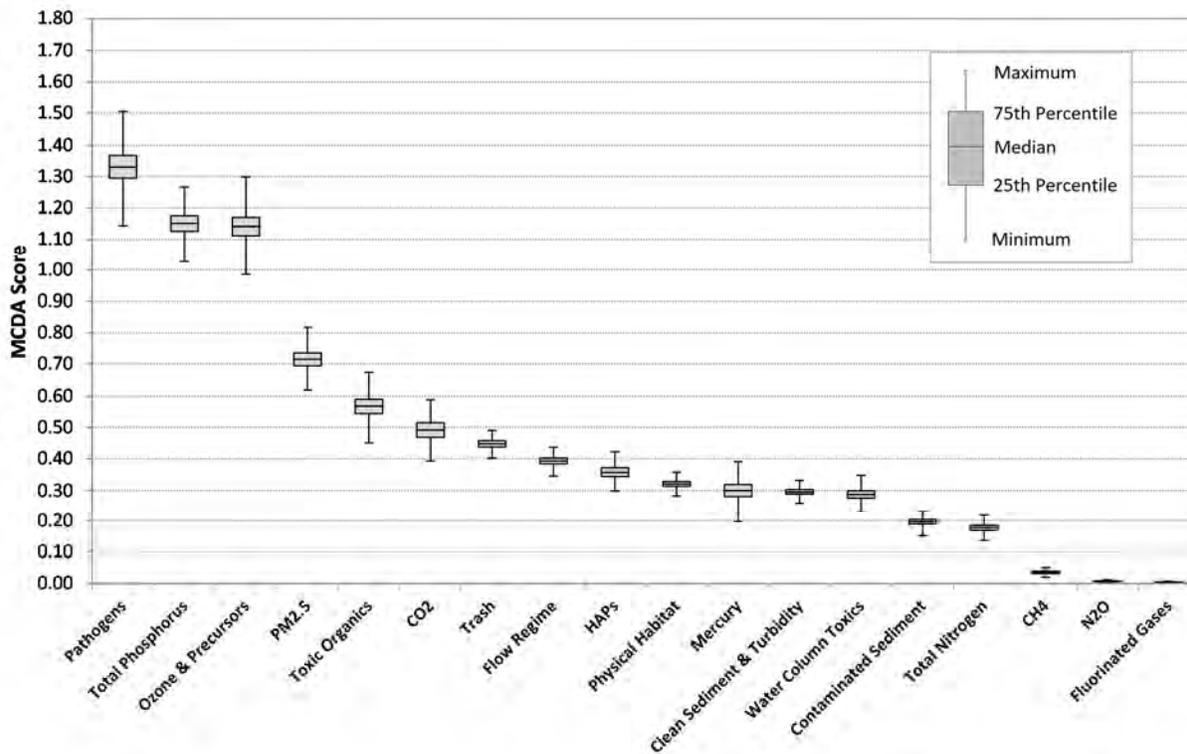


Figure 5. Estimated Range of Uncertainty for MCDA Pollution Indicator Scores. (Based on randomly generated values that follow a triangular distribution.)

10. Data Gaps

The MCDA is a data driven process that relies on the judgment of technical experts and those most knowledgeable of local pollution issues. However, it is inherent to the MCDA process that some decisions are made without a complete understanding of an issue. Where information was identified as lacking during the Expert Panel workshops, it was noted as a data gap. The intent of identifying data gaps was to help refine the MCDA process during future iterations. Data gaps identified during the workshops are summarized below.

1. **Nitrate and Bacteria Well Data** – Private wells are a significant source of drinking water outside Springfield City limits, but relatively little is known about well water quality. The Springfield-Greene County Health Department offers private well testing at the request of homeowners for a fee, but this information was not explicitly compiled as part of the MCDA process. However, as part of a limited review, Greene County determined there is relatively little nitrate data available for private wells. In 2016, just 56 of 3,700 wells with water testing were evaluated for nitrate. One of the 56 samples exceeded the nitrate limit of 10 mg/L at 17 mg/L, but further testing would be needed to track these results back to a source or determine if this outlier may have been due to laboratory error. Additional evaluation of the Health Department well data is also needed to assess whether there are drinking water issues associated with pathogens. Information on water table elevation is also important as it may correlate with pollutant concentrations. Given the importance of private wells as a drinking water source, this is considered a high priority data gap.

2. **Toxic Organic Impacts on Drinking Water Supplies** – Fulbright Spring represents an important source of drinking water for the City of Springfield and there is currently no evidence to suggest it is contaminated by toxic organics. However, the potential for contaminated legacy sites to impact Fulbright Spring at some point in the future remains unclear. Several legacy sites might be hydrologically connected to the Fulbright Spring, but further study is needed to characterize such connections. This is considered a high priority data gap.
3. **Monitoring for Exfiltration** – Flow studies suggest that the City of Springfield is losing a significant volume of sewage to exfiltration, which occurs from open joints and other sewer leaks. This suggests that exfiltration may represent a significant source of pathogens and nutrients to area streams and groundwater. However, additional monitoring is needed to better characterize the location and extent of exfiltration. Due to the potential severity of the source, this is considered a high priority data gap.
4. **Cryptosporidium and Giardia Data** – Cryptosporidium and Giardia are parasitic protozoans associated with water that cause intestinal illnesses and are relatively difficult to disinfect. Transmission of these parasites occurs when water has been contaminated with fecal matter of an animal or human that is infected with the parasite. City Utilities of Springfield (CU) has been collecting Cryptosporidium and Giardia data near the intake for the Blackman Water Treatment Plant. However, the Cryptosporidium and Giardia data compiled for purposes of the MCDA were relatively limited. CU should continue to collect additional Cryptosporidium and Giardia data to provide for a more thorough analysis. Given the potential risks associated with these pathogens, this is considered a high priority data gap.
5. **Continuous Dissolved Oxygen Data** – Characterizing dissolved oxygen (DO) is essential to understanding the health of a waterbody. The diurnal pattern of DO concentration, which increases during daylight hours in response to photosynthesis and decreases at night when photosynthesis ceases, is controlled by nutrients and algal growth. Excessive levels of nutrients and algal growth can result in large DO swings, which can be detrimental to aquatic life if DO levels go too low. Because DO fluctuates throughout the day, continuous DO data are necessary to fully characterize its patterns. DO data compiled for the MCDA are largely discrete providing little information about whether or not DO issues exist. Therefore, the lack of continuous DO data is considered a medium priority data gap.
6. **Farm Fertilizer Application Rates** – Farm fertilizer runoff potentially represents a significant source of nutrient loading in a watershed; however, little information is currently known about application rates and implementation of agricultural BMPs in the MCDA study area. The USGS SPARROW model suggests that nutrient loading from farm fertilizer is high relative to other nutrient sources including livestock manure, but this is unlikely as there is little row crop farming in the study area. Additional research is needed to determine how much fertilizer is applied to agricultural sites in the MCDA study area and whether this represents a significant source of nutrients. Additionally, information about whether this fertilizer is applied in accordance with agricultural BMPs is also important. For example, fertilizer applied at agronomically appropriate rates using appropriate methods would have less significant water quality implications than inappropriately applied fertilizer. Given the relative importance of nutrients to the health of aquatic life, this is considered a medium priority.

7. **Pathogens from Industrial Sites** – Existing data suggests that runoff from industrial sites is contributing to elevated bacteria levels in Springfield area streams. However, bacteria runoff from industrial sites is typically associated with animal droppings, which vary in terms of risk to human health. Bacteria originating from birds likely represents a lower level of risk with respect to human health than bacteria originating from rats and rodents. Additional study is needed to determine what pathogens are coming off of industrial sites and what level of risk they present for human health. This is considered a low priority data gap.
8. **Aquatic Life Pathogens** – The Expert Panel decided that aquatic life pathogens should be evaluated separately in terms of impacts on human health from fish consumption and impacts on aquatic life. However, it is currently unclear how to evaluate pathogens associated with these impacts. Therefore, it was determined that consultation with the Missouri Department of Conservation (MDC) and a literature search is necessary to better understand pathogen impacts on human health from fish consumption and on the health of aquatic life. The additional research is needed determine what types of pathogens impact fish health or create risks from fish consumption. It is also currently unclear where such pathogens come from and whether or not they represent a genuine threat. The lack of information on aquatic life pathogens is considered a low priority data gap.
9. **Nitrogen's Role in Algal Blooms** – Questions were raised during the Expert Panel workshop about nitrogen's role in controlling algal blooms in drinking water sources. One of the primary concerns about excessive nutrients is the risk of creating an algal bloom, which can result in fish kills and release of algal toxins. However, the relationship between nutrient levels and algal blooms is complex. Questions were raised during the Expert Panel workshop about nitrogen's role in controlling algal blooms in drinking water sources. Previous studies suggest local waterbodies are likely phosphorus limited, meaning nitrogen does not likely control algal productivity that may lead to blooms. Further study is needed to help characterize nitrogen's role, but this is considered a low priority data gap, based on existing studies showing phosphorus as the limiting nutrient.
10. **Links between Air and Water** – Air pollution sources can impact both air and water quality. For example, mercury and other hazardous air emissions may eventually settle to the ground as dust or be captured in rain and snow. However, contaminants from air pollutants found in waterbodies are typically of distant origin. The impacts of local air sources on local waterbodies, although likely insignificant, are not known. Therefore, links between air pollution sources and water quality were not developed for this MCDA. Understanding such links between air pollution sources and water quality would require further study. These linkages are considered a low priority data gap.

11. Summary

Phase III of the IP for City, County and CU consists of four key elements: 1) capturing the community priorities, 2) identifying and prioritizing the most significant sources of pollution, 3) identifying and prioritizing the most effective solutions, and 4) assessing the community's financial capability. Community priorities were previously captured through a series of Task Force meetings and a community survey. The purpose of this report was to address the second element by quantitatively linking those community priorities to various pollution sources.

Four tasks deemed essential to this IP include database development, MCDA development, data gap analysis, and data collection and analysis. Each task builds upon the previous such that the database informs the MCDA, which in turn informs the data gap analysis resulting in additional data collection. This process is intended to be iterative and periodically refined as new or additional information becomes available (Figure 6).

Under Task I, a comprehensive database was developed to compile environmental data from a multitude of different sources for the seven different Task Force watersheds. These watersheds included the Sac River, Little Sac River, Pomme de Terre, Fellows & McDaniel Lake, Wilsons Creek, Middle James River, and Upper James River. This information was used to help characterize environmental conditions associated with a number of different pollution indicators.



Figure 6. MCDA Task Diagram

As part of Task II, the HDR Team finalized development of an MCDA over the course of two separate Expert Panel workshops. These workshops combined the expertise of national experts in elements of water and air with those most knowledgeable of local pollution sources. Through consensus based decision-making, the structure of the MCDA was finalized and weights and ratings were assigned. From this effort, scores were calculated for each of 16 different pollution sources representing air, land and water. Based on the final scores, sources were ranked as high, medium or low priority as follows (scores are noted in parentheses):

High Priority Sources

- Agricultural Runoff (1.03)
- Urban Runoff (0.97)
- Stationary – Air (0.93)
- Sanitary Sewer Exfiltration (0.90)
- Mobile – Air (0.89)

Medium Priority Sources

- Power Generating Facilities - Air (0.60)
- Stream Bank Erosion (0.51)
- Residential Burning - Air (0.43)
- Industrial Dumping (0.39)
- Improper Disposal & Dumping (0.38)
- Permitted Wastewater Discharges (0.32)

Low Priority Sources

- Failing On-Site Wastewater Systems (0.27)
- Legacy Contaminated Sites (0.24)
- Land Disturbance Runoff (0.23)
- Sanitary Sewer Overflows (0.22)
- Significant Contaminated Sites (0.19)

These results represent the first iteration of the MCDA and may be refined as data gaps are addressed. Some of the more significant data gaps identified during the Expert Panel workshops include lack of knowledge concerning nitrates and bacteria in private drinking water wells, toxic organic impacts on drinking water supplies, the extent of exfiltration, and data on Cryptosporidium and Giardia upstream of drinking water intakes. These data gaps are considered significant because they are linked to clean drinking water, which was identified as the number one community priority.

The results of this MCDA analysis are intended to help identify solutions that address the most pressing environmental problems that matter most to the community. By prioritizing pollution sources, the MCDA helps inform the next step of the IP, which is the SROI approach. Although data gaps exist, results of an uncertainty analysis suggest the general order of the pollution source rankings is valid. Therefore, additional data may only have minimal impacts on the existing results. However, results could significantly change during future iterations if it determined that community priorities have shifted.

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