Methodology for Iowa's 2022 Water Quality Assessment, Listing, and Reporting Pursuant to Sections 305(b) and 303(d) of the Federal Clean Water Act

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Table 1: 2022 Integrated Report Cycle's "new data" consideration period:

Data Type	Data Timeframe
Beach Sampling Data	CY 2018-2020
River and Stream Water Quality Data	CY 2018-2020
Biological Sampling Data	CY 2016-2020*
Fish Kill Data	CY 2016-2020
Fish Tissue Sampling Data	CY 2016-2020
Lake Water Quality Data	CY 2016-2020
Continuous Dissolved Oxygen Sampling Data	CY 2016-2020
*Biological sites with 2015 and 2019 data were also assessed.	

Table 2: List of acronyms and abbreviations used in this document.

Acronym or Abbreviation	Definition
ADBNet	Iowa DNR's Assessment Database
AQuIA	Iowa DNR's online water quality database
BIT	Biological Impairment Threshold
BMIBI	Benthic Macroinvertebrate Index of Biotic Integrity
CALM	EPA's Consolidated Assessment and Listing Methodology
CBI	Coldwater Benthic Index
CFR	Code of Federal Register
CW	Coldwater
CWA	Clean Water Act
DDE	Dichlorodiphenyldichloroethylene
DNR	Iowa Department of Natural Resources
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EMP	Environmental Management Program of the United States Army Corps of Engineers
EPA	United States Environmental Protection Agency
FIBI	Fish Index of Biotic Integrity
FK	Fish kill
FKF	Fish kill Follow-up
FLMA	Filamentous Algae Coverage
FS	Fully Supported
FT	Fish Tissue
HH	Human Health
Geomean	Geometric Mean
IAC	Iowa Administrative Code
IDPH	Iowa Department of Public Health
IFTMP	Iowa Fish Tissue Monitoring Program
IR	Integrated Report

ISU	Iowa State University
LTRMP	Long-Term Resource Monitoring Program
MCL	Maximum Contaminant Level
mg/L	Milligrams per Liter
µg/L	Micrograms per Liter
NA	Not Applicable
NASQAN	National Stream Quality Accounting Network
NAWQA	National Water Quality Assessment Program
NIA	Nutrient Impact Assessment
NS	Not Supported
OIW	Outstanding Iowa Waters
ONRW	Outstanding National Resource Waters
PCB(s)	Polychlorinated Biphenyls
REMAP	Regional Environmental Monitoring and Assessment Program
RTAG	Region 7 Technical Assistance Group
SAV	Submersed Aquatic Vegetation
SDWA	Safe Drinking Water Act
SHL	State Hygienic Laboratory of Iowa
SSM	Single Sample Maximum
SR	Species Richness
SWC	Iowa's Surface Water Classification Document
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index (Carlson 1977)
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
UAV	Uncertainty Adjustment Value
UMR	Upper Mississippi River
UMRBA	Upper Mississippi River Basin Association
UMRCC	Upper Mississippi River Conservation Committee
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
Vision	2013 303(d) Vision
WINOFI	Waters In Need Of Further Investigation
WQS	Water Quality Standards
WQ	Water Quality
WQMAS	Iowa DNR's Water Quality Monitoring and Assessment Section
WW	Warmwater

Introduction

Iowa's 2022 assessment and listing methodology incorporates recommendations in United States Environmental Protection Agency's (EPA) historical [305(b)/303(d)/Integrated Reporting] guidance as well as the current guidance for the 2022 assessment, listing, and reporting requirements pursuant to Sections 303(d) and 305(b) of the federal Clean Water Act (EPA 2021). EPA guidance establishes the formats for an "integrated report" (IR) that satisfies the listing requirements of Section 303(d) and the reporting requirements of Sections 305(b) and 314 of the Clean Water Act (CWA). The current EPA 2022 guidance replaces all previous guidance pertaining to Sections 305(b) and 303(d) except EPA's Consolidated Assessment and Listing Methodology (CALM) (EPA 2002). Due to the continued lack of details regarding the mechanics of CWA-related water quality assessment in more recent EPA guidance (e.g., EPA 2002), the Iowa Department of Natural Resources (Iowa DNR) continues to use assessment methods described and recommended in previous EPA guidance for Section 305(b) reporting (EPA 1997). DNR uses the 1997 guidance only in cases where EPA's more recent guidance is inadequate. DNR's 2022 methodology generally meets the requirements of CWA, Section 303(d)(1)(a) and 40 CFR Section 130.24 and incorporates requirements of Iowa's credible data law (2001 Iowa Code, Section 455B.194, subsection 1). The changes in methodology between the 2020 and 2022 listing cycles are summarized in section "Changes in methodology since the 2020 reporting/listing cycle" and are explained throughout this document.

Overview of the assessment and listing process

The process of assessing water quality and adding waterbodies to the state list of "impaired" waters involves three interrelated program areas of the federal CWA: (1) establishment of state water quality standards (WQS) that identify beneficial uses for the state's waterbodies and that identify criteria to determine whether each use is being achieved, (2) development of water quality assessments by comparing water quality information to water quality criteria and internal thresholds to determine whether or not beneficial uses are being achieved, and (3) addition of the appropriate waters assessed as "not fully supported" of the beneficial uses (i.e., "impaired") to the state's Section 303(d) list. The state's 303(d) list is thus a public accounting of all assessed waterbody segments determined to be impaired where a total maximum daily load (TMDL) needs to be developed. Any waterbody segment placed on the 303(d) list has been assessed as not fully meeting one or more WQS including designated uses (e.g., for primary contact recreation, aquatic life, as a source of drinking water for a public water supply, and/or for fish consumption). The failure to fully meet state WQS can result from the following: violations of numeric criteria, violations of narrative criteria, failure to meet antidegradation requirements as defined in EPA's regulations regarding violations of WQS (40 CFR 131), and/or a determination that a specific designated use cannot be achieved. The violations of WQS might be due to an individual pollutant, multiple pollutants, or an unknown cause of impairment. As provided in EPA's guidance for integrated reporting, other waterbody segments may be assessed as impaired but not included on the 303(d) list. These segments will be included in Category 4 of the IR. Category 4 of the IR includes three types of impaired waterbody segments that do not require development of a TMDL: (1) segments for which a TMDL has been completed but WQS have not yet been attained (IR Category 4a); (2) segments where other required control measures are expected to result in attainment of WQS in a reasonable period of time (IR Category 4b); and (3) the impairment or threat is not caused by a "pollutant" as defined by EPA (IR Category 4c). In addition, Iowa waters assessed as impaired by pollutant-caused fish kills are placed in IR Category 4d if the DNR fish kill investigation identified the responsible party for the kill and monetary restitution for the value of the fish killed and cost of investigation has been received.

The Iowa Water Quality Standards

According to EPA, a water quality standard is composed of three components: (1) a description of beneficial use, (2) water quality criteria to protect this use, and (3) an antidegradation policy that ensures protection of water quality where water quality exceeds levels necessary to protect fish and wildlife propagation and recreation in and on the water. Thus, the basis for a state's Section 305(b) assessments and Section 303(d) list of impaired waters is ultimately the state's WQS. That is, the state WQS contain the benchmarks (criteria) to which water quality data are compared to determine the degree to which beneficial uses are supported. The versions of the Iowa WQS, with the effective date of June 16, 2021, and the accompanying Iowa Surface Water Classification (SWC), with the effective date of July 24, 2019, were used as the basis for water quality assessments prepared for this 2022 assessment and listing cycle. This version of the *Standards* was the most recent EPA-approved version available during the period of time assessments were completed. These versions of the standards and surface water classification are available upon request from DNR's Water Quality Monitoring & Assessment Section (WQMAS).

The Total Maximum Daily Load (TMDL)

The WQMAS of the DNR's Water Quality Bureau (WQB) conducts water quality assessments as required by Clean Water Act Section 305(b). Based on these assessments, WQMAS staff identifies waterbody segments in the state of Iowa that may require a TMDL to address the causes and sources of pollutants contributing to impairment of a designated use or other applicable beneficial use. These segments are placed into Category 5 of Iowa's IR. The segments in this category constitute Iowa's Section 303(d) list of impaired waters. Conceptually, a TMDL is the maximum pollutant load from point sources and nonpoint sources, plus a load allocated to a "margin of safety," that a waterbody can receive and continue to meet WQS. The margin of safety accounts for the lack of understanding of the relationship between pollutant loads and water quality and can provide for potential future growth.

Deadlines

According to recent EPA memos, the Section 303(d) list of impaired waterbody segments must be submitted to EPA by April 1 of every even numbered year. Thus, this methodology was designed to meet the deadline for submission of the list to be submitted to EPA in April 2022.

The "Integrated Report"

Based on previous guidance from the EPA (e.g., EPA 1997), most states, including Iowa, had historically produced separate Section 305(b) reports and Section 303(d) lists. Section 305(b) reports have attempted to characterize water quality statewide and thus identified not only designated use impairments but also water quality concerns that are worthy of note and further investigation but do not constitute Section 303(d)-type water quality impairments. The 303(d) lists, on the other hand, have represented the subset of waterbody segments assessed for Section 305(b) reporting with known and reasonably verifiable impairments of a designated use or general use as defined in the Iowa WQS that are appropriate for Section 303(d) listing. Based on development of revised guidance by the EPA (2003), however, an IR was prepared for Iowa's 2004 cycle that incorporated elements of both the Section 305(b) report and Section 303(d) list. Based on updated guidance from EPA (2005, 2015), DNR has continued to use the integrated reporting format.

In their guidance for the integrated assessment, reporting, and listing cycles, EPA recommends that reporting requirements of Sections 305(b) and 303(d) be "integrated" into a report that contains five assessment categories and associated subcategories:

- Category 1: All designated uses are met.
- Category 2: Some of the designated uses are met but there is insufficient data to determine if remaining designated uses are met.
- Category 3: Insufficient data exist to determine whether any designated uses are met.
- Category 4: Water is impaired or threatened but a TMDL is not needed because one of the following occur:
  4a: A TMDL has been completed;
  4b: Other required control measures are expected to result in attainment of WQS in a reasonable period of time;
  4c: The impairment or threat is not caused by a "pollutant."
- Category 5: Water is impaired or threatened and a TMDL is needed [IR Category 5 is the state's Section 303(d) list].

The five categories of EPA's integrated reporting and listing format used for Iowa's integrated reports since the 2004 reporting cycle are further explained below and are summarized in Table 5. In the descriptions below, the text in italics is taken from EPA's 2005 guidance for integrated reporting. The notes that follow these excerpts contain DNR's interpretations and modifications of EPA's guidance.

Category 1 waterbodies: *Segments belong in Category 1 if they are attaining all designated uses and no use is threatened. Segments should be listed in this category if there are data and information that are consistent with the State's methodology and this guidance, and support a determination that all applicable WQS are attained and no designated use is threatened.*

DNR has made no modifications to the definition or intent of IR Category 1.

Category 2 waterbodies: *Segments should be placed in Category 2 if there are data and information that meet the requirements of the State's assessment and listing methodology that support a determination that some, but not all, designated uses are attained and none are threatened. Attainment status of the remaining designated uses is unknown because data are insufficient to categorize a segment consistent with the State's listing methodology.*

DNR has made no modifications to the definition or intent of IR Category 2.

Category 3 waterbodies: *Segments belong in Category 3 if there are insufficient or no data and information to determine, consistent with the State's listing methodology, if any designated use is attained. To assess the attainment status of these segments, the State should schedule monitoring on a priority basis to obtain data and should also make efforts to obtain information necessary to move these waters into Categories 1, 2, 4, and 5.*

DNR has made the following modifications to IR Category 3: the renaming of EPA Category 3 to Category 3a and the additions of Category 3b and Subcategories 3b-c and 3b-u.

Category 3a: Insufficient data exist to determine whether any uses are met; no uses are assessed [either "evaluated" or "monitored"]. This wording is consistent with the EPA's definition of IR Category 3.

Category 3b: At least one use is assessed as potentially impaired based on an "evaluated" assessment. This subcategory allows tracking of the "impaired/evaluated" waterbody segments. Waters placed into subcategory 3b are added to Iowa's list of "waters in need of further investigation" (WINOFI). However, waters in subcategory 3b are considered "not assessed" for purposes of Integrated Reporting.

Category 3b-c [calibrated]: the aquatic life use of a stream segment within the calibrated range of the biological assessment protocol has been assessed as potentially impaired;

Category 3b-u [un-calibrated]: the aquatic life use of a stream segment with a watershed size outside the calibrated range of the biological assessment protocol has been assessed as potentially impaired.

Category 4 waterbodies: *Water segments belong in Category 4 if one or more designated uses are impaired or threatened but establishment of a TMDL is not required. States may place an impaired or threatened water segment that does not require a TMDL in one of the following three subcategories:*

- Category 4a: a TMDL has been completed for the water-pollutant combination. Segments should only be placed in Category 4a when all TMDLs needed to result in attainment of all applicable WQS have been approved or established by EPA. Current regulations do not require TMDLs for all segments.

- Category 4b: other required control measures are expected to result in the attainment of WQSs in a reasonable period of time. Some segments may be excluded from Category 5, and placed into Category 4b. In order to meet the requirements to place these waters into Category 4b, the State must demonstrate that "other pollution control requirements (e.g., best management practices) required by local, State or Federal authority" (see 40 CFR 130.7(b)(1)(iii)) are expected to address all water-pollutant combinations and attain all WQS in a reasonable period of time. The EPA expects that states will provide adequate documentation that the required control mechanisms will address all major pollutant sources and establish a clear link between the control mechanisms and WQS.

- Category 4c: the impairment or threat is not caused by a pollutant. Segments should be listed in Category 4c when an impairment is not caused by a pollutant. "Pollution," as defined by the CWA, is the "man-made or man-induced alteration of the chemical, physical, biological and radiological integrity of water." In some cases, the pollution is caused by the presence of a pollutant and a TMDL is required. In other cases, pollution does not result from a pollutant and a TMDL is not required. An example of a pollutant stressor would be copper; an example of a non-pollutant stressor ("pollution") would be "low flow."

DNR made no modifications to the definitions or intents of IR Categories 4a, 4b, or 4c. DNR did, however, make the following modification to IR Category 4: the addition of Category 4d.

Category 4d: Segment is impaired due to a pollutant-caused fish kill and enforcement actions were taken against the party responsible for the kill: a TMDL is neither appropriate nor needed. For purposes of Section 305(b) assessments in Iowa, all segments affected by a fish kill caused by a known pollutant or a suspected pollutant are assessed as impaired. Those kills where a pollutant cause was identified are placed into either Category 4d (responsible party identified and enforcement action taken: TMDL not required) or Category 5 (no responsible party identified; enforcement action not taken: a pollutant problem may remain and a TMDL is potentially needed).

Category 5 waterbodies: *This category constitutes the Section 303(d) list that EPA will approve or disapprove under the CWA. Segments should be placed in Category 5 when it is determined, in accordance with the State's assessment and listing methodology that a pollutant has caused, is suspected of causing, or is projected to cause an impairment or threat. If that impairment or threat is due to a pollutant, the water should be placed in Category 5 and the pollutant causing the impairment identified.*

DNR made the following modifications to IR Category 5: the renaming of EPA's Category 5 to Category 5a and the addition of categories 5b (and subcategories 5bt and 5bv) and 5p.

Category 5a: Segment is impaired or threatened by a pollutant stressor and a TMDL is needed. This wording is consistent with the EPA's definition of IR Category 5.

Category 5b: Impairment is based on results of biological sampling or a fish kill investigation where specific causes and/or sources of the impairment have not yet been identified. The biological assessment adequately demonstrates that an impairment exists, but either the cause or the source of the impairment is unknown. The primary use of this subcategory is for biologically-based impairments with the cause listed as "unknown" and for fish kill-based impairments where a pollutant cause was identified but no source was found. Additional sampling/investigation, such as that conducted as part of DNR's stressor identification procedure, is needed to determine causes or sources before the TMDL can be developed.

As part of revisions to its biological assessment protocol for the 2010 Integrated Reporting cycle, DNR added the following subcategories to IR Subcategory 5b to improve DNR's ability to track the impairment status of streams and river segments and to better target follow-up monitoring where both biological impairments and potential delistings have been identified.

5bt [tentative]: The aquatic life use of a stream segment with a watershed size within the calibration range of the DNR biological assessment protocol (~10 to 500 square miles) is assessed as Section 303(d)-impaired based on an evaluated assessment. The reasons for residency in this subcategory include: 1) data quantity (only one of the two biological samples needed to identify an impairment have been collected), 2) data age (data older than five years), 3) data quality (marginal sampling conditions for biota), and 4) sampling frequency (multiple samples collected in same year, not multiple years).

5bv [verified]: The aquatic life use of a stream segment with a watershed size within the calibration range of DNR biological assessment protocol (~10 to 500 square miles) is assessed as Section 303(d)-impaired based on results of the required two or more biological sampling events in multiple years within the previous five years needed to confirm the existence of a biological impairment.

Category 5p: Impairment occurs on a segment presumptively designated for Class A1 primary contact recreation use or Class BWW1 aquatic life use. Due to changes in the Iowa WQS that became effective in March 2006, all perennially-flowing streams and intermittent streams with perennial pools are presumed to be capable of supporting the highest level of primary contact recreation use (Class A1) and the highest level of aquatic life use (Class BWW1). These changes to the Iowa WQS were approved by the EPA in February 2008. Under this approach to stream classification, the Class A1 (primary contact recreation) use is presumptively applied to all of Iowa's perennial rivers and streams and to intermittent streams with perennial pools, and the Class BWW1 aquatic life use is similarly applied to all of Iowa's perennial rivers and streams and intermittent streams with perennial pools unless the water is already designated for Class BWW2 or Class BWW3 uses in SWC. A "use attainability analysis" (UAA) must be conducted, including field investigations, to determine whether a presumptively-applied use is, in fact, the appropriate designated use for the stream segment in question. Until the time when a UAA has been conducted and the appropriate designated uses have been applied and approved by EPA, any impairments on presumptively-designated Iowa streams will be placed in IR Category 5p. Note: The upstream and downstream boundaries for most stream/river segments in Iowa's IR assessment database (ADBNet) are not consistent with results of DNR-proposed and EPA-approved changes in designated uses based on results of the UAA process as reflected in SWC.

According to EPA's 2005 guidance, the Section 303(d) list is composed of segments included in IR Category 5 of the Integrated Report which includes those segments for which a TMDL needs to be developed. This list includes segments impaired by "pollutants" such as ammonia and indicator bacteria. The source of impairment might be from point sources, nonpoint sources, groundwater, or atmospheric deposition. Some sources of impairment of Iowa segments originate outside of the state. Historically, Iowa has listed impaired segments regardless of whether the source of pollutant is known and regardless of whether the pollutant source(s) can be legally controlled or acted upon by the State of Iowa. This methodology is consistent with that history.

As specified in Iowa's credible data law (2001 Iowa Code, Section 455B.194, subsection 1), segments where the assessment indicates a potential impairment, but where sufficient and credible data are lacking, will not be included on the state's 303(d) list (IR Category 5). According to this methodology, these segments will be included in IR subcategory 3b and placed on the WINOFI list as provided for by Iowa's credible data legislation.

Changes in methodology since the 2020 reporting/listing cycle

- DNR removed the "partially supported" (PS) support level from the assessments, IR methodology, and ADBNet, and added the "WINOFI" support level. For monitored assessments, there are only two outcomes for the assessment: "fully supported" (FS) and "not supported" (NS). For evaluated assessments, there are only two outcomes for the assessment: "fully supported" (FS) and "WINOFI."

- DNR assessed the recreational use (A1, A2, or A3) of all segments by calculating annual geometric means (geomeans) and annual single sample maximum (SSM) violations for indicator bacteria (*E. coli*) and comparing those values to the respective criteria. See Table 12 for more information. In previous assessment cycles, SSM violations were assessed over the combined three year assessment period.

- Based on conversations with EPA Region 7, DNR changed the fish kill methodology to require two fish kills in a five-year period for a segment to be considered "impaired" (Category 5b). Segments with a single fish kill in a five-year period are assessed as "WINOFI" (Category 3b). For the 2022 IR cycle, the new fish kill assessment methodology applied to fish kills from 2016 through 2020. No historic fish kill assessments were modified based on the new fish kill methodology.

- The magnitude of impairment is now captured in ADBNet using "Slight", "Moderate", and "High." This capability in ADBNet has been in place since the 2016 assessment cycle; however, methodology primarily used the "partially supported" and "not supported" assessment levels to indicate the magnitude of impairment. With the removal of "partially supported" from the assessment methodology and ADBnet, this update was required.

- DNR used pH data, where available, to assess all segments with the Class C designated use.

The Assessment and Listing Process

Preparation of Iowa's integrated report includes the following basic steps:

- Assemble all existing and readily available water quality-related data;
- Identify water quality-related data and information of sufficient quality and quantity for purposes of developing scientifically defensible water quality assessments;

- Compare these water quality-related data and information to state WQS to determine the degree to which assessed segments meet these standards;
- Identify Section 303(d) impairments that are based on water quality-related data and information that meet the state's requirements for data quantity and data quality (Table 8);
- Place all segments into one of the five categories specified in EPA's IR guidance (2003, 2005) for water quality assessment and listing;
- Prepare the state list of segments in need of further investigation;
- Prioritize the waterbody segments on the draft Section 303(d) list (Category 5) for TMDL development;
- Provide the draft integrated report, including the draft Section 303(d) list (Category 5), to the public for review and comment;
- Revise and finalize the integrated report based on new information and public input;
- Submit the final integrated report, including the Section 303(d) list, to EPA for approval/disapproval;
- Develop a schedule for development of TMDLs for Section 303(d)-listed (IR Category 5) waterbody segments;
- Upload integrated report into ATTAINS.

Sources of existing and readily available water quality-related data and information

As specified in EPA's current 1992 TMDL rule (40 CFR 130.7), sources of existing and readily available water quality-related data and information to be considered as part of Section 303(d) listing include, but are not limited to, the following:

- The state's most recent CWA Section 305(b) assessments;
- CWA Section 319 nonpoint source assessments;
- Dilution calculations, trend analyses, or predictive models for determining the physical, chemical, or biological integrity of streams, rivers, lakes, and estuaries;
- Water quality-related data and water-related information from local, State, Territorial, or Federal agencies (especially the United States Geological Survey's National Water Quality Assessment Program (NAWQA) and National Stream Quality Accounting Network (NASQAN)), Tribal governments, members of the public, and academic institutions.

Historically, the majority of information used by DNR to develop Iowa's Section 303(d) list of impaired segments has been taken from its Section 305(b) assessments. Data sources used to assess water quality conditions in Iowa for purposes of Section 305(b) assessment include, but are not limited to, the following:

- Physical, chemical, and biological data from ambient fixed station water quality monitoring networks conducted by DNR and other agencies (e.g., United States Geological Survey (USGS); United States Army Corps of Engineers (USACE));
- Data from water quality monitoring conducted by adjacent states on border rivers and waters flowing into or out of the state;
- Data from DNR's ambient biological monitoring program as conducted in cooperation with the State Hygienic Laboratory at the University of Iowa (SHL);
- Data from the ongoing DNR-sponsored statewide lake monitoring project conducted by Iowa State University or SHL;
- Data from monitoring of bacterial indicators in rivers and at beaches of publicly-owned lakes;
- Data from programs to monitor fish tissue for toxic contaminants;
- Reports of pollutant-caused fish kills;
- Data from public water supplies on the quality of raw and finished water;
- Drinking water-related source water assessments under Section 1453 of the Safe Drinking Water Act;
- Data from special studies of water quality and aquatic communities;
- Best professional judgment of DNR staff;
- Results of volunteer monitoring;
- Water-related information received from the public.

The cutoff date for the data collection period for Iowa's current IR is the end of the previous even-numbered calendar year (Table 1). This is a general guideline used by the DNR. A considerable amount of staff time is needed to summarize monitoring data from the various monitoring agencies, to compare the summarized results to WQS, to develop the waterbody-specific assessments of the degree to which designated uses are supported, and to solicit and respond to public comments on the draft Section 303(d) list. Also, water quality data generated by the various agencies are not available immediately following sample collection: a lag time from a few months up to a year or more is associated with obtaining results of water quality monitoring networks. Given these time requirements, and given the other work responsibilities of DNR staff that prepare Iowa's IR, the allowance of a 15-month window for report preparation prior to the April deadline is not excessive.

For purposes of developing stream/river water quality assessments for integrated reporting, three years of water quality data from streams and rivers are typically used for both conventional pollutant parameters (e.g., indicator bacteria) and the less frequently monitored toxic parameters (e.g., toxic metals). Since the 2004 IR cycle, DNR has used a three-year data gathering period (Table 1). For most assessments, the use of three years of data increases the number of samples upon which the decision on use support is based and helps address the problem of weather-related year-to-year fluctuations in water quality.

Due to the lower sampling frequency in Iowa's ambient lake monitoring programs, five years of data are used for developing Section 305(b) assessments and for identifying Section 303(d) listings for Iowa lakes (Table 1).

As specified in Iowa's credible data law, and based on the uncertainty inherent in using old data to characterize current water quality conditions, data between five and ten years old are used for Section 305(b) assessments but are not used for purposes of adding segments to Iowa's Section 303(d) list of impaired waters (i.e., Category 5 of the Integrated Report). Chemical/physical data older than five years are generally believed to be less reflective of current ambient water quality than are more recent data (EPA 1997, pages 1-5 and 1-9). However, nearly all recent water quality data from Iowa waters have already been used for Section 305(b) assessments and thus have already been considered for Section 303(d) listings. Also, a listed waterbody will not be removed from the state's Section 303(d) list simply because the data upon which the impairment was based have aged beyond five or ten years. Thus, the restrictions placed on use of old water quality data by Iowa's credible data law have little effect on impaired waters listings or delistings in Iowa.

The sources of water quality data used for water quality assessments and impaired waters listings in Iowa are discussed in more detail below.

- **Physical, chemical, and biological data from ambient fixed station water quality monitoring networks conducted in Iowa by the DNR and other agencies**
  The DNR, in cooperation with the SHL, has conducted statewide routine ambient monitoring of river water quality in Iowa since the early 1980s. Iowa rivers are now monitored monthly at approximately 60 sites for a variety of physical, chemical, and bacterial parameters through a contract with the SHL which provides both data collection and laboratory services. These sites are classified as ambient (background) sites and are distributed throughout every major river basin in an effort to provide good geographic coverage of the state. For more information on the DNR's ambient monitoring program see the following website: http://www.iowadnr.gov/Environment/WaterQuality/WaterMonitoring/MonitoringPrograms.aspx.

  Long-term ambient water-quality monitoring has also been conducted in Iowa by the following agencies: USACE, and water utilities such as the Des Moines Water Works, the Cedar Rapids Water Department, and the Rathbun Rural Water Association. The monitoring networks in Iowa conducted by agencies other than DNR are typically designed to answer questions specific to drinking water sources or to the effects of in-stream structures or large facilities on water quality (e.g., flood control reservoirs or power generating facilities). These networks provide a relatively long-term database that can be used to characterize water quality conditions.

  The USGS also conducts routine water quality monitoring in Iowa. Sampling results from USGS monitoring in Iowa are available at the following website: http://waterdata.usgs.gov/nwis/sw.

- **Data for Iowa tributaries of the Upper Mississippi River generated by the Long-Term Resource Monitoring Program**

Intensive water quality monitoring of Pool 13 of the Upper Mississippi River (UMR) and several Iowa tributaries is conducted by DNR staff at Bellevue, Iowa, as part of the Long-Term Resource Monitoring Program (LTRMP). The LTRMP was authorized under the Water Resources Development Act of 1986 as an element of the USACE "Environmental Management Program" (EMP) and is currently being implemented by the USGS in cooperation with the five UMR basin states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). State staff at six field stations in the UMR system conduct monitoring of fisheries and vegetation, as well as water quality on specified reaches of the river. Water quality monitoring by the LTRMP began in 1988 and continues. LTRMP stations with chemical data used for Section 305(b) water quality assessments and Section 303(d) listings in Iowa are summarized in Table 6. Data from this network are available from the Upper Midwest Environmental Sciences Center (see http://www.umesc.usgs.gov/data_library/water_quality/water_quality_data_page.html).

- **Data from water quality monitoring conducted by adjacent states on border rivers and waters flowing into the state**
  States adjacent to Iowa (South Dakota, Minnesota, Wisconsin, Illinois, Missouri, and Nebraska) also have fixed station ambient water quality monitoring programs that generate data useful for purposes of water quality assessments in Iowa. Data from these monitoring networks are available through the EPA's national water quality database "WQX" (https://www.epa.gov/waterdata/water-quality-data-wqx) or through personal contacts with water quality monitoring staff of environmental agencies in these states. These data are used with the guidelines described in this document to assess the degree to which the relevant Iowa WQS are being met. The lists of segments are summarized in Attachment 7. In addition, decisions on assessment and listing for interstate waters are coordinated to the extent possible with water quality staff from the adjacent states. For example, assessments and listings for the Iowa portion of the UMR are made in consultation with the states of Minnesota, Wisconsin, Illinois, and Missouri as part of ongoing interstate 305(b)/303(d) consultations through the Upper Mississippi River Basin Association's (UMRBA's) Water Quality Task Force (https://umrba.org/group/water-quality-task-force). UMRBA consultations and coordination or assessments and listings are based on a uniform set of assessment reaches for the UMR that was adopted by all five UMR states in 2004 (Table 7).

- **Data from ambient biological monitoring being conducted by the DNR in cooperation with the State Hygienic Lab**
  Biological criteria or "biocriteria" are narrative or numeric expressions that describe the best attainable biological integrity (reference condition) of aquatic communities inhabiting segments of a given designated aquatic life use. In order to develop biocriteria, knowledge of the variation in the ecological and biological conditions within a state is necessary. Ecoregions--generally defined as regions of relative homogeneity in ecological systems and relationships between organisms and their environments--have been used by several states when developing biocriteria for their WQS (see Figure 2-1 in Attachment 2). Biological reference sites are located on the least impacted streams within an ecoregion. Monitoring results from regional reference sites can thus serve as benchmarks to which other streams in the region can be compared.

  In Iowa, a list of wadeable warmwater (WW) candidate stream reference sites was generated in the early 1990s for the state's ten ecoregions and subecoregions. Sampling of these WW reference sites began in 1994 and continues; the current rate of sampling is 25 sites per year with the goal of sampling the complete set of reference sites every five years. A list of coldwater (CW) reference sites was developed in 2010 for the CW streams of the northeastern corner of Iowa; the current rate of sampling is four sites per year with the goal of sampling the complete set of reference sites every five years. See Attachment 2 for details on DNR's bioassessment methodology.

- **Data from the DNR-sponsored lake monitoring conducted by Iowa State University and the DNR's Water Quality Monitoring and Assessment Section**
  Historically, data from statewide surveys of Iowa lakes completed in the early 1980s and early 1990s by Iowa State University served as the basis for assessments of lake water quality in Iowa. The Ambient Lake Monitoring Program was developed in the year 2000 and has expanded over the years to incorporate more lakes into the program.

Each lake is sampled three times during the summer season to assess seasonal variability. Lakes are sampled at the lake's historic deep point. Lake depth profiles of temperature, dissolved oxygen, specific conductivity, total dissolved solids, pH, and turbidity are collected and used to determine if a lake is stratified (indicated by the presence of a thermocline) during each sampling event. Water chemistry and phytoplankton samples are collected using an upper mixed zone integrated water column sampler (sampled above the thermocline when present; maximum sampler depth of 2 meters or approximately 6.5 feet).

- **Data from monitoring of bacterial indicators in rivers and at beaches of publicly-owned lakes**
  Indicator bacteria, such as fecal coliform bacteria and *E. coli*, are commonly monitored by state environmental agencies to indicate the degree to which surface water segments support their primary contact recreation designated use. High levels of these indicator bacteria suggest that using a river or lake for either primary contact recreation (e.g., swimming or water skiing) or secondary contact recreation (e.g., wading while fishing) presents a health risk due to the potential for users contracting a waterborne disease.

  As part of fixed station monitoring networks in Iowa, river and stream reaches designated for primary or secondary contact recreation uses are monitored for bacterial indicators on a monthly basis.

  The DNR's WQMAS conducts the State Park Beach Monitoring program. Since 2001, annual monitoring of beaches at state-owned lakes has been conducted on a weekly basis from May through September.

  In addition, beaches at city and county-owned lakes were monitored for indicator bacteria during the same assessment period. The data from this monitoring is available in the DNR's water quality database AQuIA (https://programs.iowadnr.gov/aquia/). These data are evaluated to determine the degree to which the primary contact recreation (Class A1) use was supported.

- **Data from programs to monitor fish tissue for toxic contaminants**
  Annual routine monitoring for bioaccumulative toxics in Iowa fish tissue is conducted as part of three long-term programs: (1) DNR fish contaminant monitoring, (2) water quality studies of the Des Moines River near Saylorville and Red Rock reservoirs conducted by Iowa State University under contract with the USACE, and (3) water quality studies of the Iowa River near Coralville Reservoir also conducted under contract with the USACE.

  DNR has conducted annual fish collection and analysis activities in Iowa since 1980. The Iowa Fish Tissue Monitoring Program (IFTMP) involves (1) the collection of predator and bottom feeding fish from approximately 30 locations on rivers and lakes in Iowa, (2) monitoring for trends in levels of toxics in bottom feeding fish (Common Carp) at 15 fixed sites on Iowa's larger rivers and (3) follow-up monitoring designed to verify the existence of high contaminant levels and to determine whether the issuance of consumption advisories is justified. Iowa currently analyzes the bottom feeding fish for five parameters: mercury, polychlorinated biphenyls (PCBs), chlordane, dichlorodiphenyldichloroethylene (DDE), and dieldrin, while predator fish are only analyzed for mercury. Annual reports for fish tissue monitoring in Iowa can be found at http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Fish-Tissue.

  Iowa State University (Department of Civil Engineering, Environmental Engineering Section) conducts annual fish contaminant monitoring for bottom-feeding fish (Common Carp) at Saylorville and Red Rock reservoirs as part of USACE water quality monitoring. The University of Iowa and Iowa State University have conducted fish contaminant monitoring as part of a similar program at Coralville Reservoir.

- **Reports of pollutant-caused fish kills**
  The DNR routinely receives reports of fish kills that are investigated by staff from the Fisheries Bureau and/or the Compliance & Enforcement Bureau. Information from the reports of these kills, including location, the cause and source of the kill, the size of waterbody affected, and the number of fish killed, is entered into the DNR Fish Kill Database (see http://www.iowadnr.gov/Environment/WaterQuality/WaterMonitoring/FishKills.aspx).

- **Data from public water supplies on the quality of surface water sources and finished water**
  The DNR's Water Quality Bureau administers the public drinking water program in Iowa under delegation of authority from the EPA. As required by the Safe Drinking Water Act of 1996, DNR prepares an annual report of violations of national primary (finished) drinking water standards by public water supplies in the state (reports are available at https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Supply-Engineering/Annual-Compliance-Report).

- **Data from special studies of water quality and aquatic communities**
  Special/intensive studies of water quality are typically conducted over a finite time period and are targeted toward understanding or characterizing specific water quality issues. This type of study differs from "routine" monitoring that is conducted over a long timeframe and typically generates information necessary to describe general water quality conditions. The sampling protocol for intensive studies is site-specific and is based on the contaminant(s) of concern. These studies typically require multiple samples per site over a relatively short time frame. If the contaminants of concern have significant seasonal or daily variation, season of the year and time of day variation are accounted for in sampling design. The number of sampling sites, sampling frequency and parameters vary depending on the study.

  Each year, a number of special water quality studies are conducted in the state; these studies include monitoring conducted in support of TMDL development and watershed monitoring projects. Results of special studies may be summarized in the form of a published document, an unpublished report, or may exist only as raw data. Surveys of aquatic communities are occasionally conducted by DNR staff as part of special studies. Special water quality studies conducted by colleges and universities as part of undergraduate and graduate projects are also potential sources of water quality data and other water-related information.

- **Best professional judgment of DNR staff**
  DNR utilizes observations of professional staff of the DNR bureaus of Fisheries and Wildlife, as well as professional staff in other agencies, to assess support of the aquatic life use in certain types of Iowa waterbody segments that have historically lacked chemical, physical, and/or biological water quality data.

- **Results of volunteer monitoring**
  Any data collected by volunteer monitors that meet Iowa's credible data requirements are considered for use in the development of the IR.

Identifying impairments:

As specified in EPA's regulations for TMDLs (40 CFR 130.7), sources of existing and readily available water quality-related data and information to be considered as part of Section 303(d) listing include but are not limited to the following:

- The state's most recent CWA Section 305(b) report;
- CWA Section 319 nonpoint source assessments;
- Dilution calculations, trend analyses, or predictive models for determining the physical, chemical or biological integrity of streams, rivers, lakes, and estuaries; and
- Water quality-related data and information from local, State, Territorial, or Federal agencies [in Iowa, especially the NAWQA and NASQAN projects, tribal governments, members of the public, and academic institutions].

The majority of information used by the DNR to develop the Section 303(d) list of impaired waters (IR Category 5) is taken from the most recent Section 305(b) assessments for the state of Iowa. As noted in this methodology, DNR staff attempt to utilize water quality data and related information from a variety of sources. DNR has not, however, used results of dilution calculations or predictive models to add waterbody segments to Iowa's Section 303(d) list. Due to the importance of data quality and quantity in developing accurate assessments, and due to requirements of Iowa's credible data law that require site-specific, high-quality data upon which to base listings, only a subset of the available 305(b) information is used for purposes of placing segments into Category 5. The process of determining whether or not data from the above data sources are appropriate for placing segments in Category 5 is described below.

Types of Assessments: *Evaluated* and *Monitored*

For purposes of developing Section 305(b) assessments, the existing and readily available water quality data described above are used to make two types of water quality assessments: "evaluated" and "monitored." As described in guidelines for Section 305(b) reporting (EPA 1997, pages 1-5 and 1-9):

Evaluated waters are:

> those for which the use support decision is based on water quality information other than current site-specific data such as data on land use, location of sources, predictive modeling using estimated input values, and some questionnaire surveys of fish and game biologists. As a general rule, if an assessment is based on older ambient data (e.g., older than five years), the State should also consider it "evaluated."

For example, water quality assessments based on results from only a few grab samples or on professional judgment of local biologists, in the absence of any supporting data, would be considered "evaluated" assessments.

Monitored waters are:

> those for which the use support decision is principally based on current, (five years old or less) site-specific ambient monitoring data believed to accurately portray water quality conditions. Segments with data from biosurveys should be included in this category along with segments monitored by fixed-station chemical/physical monitoring or toxicity testing. To be considered "monitored" based on fixed station chemical/physical monitoring, segments generally should be sampled quarterly or more frequently.

Although EPA's more recent guidelines for integrated reporting (EPA 2005) do not distinguish between "monitored" and "evaluated" assessments, DNR maintains that the distinction is important for determining the relative scientific strength and confidence of the water quality assessments developed. In addition, this distinction (monitored versus evaluated) allows DNR to better target assessed segments for additional monitoring, and is the basis for identifying segments in need of additional monitoring. Thus, the online DNR assessment database (ADBNet) is designed to track "monitored" versus "evaluated" assessments while still complying with the integrated reporting format recommended by EPA (2005).

In terms of the ability of Section 305(b) assessments to characterize current water quality conditions, DNR considers evaluated assessments as having relatively lower confidence while monitored assessments are of relatively higher confidence. This approach is consistent with guidance from EPA (EPA 1997). DNR considers monitored assessments as sufficiently accurate to be appropriate for both Section 305(b) assessment and Section 303(d) listing (i.e., for placing segments into Category 5). The lower confidence evaluated assessments, however, are viewed as appropriate only for Section 305(b) reporting. Thus, any segments "evaluated" as "impaired" are placed in IR Categories 2b or 3b (i.e., categories for potentially impaired waterbody segments with insufficient information for determining whether uses are met). Such segments are added to Iowa's WINOFI list as provided for in Iowa's credible data law and will be considered for follow-up monitoring to better determine current water quality conditions and the existence of any impairments.

Magnitude of Impairment

In addition to DNR's retention of the distinction between "evaluated" and "monitored" segments, DNR continues to estimate the magnitude of impairment (slight, moderate, or high) for each cause of impairment. This information is useful for improved communication on the relative severity of water quality problems and for prioritization for TMDL development. Information on the degree of impairment and on the magnitude of the cause of impairment is available in DNR's ADBNet. DNR uses the following impairment levels:

Slight (=303(d) impaired): A slight impairment suggested by occurrence in the lower impairment range. The following example would result in an impairment magnitude of "Slight": a water quality criteria violation frequency just over the required impairment threshold or the mean or median is slightly above the criterion.

Moderate (=303(d) impaired): A moderate impairment suggested by occurrence in the middle to lower impairment range. The following examples would result in an impairment magnitude of "Moderate": a water quality criteria violation frequency significantly greater than 10% but less than 25%; the score for only one of the two indexes of biotic integrity (fish and aquatic macroinvertebrates) is in the impairment range; one pollutant-caused fish kill occurred during the data collection period; the lower tier of fish consumption advisories (one meal/week) is in effect; the geometric mean for *E. coli* is greater than the respective criterion but is less than eight times the criterion.

High (=303(d) impaired): A severe impairment suggested by occurrence in the middle to upper impairment range. The following examples would result in an impairment magnitude of "High": a water quality criteria violation frequency greater than 25%; scores for both indexes of biotic integrity (fish and aquatic macroinvertebrates) in the impairment range; more than one pollutant-caused fish kill during the data collection period; upper tier of fish consumption advisories ("do not eat") in effect; geometric mean for *E. coli* greater than eight times the respective criterion (i.e., greater than 1,000 *E. coli* orgs/100 ml for the Class A1/A3 recreation uses).

Data *quantity* considerations ("data completeness" guidelines)

For purposes of Section 303(d) listing in Iowa (i.e., placing segments in Category 5), data quantity issues are addressed in this methodology. Beginning with Iowa's Section 305(b) report for 1990, DNR staff developed "data completeness" guidelines to avoid basing water quality assessments on inadequate amounts of water quality data and to reduce errors in assessments (for example, incorrectly concluding that an impairment exists). For the various parameters used to develop water quality assessments, these guidelines establish the minimum number of data points needed over a given assessment period to adequately determine whether the applicable WQS are being met. Assessments that meet these data completeness guidelines are of relatively high confidence and are considered "monitored." Assessments based on an insufficient amount of data to meet these guidelines are of relatively low confidence and are thus considered "evaluated." DNR's interpretations of the terms "evaluated" and "monitored" are identical to those of EPA (1997). DNR's Section 305(b) data completeness guidelines are presented in Table 8. The significance of data completeness guidelines and Iowa's credible data law to Iowa's Section 305(b) water quality assessments and Section 303(d) listings is summarized in Figure 3.

Data *quality* considerations ("credible data" requirements)

As defined by EPA, *data quality objectives* are qualitative and quantitative statements that clarify objectives, define appropriate types of data, and specify levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support assessment decisions. In this context, Iowa's credible data law defines the appropriate types of data for developing the state's Section 303(d) listings. These objectives are as follows:

- "*Credible data*" means scientifically valid chemical, physical, or biological monitoring data collected under a scientifically accepted sampling and analysis plan, including quality control and quality assurance procedures.
- Data dated more than five years before the department's date of listing or other determination under section 455B.194, subsection 1 (Iowa's credible data law), shall be presumed not to be credible data unless the department identifies compelling reasons as to why the data is credible.

As stated in the 2001 Iowa Code, Section 455B.194, subsection 1, the department shall use "credible data" when doing any of the following:

- Developing and reviewing any water quality standard.
- Developing any statewide water quality inventory or other water assessment report. (Note: Iowa's Section 305(b) assessments are not subject to the provisions of Iowa's credible data law.)
- Determining whether any water of the state is to be placed on or removed from any Section 303(d) list.
- Determining whether any water of the state is supporting its designated use or other classification. (Note: the credible data law does not require the use of credible data for establishment of a designated use or other classification of a water of the state.)
- Determining any degradation of a water of the state under 40 CFR 131.12 (antidegradation policy).
- Establishing a TMDL for any water of the state.

The credible data law has occasionally been criticized as being an obstacle to the addition of impaired segments to Iowa's Section 303(d) list. This criticism is often directed at the requirement that data older than five years are presumed not to be credible. However, because all readily available water quality data are reviewed biennially and assessed for Section 303(d) impairments as the data become available, and most water quality data in Iowa are generated by DNR, its designees, or other government agencies, the credible data requirements rarely influence DNR's listing decisions.

Rationale for any decision not to use existing and readily available data for Section 303(d) listings

DNR reviews all existing and readily available water quality-related data and information for purposes of water quality reporting and impaired waters listing as required by Sections 305(b) and 303(d) of the CWA (see section on Sources of Existing and Readily Available Water Quality Data in this methodology). Certain categories of water quality information, however, do not meet requirements of either Iowa's credible data law or DNR's data completeness guidelines for water quality assessments and impaired waters listings. The ultimate reasons for not using certain "existing and readily available data" are (1) the need for reasonably accurate assessments of water quality and (2) the desire to add only waterbody segments to the state's Section 303(d) list (Category 5) that are actually "impaired." Placing segments on the state's Section 303(d) list on the basis of inaccurate and/or incomplete data increases the risk that the DNR's limited resources, including staff time and monitoring dollars, will be used unwisely. Examples of water quality information that typically would not be considered appropriate as the basis for Section 303(d) listing include the following:

- **Best professional judgment of DNR staff:** DNR utilizes observations of professional staff of the DNR bureaus of Fisheries and Wildlife, as well as professional staff in other agencies for purposes of water quality (Section 305(b)) reporting. Best professional judgment is used to assess support of the aquatic life use for certain types of Iowa waterbodies that have historically lacked chemical, physical, and/or biological water quality data (primarily wetlands). To be added to Iowa's list of impaired waters (Category 5), all assessments of impairment based solely on best professional judgment will need to be further investigated to better document any failure to meet WQS. Past experience with impairment decisions based primarily on best professional judgment (e.g., for wetlands) has demonstrated that such follow-up investigations are necessary to (1) better determine whether a Section 303(d) water quality impairment actually exists and (2) more accurately identify the causes and sources of any existing impairment. Field biologists and other field staff are extremely knowledgeable regarding the water resources they manage but are much less knowledgeable regarding the intent and basis for Clean Water Act Section 303(d) listing. Segments assessed as "impaired" solely on the basis of best professional judgment will be added to Subcategory 3b of the Integrated Report; this subcategory comprises the WINOFI list as provided for in Iowa's credible data law.

- **Data or information older than five years from the end of the most recent Section 305(b) reporting cycle:** Data collected more than five years before the end of the current Section 305(b) data consideration period (Table 1) are presumed under state law to be "not credible" unless DNR identifies compelling reasons as to why these older data are credible. This provision of Iowa's credible data law was based on and is consistent with the EPA's (1997) recommendation that data older than five years should not be used to make the type of water quality assessment (a "monitored" assessment) that is believed to accurately portray site-specific water quality conditions. Data older than five years, however, may be used for identifying water quality trends for any water of the state for which credible data exist. Historically, data older than five years have been routinely used for Section 305(b) reporting in Iowa, but these data have not been used to identify new Section 303(d) listings. All such assessments are considered "evaluated" and are thus of relatively lower confidence than "monitored" assessments which are based primarily on recent, site-specific ambient monitoring.

As the data upon which non-303(d) assessments are based age beyond five years-and if more recent data are not available-the assessment type is changed from "monitored" (higher confidence) to "evaluated" (lower confidence) as part of the biennial Section 305(b) assessment process. Once placed in IR Category 5 (i.e., once placed on the state's Section 303(d) list), however, a waterbody will not be moved to a non-TMDL required category without "good cause" as defined by EPA regulations at 40 CFR 130.7 (e.g., a TMDL for the waterbody is approved by EPA or new monitoring data suggest that the impairment no longer exists). EPA regulations do not consider the age of the data used to impair a waterbody as a "good cause" for removing a Section 303(d) impairment.

The issue of "old data" is seldom relevant to Section 303(d) listing in Iowa. Water quality data are used for developing the biennial Section 305(b) assessments as they become available and are thus considered for Section 303(d) listing when the data most likely represent current water quality conditions. This process occurs long before the data age beyond their ability to accurately represent current water quality conditions. As the data age beyond five years, the Section 305(b) assessment type is changed from "monitored" to "evaluated" to reflect the lowered level of confidence in assessments based on older data that may not represent current water quality conditions. Any non-303(d) Section 305(b) assessments based on data that have aged beyond ten years are not included in the current assessment cycle. The previous assessments based on these old data, however, remain in DNR's assessment database (Iowa ADBNet).

- **Data that do not meet "completeness guidelines" developed for Section 305(b) reporting:** In order to improve the accuracy of water quality assessments, DNR has identified "data completeness guidelines" for using results of routine water quality monitoring for Section 305(b) reporting (Table 8). These guidelines identify the numbers of samples needed for water quality assessments that can support Section 303(d) listings (i.e., *monitored* assessments). These guidelines also identify assessments appropriate only for Section 305(b) reporting (i.e., *evaluated* assessments). These criteria were first developed for Iowa's 1990 Section 305(b) report and are designed to improve-within the constraints of (1) resources available for monitoring and (2) the designs of existing monitoring networks-the accuracy of Section 305(b) water quality assessments. The improvement in assessment accuracy increases the confidence with which waterbodies are added to Iowa's Section 303(d) list. Although DNR ambient water quality monitoring networks and networks of other agencies are designed to produce sufficient data to meet Iowa's "completeness guidelines," not all monitoring networks are so-designed. Thus, the use of these guidelines will eliminate certain data from consideration for Section 303(d) listing. Any waterbodies assessed as "impaired" only on the basis of incomplete data, however, will be placed in IR Subcategory 3b and will be added to the WINOFI list as provided for in Iowa's credible data law.

- **Results of volunteer monitoring that do not meet requirements specified in Iowa's credible data legislation and/or Section 305(b) data completeness guidelines:** Results from volunteer monitoring can only be used for Section 303(d) listing if requirements of Iowa's credible data law are met or if overwhelming evidence of impairment is indicated. To be considered for Section 303(d) listing, DNR rules [567 IAC 61.10 through 61.13 (455B) in the Iowa WQS] require that volunteer monitoring must be supported by an DNR-approved sampling and analysis plan that includes quality control and quality assurance procedures. Waterbodies assessed as "impaired" only on the basis of volunteer data from non-qualified volunteers will not be added to the Iowa's Section 303(d) list but may be added to the WINOFI list. If, however, results of volunteer monitoring show the existence of gross pollution such that Iowa's narrative criteria are violated, such segments can be added to Iowa's Section 303(d) list due to overwhelming evidence of impairment.

- **Results of habitat assessment:** Although detailed information on the quality of aquatic habitats is collected as part of biological monitoring conducted for the DNR/SHL stream biocriteria and Regional Environmental Monitoring and Assessment Program (REMAP) projects, this information is not directly used to identify Section

303(d) impairments of aquatic life uses. Historically, DNR tried to assign causes and sources based on the limited water quality and habitat data collected at that same time as the biological data. This was a purely qualitative approach based on best professional judgment. However, that process was discontinued because of the complexity of the causes and sources of aquatic life use impairments. Presently, all aquatic life use impairments, based on biological data, are assigned "unknown" cause and "unknown" source, with one exception: habitat. In 2015, the DNR developed the Fish Habitat Indicators for the Assessment of Wadeable, Warmwater Streams document (http://publications.iowa.gov/21408/). This document contains a new quantitative habitat index, and comparison approach, that is used to determine if the physical habitat in the sampling reach is suppressing the fish community (FIBI score) enough that the segment is unable to pass the standard ecoregion BIT. DNR first used this FIBI/habitat approach for the 2016 IR cycle.

- **Assessments of headwater stream segments.** As explained below, Section 303(d) impairments based on results of chemical/physical water quality monitoring on headwater stream segments will be added to Iowa's Section 303(d) list. Due to the lack of a calibrated biological assessment protocol for headwater segments, however, impairments based on results of biological monitoring in headwater segments will not be placed on the Section 303(d) list but will be placed into IR Subcategory 3b and added to Iowa's WINOFI list. DNR expects to have a biological headwater assessment protocol developed by 2025.

  Assessments of headwater stream segments based on chemical/physical water quality data: Monitoring data from all currently non-designated and formerly "general use" headwater stream segments will be assessed against the presumptively-applied Class A1/Class BWW1 water quality criteria for purposes of the IR. Any Section 303(d) impairments identified for a presumptively designated stream segment will be placed into state-defined Subcategory 5p (i.e., "5-presumptive") of Iowa's IR. DNR IR staff that prepare Iowa's Section 303(d) list will coordinate with DNR WQS staff to determine, to the degree possible, whether UAAs have been conducted for the presumptively-impaired stream segments. If the appropriate uses have been determined through a UAA, the impairment will be placed in IR Category 5a (pollutant-caused impairment) as appropriate.

  Assessments of headwater stream segments based on biological data: Biological monitoring is conducted on Iowa's headwater stream segments (i.e., having watersheds draining less than ~25 square miles). The use of biological assessment methods developed and calibrated for the larger, more stable, and more diverse streams to assess headwater segments will likely overstate the existence of impairment. For this reason, headwater stream segments that show impairment based on a failure to meet regional expectations for aquatic biota (fish or aquatic macroinvertebrates) of presumptive Class BWW1 and Class BWW2 streams will not be added to Iowa's Section 303(d) list of impaired waters. The assessment type for these segments will be considered "evaluated" (indicating an assessment with relatively lower confidence) as opposed to "monitored" (indicating an assessment with relatively higher confidence). Such segments will be placed in Subcategory 3b-u (i.e., potentially impaired based on un-calibrated assessment) and will be added to the state's WINOFI list as provided for in Iowa's credible data law. Once on this list, the assessments can be reviewed to better determine the nature of the water quality problems suggested by biological monitoring and to determine whether follow-up monitoring is justified. See Attachment 2 of this methodology for additional information on DNR's approach for biological assessment of Iowa's wadeable streams. DNR staff continue to pursue development of a biological assessment protocol for headwater streams segments.

List of waters in need of further investigation

Although not appropriate for identifying Category 5 (Section 303(d)) segments, the above types of water-related information can be used for Section 305(b) water quality assessments and thus can be used to place waterbodies on a separate list of Iowa waterbodies in need of further investigation (WINOFI list). As provided for in Iowa's credible data law, the WINOFI list is not part of the Section 303(d) process in Iowa and includes waterbodies where limited information suggests, but does not credibly demonstrate, a water quality impairment. The state's WINOFI list is comprised of those waterbodies assessed (evaluated) as potentially "impaired." That is, the assessment of a designated use in these waterbodies as "impaired" is based on less than complete information; thus, the assessment is of relatively low confidence and is not appropriate for addition to the list of Section 303(d) waterbodies. These potentially-impaired segments are thus placed in Subcategory 3b of the Integrated Report which comprises the list of waters in need of further investigation. Category 3 is for segments where sufficient information is lacking to assess any designated use. If the results of further investigative monitoring demonstrate with credible data that a water quality impairment exists, the affected waterbody can be added to Iowa's Section 303(d) list (IR Category 5).

Overwhelming evidence of impairment

Situations exist where reliable information can accurately indicate a Section 303(d) impairment of designated beneficial uses even though this information does not meet the DNR requirements for Section 303(d) listing (Table 8). Such waterbody segments would be considered for addition to IR Category 5 (Section 303(d) list) of Iowa's IR.

How water quality data and other water-related information are summarized to determine whether segments are Section 303(d) "impaired"

- **Physical, chemical, and bacterial data from fixed station water quality monitoring networks:** These types of data are used with methods for Section 305(b) water quality assessments developed by EPA, with some of these methods being modified by DNR (see Table 9a through Table 15).

  Conventional Parameters: EPA's 1997 Section 305(b) assessment guidelines specify that aquatic life uses of surface waters with more than 10% of samples in violation of state water quality criteria for conventional parameters (for example, dissolved oxygen, ammonia, pH, and temperature) should be assessed as "impaired." This assessment approach is sometimes referred to as "the 10 percent rule" (the 10% rule). DNR has historically not used the 10% rule to assess water quality with datasets of less than ten samples due to the large degree of uncertainty associated with basing impairment decisions on small datasets. The DNR requirement of at least ten samples was based on the resultant improvement in the ability of the EPA's recommended assessment approach to accurately identify an impairment based on a critical value of 10% violation. For example, at sample sizes less than ten, the probability of incorrectly concluding that impairment exists (Type 1 error) with EPA's approach is approximately 60%; with ten samples, the probability of this type of error decreases to approximately 30% (Smith et al. 2001). Despite this approach, the probability of a Type I error remains high (30%). In addition, comparison of raw percentages to water quality criteria have often been problematic in that they seem to give a contradictory signal of impairment. The most common scenario is the following: more than 10 percent of samples exceed the criterion for pH or dissolved oxygen (thus indicating "impairment") while all other water quality indicators suggest "full support."

  Alternative assessment approaches have been developed that (1) avoid the need to compare raw percentage values to state criteria to identify impairments and (2) incorporate estimates of the numbers of samples and the corresponding number of violations that represent a significant exceedance of the 10% rule. The state of Nebraska (NDEQ 2006), drawing on information from Lin et al. (2000), adopted an assessment approach where the sample sizes and the corresponding number of violations needed to identify a significant exceedance of the 10% rule with greater than 90 percent confidence are specified. This approach is based on the binomial method for estimating the probability of committing Type I and Type II errors (see Table 16). DNR first used this binomial-based approach for identifying impairments based on violations of the 10% rule for the 2006 assessment/listing cycle and continues to use this approach.

  Toxic parameters: U.S EPA 1997 guidelines state that, for toxic parameters (e.g., toxic metals and pesticides; see https://www.epa.gov/eg/toxic-and-priority-pollutants-under-clean-water-act), more than one violation of an acute or chronic water quality criterion over a three-year period suggests impairment of aquatic life uses. Thus, for purposes of identifying candidates for Section 303(d) listing, Iowa will simply consider any violation of a criterion of a toxic parameter, whether chronic or acute, to be equivalent to violation of an acute criterion. Table 9b contains an explanation on how DNR determines violations for metals data with criteria-specified fraction or portion.

EPA has also developed separate assessment methodologies (1997, 2002) for using results of fixed station and other ambient monitoring to determine support of drinking water uses. DNR has modified EPA's Section 305(b) water quality assessment guidelines for assessing drinking water uses with data for nitrate in surface water sources (see Table 14). Also, DNR has developed assessment methods for toxic data types and assessment categories for which the EPA does not provide specific assessment methods (e.g., using fish kill information).

Chloride, sulfate: An DNR rulemaking effort in 2009 resulted in adoption of acute and chronic aquatic life criteria for chloride and sulfate. These new criteria are seen as better indicators of aquatic life health than the previous criterion for Total Dissolved Solids, a measure of all ionic constituents in waters including chloride and sulfate. As part of Iowa's 2012 IR cycle, monitoring data for chloride and sulfate generated during the 2010-2012 period were compared to these newly-adopted criteria. Because chloride and sulfate are not considered priority pollutant toxics (see https://www.epa.gov/eg/toxic-and-priority-pollutants-under-clean-water-act), assessments of support of aquatic life based on data for these parameters will be determined using the 10% rule.

- **Data from biological monitoring being conducted by DNR in cooperation with SHL**
  Benthic macroinvertebrate and fish sampling data from the DNR/SHL stream biological sampling sites are used to identify impairments of warmwater stream aquatic life uses. DNR uses a benthic macroinvertebrate index of biotic integrity (BMIBI) and a fish index of biotic integrity (FIBI) to summarize biological sampling data. The BMIBI and FIBI combine several quantitative measurements or "metrics" that provide a broad assessment of stream biological conditions. A metric is a characteristic of the biological community that can be measured reliably and responds predictably to changes in stream quality. The BMIBI and FIBI each contain metrics that relate to species diversity, relative abundance of sensitive and tolerant organisms, and the proportion of individuals belonging to specific feeding and habitat groups. The metrics are numerically ranked and their scores are totaled to obtain an index rating from 0 (poor) - 100 (optimum). Qualitative scoring ranges of poor, fair, good, and excellent have been established that reflect the biological community characteristics found at each level. The category of "poor" indicates an impairment of the aquatic life use. The category of "fair," however, may or may not indicate impairment. A framework for using these data to assess support of aquatic life uses was first developed for Iowa's 2000 Section 305(b) reporting cycle. This same basic framework has been used for subsequent reporting/listing cycles. Several modifications to the process of identifying Section 303(d) biological impairments were made for the 2010 cycle including a more rigorous approach for identifying Section 303(d) biological impairments; these modifications remain in-place. The most significant of these modifications was incorporation of an EPA recommendation to require two independent samples within a five-year period to determine support of aquatic life use. A detailed description of the framework used for Iowa's IR cycles is included in this methodology as Attachment 2.

- **Data from the DNR sponsored lake monitoring conducted by Iowa State University and DNR Water Quality Monitoring and Assessment Section**
  The DNR sponsored statewide lake water quality monitoring program began in 2000 and continues. Each lake is sampled at least three times during summer seasons to assess seasonal variability of chemical, physical, and biological parameters (e.g., plankton populations). Samples are taken at the deepest point in each lake basin.

  Due to year-to-year variability in lake water quality, state limnologists participating in the EPA Region 7 technical assistance group (RTAG) for nutrient criteria development recommended that the combined data from at least three years of monitoring results from this type of lake survey is needed to identify nutrient-related water quality impairments. Thus, DNR uses overall median water quality values from a three- to five-year period to calculate a trophic state index (TSI) (Carlson 1977). Median-based TSI values are used with the lake assessment framework described in Attachment 3 to determine the existence of an impairment. This framework is based on using the TSI as a numeric translator for Iowa's existing narrative water quality criteria protecting against aesthetically objectionable conditions and/or nuisance aquatic life. For the reporting/listing cycle, lake data for a five-year period were used to identify lake water quality impairments (Table 1).

- **Data from DNR sponsored monitoring at Iowa's shallow natural lakes**

In 2006, DNR began conducting water quality monitoring on several of Iowa's shallow natural lakes; this monitoring has continued. Due to the availability of sufficient data, results of monitoring for chlorophyll a and total suspended solids from this monitoring have been used to assess support of aquatic life uses at these waterbodies. Data for chlorophyll a are used with Carlson's TSI to identify shallow lakes that exceed the TSI impairment threshold of 65. Data for total suspended solids (TSS) are used with a protocol developed by the Upper Mississippi River Conservation Committee's (UMRCC) water quality technical section (UMRCC 2003) for protecting growth of submersed aquatic vegetation (SAV). This protocol is designed to identify waters where light penetration is insufficient to support SAV growth. Shallow lakes where growing season median levels of total suspended solids are greater than 30 mg/L are considered impaired and will be considered for addition to Iowa's Section 303(d) list. Impairments suggested by either the TSI or SAV protocol will be supplemented with information from DNR field staff responsible for management of the respective shallow lake. See Attachment 4 for a detailed explanation of DNR's approach to assessing support of aquatic life uses at Iowa's shallow lakes.

- **Data from monitoring of bacterial indicators in rivers, lakes, and beach areas**
  In July 2003, DNR adopted criteria for *E. coli* in place of the previous criterion for fecal coliform bacteria into the Iowa WQS (Table 10). This change was a response to a long-standing recommendation from EPA. In addition, a proposal was made to subdivide the Class A (primary contact) use designation into three designations:
  - Class A1 (primary contact recreation) (same as the previous Class A designation),
  - Class A2 (secondary contact recreational use),
  - Class A3 (children's recreational use).

  With the adoption of this proposal into the Iowa WQS, the state of Iowa now considers Class A1 and Class A3 segments with geomean levels of *E. coli* greater than the geomean standard for Classes A1/A3 to present an unacceptable risk of waterborne disease to swimmers, water skiers, and other persons using surface waters for primary body contact recreational activities where ingestion of water is likely to occur (567 IAC 61.3(3), Iowa WQS). In addition, Class A2 segments with geomean levels of *E. coli* greater than the geomean standard for Class A2 present an unacceptable risk of waterborne disease to persons using surface waters for secondary body contact recreational activities (567 IAC 61.3(3), Iowa WQS). Secondary body contact includes limited and incidental contact with the water that may occur during activities such as fishing and recreational boating.

  Temporal correlation of *E. coli* samples: Several *E. coli* datasets used to determine attainment of the Class A use contain *E. coli* data from multiple samples collected on the same day or from samples collected on consecutive days. A study of temporal variations in *E. coli* concentrations in the Raccoon River in central Iowa showed a temporal correlation of *E. coli* concentrations within a span of about four days (Schilling et al. 2009). Failure to account for this correlation could result in calculations of geomeans that are biased due to inclusion of temporally correlated repeated measures of either high levels or low levels of bacteria in samples collected within this four-day period. Average values may be calculated for multiple *E. coli* samples collected within a four-day period. This average value is considered an independent estimate of the bacterial concentration during that four-day period and is used to calculate the geometric mean for the dataset being reviewed, where applicable. This approach was incorporated into Iowa's 2010 IR methodology and DNR reserves the right to use this approach on high density *E. coli* samples in the future.

  Identifying bacterial impairments:
  For the recreational designated uses of Class A1 (primary contact) or Class A3 (children's recreation), for waters that are not Outstanding Iowa Waters (OIW) or Outstanding National Resource Waters (ONRW), to be assessed as "fully supported", the following conditions must be met: (1) the recreation season geomeans of at least seven *E. coli* samples collected during any of the three recreational seasons (March 15 to November 15) of the current data gathering period (Table 1) should not exceed the respective water quality criterion of the geometric mean standard for Classes A1/A3, and (2a) for any of the recreational seasons (March 15 to November 15) with at least 10 *E. coli* samples the count of exceedances of the Iowa's single sample maximum (SSM) standard for Classes A1/A3 should not exceed the maximum allowable density of the SSM standard based on the significantly greater than 10% (the 10% rule), or (2b) for any of the recreational seasons (March 15 to November 15) with 7 to 9 *E. coli* samples the count of exceedances of the Iowa's single sample maximum (SSM) standard for Classes A1/A3

should not exceed 0 samples. In addition, no swimming area closures can have been issued during the assessment period (Table 1). DNR will continue to use the binomial assessment approach for implementing the 10% rule that accounts for uncertainty in the use of small sample sizes to identify impairments (see Lin et al. 2000). If a recreation season geomean exceeds the Class A1/A3 criterion (minimum of 7 samples per recreation season required), or if significantly greater than 10% of the samples collected over a recreation seasons exceeds Iowa's SSM criterion (minimum of 10 samples per recreation season required), or if a minimum of 3 samples collected over a recreation seasons exceeds Iowa's SSM criterion from sampling season where at least 7 to at most 9 samples were collected, the assessed segment will be considered for Section 303(d) listing.

Full support of the Class A2 (secondary contact recreation) use for waters that are not OIW or ONRW, or also have the Class BCW1 aquatic life use designation will be assessed in a similar manner: (1) the annual geometric mean of at least seven samples collected during any one of the three recreational seasons (March 15 to November 15) of the current data gathering period (Table 1) should not exceed the respective Class A2 water quality criterion of the geomean standard for Class A2, and (2a) for any of the recreational seasons (March 15 to November 15) with at least 10 *E. coli* samples the count of exceedances of the Iowa's single sample maximum (SSM) standard for Classes A2 should not exceed the maximum allowable density of the SSM standard based on the significantly greater than 10% (the 10% rule), or (2b) for any of the recreational seasons (March 15 to November 15) with 7 to 9 *E. coli* samples the count of exceedances of the Iowa's single sample maximum (SSM) standard for Classes 2 should not exceed 0 samples. If an annual geomean exceeds the Class A2 criterion (minimum of 7 samples per recreation season required), or if significantly greater than 10% of the samples collected over a collection year exceeds Iowa's SSM criterion (minimum of 10 samples per recreation season required), or if a minimum of 3 samples collected over a collection year exceeds Iowa's SSM criterion from sampling season where at least 7 to at most 9 samples were collected, the assessed segment will be considered for Section 303(d) listing.

For Class A1, A2, or A3 waters that are OIW or ONRW waters, and Class A2 (secondary contact recreation) waters that are also designated for the Class BCW1, the recreational uses to be assessed as "fully supported", the following conditions must be met: (1) the annual geomean of at least seven samples collected during any one of the three collection years (January 1 to December 31) of the current data gathering period (Table 1) should not exceed the respective Class A1/A3 or A2 water quality criterion of the geomean standard for the respective Class A1/A3 or A2, and (2a) for any of the recreational seasons (March 15 to November 15) with at least 10 *E. coli* samples the count of exceedances of the Iowa's single sample maximum (SSM) standard for the respective Class A1/A3 or A2 should not exceed the maximum allowable density of the SSM standard based on the significantly greater than 10% (the 10% rule), or (2b) for any of the recreational seasons (March 15 to November 15) with 7 to 9 *E. coli* samples the count of exceedances of the Iowa's single sample maximum (SSM) standard for the respective Class A1/A3 or A2 should not exceed 0 samples. If an annual geomean exceeds the respective Class A1/A3 or A2 criterion (minimum of 7 samples per recreation season required), or if significantly greater than 10% of the samples collected over a collection year exceeds Iowa's SSM criterion (minimum of 10 samples per recreation season required), or if a minimum of 3 samples collected over a collection year exceeds Iowa's SSM criterion from sampling season where at least 7 to at most 9 samples were collected, the assessed segment will be considered for Section 303(d) listing.

In the event that a lake's swimming beach was closed to swimming during the current data gathering period (Table 1), the Class A1 uses would be assessed as "not supported." However, levels of indicator bacteria that result in DNR's posting of signs at beaches warning about increased health risk associated with swimming-including both the "Caution: Water Quality Advisory" and the "Water Quality Notice" signs-do not constitute impairment of the Class A1 uses. Neither of these signs is intended to indicate closure of beaches but is posted to warn swimmers of the potential for an increased health risk from swimming. For additional information on how DNR determines support of primary contact and secondary contact recreation uses, see Table 12.

- **Data from programs to monitor fish tissue for toxic contaminants**

The existence of, or potential for, a fish consumption advisory has been, and remains, the primary basis for Section 305(b) assessments of support of the Class HH (fish consumption) use in Iowa's rivers and lakes. If a waterbody is covered by a consumption advisory, the fish consumption use is assessed as "impaired" (Table 15).

In 2005, the Iowa Department of Public Health (IDPH), in an effort to make Iowa's advisory protocol more protective and more compatible with the various protocols used by adjacent states, developed the following revised advisory protocol for Iowa that covers these contaminants:

Table 3: Summary of fish consumption advisory contaminants and their respective evaluation criteria.

Contaminant	Concentration in Fish	Consumption Advice	Support Level	IR Category
Methylmercury	0 to <0.3 ppm*	Unrestricted consumption	Full	1
	0.3 to <1.0 ppm	One meal per week	Not	5a
	1.0 ppm and over	Do not eat	Not	5a
PCBs (sum of Aroclors 1248, 1254 and 1260)	0 to <0.2 ppm	Unrestricted consumption	Full	1
	0.2 to <2.0 ppm	One meal per week	Not	5a
	2.0 ppm and over	Do not eat	Not	5a
Technical Chlordane	0 to <0.6 ppm	Unrestricted consumption	Full	1
	0.6 to <5.0 ppm	One meal per week	Not	5a
	5.0 ppm and over	Do not eat	Not	5a
*The level of 0.3 ppm methylmercury in fish tissue is also the EPA recommended fish tissue residue criteria to be utilized in the determination of impaired waters.				

See IDPH (2007) and http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Fish-Tissue for more information on Iowa's revised fish consumption advisory protocol.

Other than the changes to the risk-based advisory levels and the addition of a "restricted consumption" category, the steps in issuing a consumption advisory in Iowa remain the same:

- Decisions to issue consumption advisories remain based on results of annual fish contaminant monitoring conducted either as part of the DNR fish tissue monitoring program or as part of other fish tissue contaminant monitoring programs in Iowa.
- Due to the large amount of variation in contaminant levels within fish populations, two consecutive samplings showing that an average contaminant level in the edible portion of a fish tissue sample is greater than an DNR/IDPH advisory trigger level is needed to justify issuance of an advisory and to identify a Section 303(d) impairment.
- Similarly, two consecutive samplings showing that average contaminant levels are less than the DNR/IDPH advisory level are needed to remove a consumption advisory and to remove the Section 303(d) impairment.
    - Note: *average contaminant level* in the context of fish contaminants refers to either the arithmetic sample average of tissue plug concentrations or to the contaminant concentration in a composite sample from three to five individual fish.

In general, these "consecutive" samples are collected in consecutive years (but not required) as part of DNR's fish tissue monitoring program or as part of special follow-up studies conducted by DNR. Waterbodies covered by consumption advisories are re-sampled periodically as part of "follow-up" monitoring to identify any changes in contaminant levels and to justify the need to continue or rescind the advisory.

- **Reports of pollutant-caused fish kills**

The occurrence of a single fish kill on a lake or river segment during the current 5-year assessment period (Table 1) indicates a potential impairment and suggests that the aquatic life use should be assessed as "WINOFI." Regardless of the cause of the fish kill, the assessment type will be considered "evaluated." Such assessments, although suitable for Section 305(b) reporting, either are inappropriate for state Section 303(d) listing (no pollutant load to allocate) or lack the degree of confidence to support addition to the state's Section 303(d) list of impaired waters. Waterbody segments affected by single fish kills will be placed in IR Subcategory 3b and will be added to the state list of waters in need of further investigation.

The occurrence of more than one fish kill on a lake or river segment during the current five-year assessment period (Table 1) indicates an impairment and suggests that the aquatic life use should be assessed as "impaired." The lone exception to the two fish kills in five years rule is if multiple non-pollutant caused fish kills (e.g., winterkill) occur on a segment in a five year period. Those segments will be assessed as "WINOFI." All other waterbody segments affected by multiple fish kills will be handled as follows:

- TMDLs will not be developed for segments with multiple fish kills where all the fish kills were caused by a one-time illegal or unauthorized release of manure or other toxic substances where enforcement actions were taken. Such segments will be placed into Integrated Report subcategory 4d as defined by DNR. In this way, the impairment status of the affected waterbody remains highlighted. The rationale for this approach is as follows:
    - As a result of the fish kills, consent orders were issued to the parties responsible for the fish kills and monetary restitution was sought and received for the fish killed. A consent order is issued in settlement of an administrative order or as an alternative to issuing an administrative order. A consent order indicates that DNR has voluntarily entered into a legally enforceable agreement with the other party. DNR maintains that these enforcement actions are more appropriate, efficient, and effective for addressing a spill-related impairment than the TMDL process would be.
    - No daily load allocation process is possible with a pollutant that is discharged only once.

- Segments with multiple fish kills where one or more of the fish kills was attributed to a pollutant (or suspected pollutant), but where no DNR enforcement actions were taken, will be placed into Integrated Report subcategory 5b. The intent of placing these waterbody segments into Category 5 is not necessarily to require a TMDL but to keep the impairment highlighted due to the potential for similar future kills from the unaddressed causes and/or sources.

- Segments with multiple fish kills where all of the fish kills were attributed to authorized discharges (e.g., a wastewater discharge meeting permit limits) are considered for Section 303(d) listing (subcategory 5a) as the existing, required pollution control measures are not adequate to address this impairment, and a TMDL is needed.

The following approach is used for the delisting of fish kill impairments in Iowa:

Fish kill impairments will remain in IR Category 5 and on Iowa's Section 303(d) list until either DNR biological sampling or DNR "fish kill follow-up" sampling has been conducted.

- If DNR biological sampling is conducted such that two sample events within a five-year period show "full support" of the aquatic life use, the fish kill impairment will be delisted due to existence of "new data" and the assessment will be moved to a non-impairment ("fully supported") category (IR 1).
- If DNR fish kill follow-up sampling is conducted, and if the results of the sampling indicate recovery of the fish community from the fish kill event, the impairment will be moved from IR Category 5 to the non-assessed category of the Integrated Report (IR 3a). Although capable of identifying recovery of the fish community, DNR's fish kill follow-up monitoring protocol lacks the assessment rigor to identify "full support" of aquatic life uses. See Attachment 5 for a description of DNR's fish kill follow-up methodology.

For IR Category 4d segments (i.e., a fish kill-impaired segment where enforcement actions were taken against the party responsible for the kill(s)), if no additional fish kills have been reported for five years subsequent to the kill, any impact from the fish kill upon which the impairment was based likely has long-ago dissipated (see Wilton (2002) for more information on recovery of fish kill streams in Iowa). The IR category for the kill will be changed from 4d to 3b (potentially impaired) and added to the state list of waters in need of further investigation. If no additional kills have been reported for an additional five-year period, the IR category will be changed from IR 3b to 3a (water not assessed).

For IR Category 3b segments (i.e., WINOFI), if no additional fish kills have been reported for five years subsequent to the kill, any impact from the fish kill upon which the impairment was based likely has long-ago dissipated (see Wilton (2002) for more information on recovery of fish kill streams in Iowa). If no additional kills have been reported for a five-year period (10 years total), the IR category will be changed from IR 3b to 3a (water not assessed).

Please refer to the Methodology for Iowa's 2020 Water Quality Assessment, Listing, and Reporting Pursuant to Sections 305(b) and 303(d) of the Federal Clean Water Act for information on how fish kill assessments were completed prior to the 2022 IR cycle.

- **Data from the statewide survey of freshwater mussels**
Information from *Statewide Assessment of Freshwater Mussels (Bivalva: Unionidae) in Iowa Streams: Final Report* (Arbuckle et al. 2000) were used for the current IR to assess support of aquatic life uses of Iowa streams and rivers. Until 2011, only a limited number of localized mussel surveys had been conducted since the statewide survey of Arbuckle et al. (2000). In 2011, however, DNR began a multi-year distributional study of Iowa's freshwater mussels. Results from this ongoing study were used to update existing assessments of aquatic life use support.

The methodology used to develop assessments of aquatic life use support based on freshwater mussel communities is as follows. The survey conducted by Arbuckle et al. (2000) involved re-sampling of sites visited in the mid-1980s by Frest (1987). For purposes of identifying candidates for Section 303(d) listing, the number of mussel species reported for a given waterbody by Frest was compared to the number of species reported for the same waterbody by Arbuckle et al. The degree to which aquatic life use was supported was based on the percent change in the number of mussel species from the 1984-85 period to the 1998-99 period. If the mean waterbody species richness (SR) was four or greater in the 1984-1985 survey period, then the following assessment approach using percent change from the 1984-85 to 1998-99 survey periods was used to identify candidates for Section 303(d) listing:

Table 4: Freshwater mussels assessment methodology, use support, and IR categories.

Species Richness (SR) decline from 1984-85 to 1998-99 (for 1984-85 sites with SR ≥4)	Use Support	Integrated Report Category
≤ 50%	Fully Supported	1
> 50%	Not Supported ("impaired")	5b

The decision to consider only those sites having four or more species reported in the 1984-85 survey is based on (1) a review of the historical distributions of freshwater mussels in Iowa as shown by Cummings and Mayer (1992) and (2) the framework (i.e., percent decline approach) described in the Table 4 above. For the Iowa ecoregions that show historical presence of a stream/river community of freshwater mussels (i.e., all ecoregions except 47e and the portions of ecoregions 47f and 40 in the Missouri River drainage), a SR of approximately four appears to characterize average SR from the 1984-85 survey by Frest. The decision to identify a waterbody as impaired due to a decline in SR between the 1984-85 and 1998-99 survey periods was originally based on quartiles. Current methodology only assesses "fully supported" and "not supported." Any decision to add a waterbody to the state list of impaired waters based on a percent decline of between 26 and 50 percent will be made on a case-by-case basis, with impairment and listing more likely as the percent decline approaches 50 percent. Using four species as a minimum for this assessment approach allows for some apparent decline between the survey periods without identifying the waterbody as "impaired." Such declines may be due to problems with sampling efficiency as opposed to the actual elimination of species.

As presented by Arbuckle et al. (2000), the potential causes of declines in SR of Iowa's freshwater mussels include siltation, destabilization of stream substrate, stream flow instability, and high in-stream levels of nutrients (phosphorus and nitrogen). Their study also suggested the importance of stream shading provided by riparian vegetation to mussel SR. For purposes of Section 305(b) reporting and Section 303(d) listing, the following causes and sources will be identified for all segments assessed as "impaired" due to declines in the mussel community: siltation from agricultural and natural sources; flow modification due to hydromodification of the watershed; and nutrients from agricultural and natural sources. Because site-specific causes and sources of these impairments were not identified by Arbuckle et al. (2000), any segments assessed as impaired due to declines in the freshwater mussel community will be placed into subcategory 5b. As is typical for Section 305(b) water quality assessments, the sources of impairment identified for Iowa's freshwater mussel community are only *potential* sources. The logistics of a statewide water quality assessment process does not often allow precise site-specific determinations of pollutant sources. More accurate information on sources would typically be gathered during the stressor identification phase of TMDL development.

The following approach is used for delisting freshwater mussel impairments in Iowa:

- If a follow-up mussel survey is conducted by DNR or other natural resource agency staff, and if the SR from the follow-up survey is greater than 50% of the SR from the Frest 1987 surveys of the mid-1980s, the impairment will be delisted. Similar to the process for listing a mussel impairment, only one follow-up sampling is needed to justify a delisting. All delisting decisions will be reviewed by DNR to ensure that the results of the follow-up survey show recovery from the original impairment.
- Because DNR lacks a protocol for identifying biological thresholds that indicate a "fully supported" mussel community, recovery of the SR of the mussel community from a previous decline does not necessarily indicate "full support" of the designated Class B aquatic life use. Rather, the results of such surveys indicate only that the mussel community has recovered to approximately the baseline condition found during the surveys in the mid-1980s (which is the basis for identifying mussel impairments). Thus, segments where mussel impairments have been delisted (removed from IR Categories 4 or 5) are most appropriate for placement in IR Subcategory 3a (insufficient information is available to determine whether the designated use is supported).

- **Data from public water supplies on the quality of raw and finished water**

  Data for the quality of raw (untreated) water from a surface water source will be used with the methodology for identifying impairments in Class C (drinking water use) segments described in Table 14. Three types of contaminants are considered as part of Section 305(b) assessments to determine the degree to which the designated Class C uses are supported: metals, pesticides, and inorganics (nitrate). Impairment of Class C uses for these contaminants will be determined as follows:

  Data for metals or pesticides (except atrazine) in the raw water source:

  Impairment of the Class C (drinking water) use will be identified if average levels of toxic metals or pesticides over the three-year Integrated Reporting assessment period exceed the respective human health criteria (HH) or maximum contaminant levels (MCLs) as specified in the Iowa WQS. Table 9b contains an explanation on how DNR determines violations for metals data with criteria-specified fraction or portion.

  Data for atrazine in the raw water source:

  For routine quarterly or more frequent sampling, where sampling frequency is similar throughout the year, moving annual average values for the three-year assessment period will be compared to the respective Class C criterion (see Table 14). If any moving annual average exceeds the Class C criterion, the Class C uses will be assessed as impaired (not supported). When calculating moving annual averages, non-detect values will be set to half the DNR ambient monitoring non-detect level. Situations where non-detect levels exceed water quality criteria will be handled on a case-by-case basis.

  When sampling frequency is biased toward certain times of year such that calculating meaningful annual averages is not possible, an atrazine impairment of the Class C uses will be identified if significantly greater than 10% of the samples exceed the MCL. The methodology of Lin et al. (2000) (Table 16) will be used to determine whether significantly more than 10% of the samples exceed the MCL.

  Data for inorganics (i.e., nitrate) in the raw water source:

  If, over the three-year assessment period, significantly more than 10% of the samples violate Iowa's Class C criterion for nitrate for drinking water use (i.e., the maximum contaminant level (MCL)), impairment of the Class C uses will be identified. The methodology of Lin et al. (2000) (Table 16) will be used to determine whether significantly more than 10% of the samples exceed the MCL.

Impairments related to the quality of finished (treated) water will be determined through review of current assessment cycle's annual DNR public drinking water program compliance reports available at *http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Supply-Engineering/Annual-Compliance-Report*. Information from these reports on violations of Class C water quality criteria and issuance of drinking water advisories will be used with methods described in Table 14 to determine the existence of impairment of drinking water uses.

- **Data from special studies of water quality and aquatic communities**
  Results of special water quality studies that meet all requirements of Iowa's "credible data" law, including the availability of a quality assurance project plan (or equivalent plan or methodology for sampling and analysis), will be considered on a case-by-case basis. DNR will review all relevant quality assurance project plans for special studies prior to the decision to use study results for purposes of Section 303(d) listing. Results from special studies that meet "credible data" requirements will be compared to water quality criteria as specified in the Iowa WQS with the methods described in this document.

- **Data from results of continuous monitoring for dissolved oxygen:**
  DNR staff have long used results of monitoring of dissolved oxygen (DO) generated through analysis of grab samples to assess support of aquatic life uses. Historically, if significantly more than 10% (the 10% rule) of the DO values generated through routine ambient monitoring violated the applicable state water quality criteria, the aquatic life uses would be assessed as "impaired." The data generated through continuous (24-hour) monitoring for DO, however, are not directly applicable to this method of identifying impairments of aquatic life uses. Thus, a separate methodology was developed by DNR staff for the 2014 IR cycle that is designed to identify impairments of aquatic life uses due to low levels of DO (see Attachment 6).

- **Results of volunteer monitoring that meet "credible data" requirements**
  Results of volunteer monitoring that meet all requirements of Iowa's "credible data" law, including the availability of an DNR-approved quality assurance project plan (or equivalent plan or methodology for sampling and analysis), will be considered on a case-by-case basis. DNR will review all relevant quality assurance project plans for volunteer monitoring studies prior to the decision to use study results for purposes of Section 303(d) listing. Results from volunteer monitoring studies that meet "credible data" requirements will be compared to the appropriate water quality criteria as specified in the Iowa WQS with the methods described in this document.

Removal (delisting) of waters from the 2020 Section 303(d) list

According to EPA regulations (40 CFR 130.7), a state must demonstrate "good cause" for exclusion of previously impaired waterbody segments. According to these regulations, "good cause" includes, but is not limited to, more recent or accurate data, more sophisticated water quality modeling, flaws in the original analysis that led to the water being listed, or changes in conditions (e.g., new control equipment or the elimination of discharges). Thus, the following can be used to demonstrate good cause for removing a previously-listed waterbody from the Section 303(d) list or to decrease the scope of impairment to a listed waterbody:

More recent or accurate data. Additional monitoring data or information from a waterbody may demonstrate that it now meets applicable WQS. In general, removal of an existing impairment due to violation of Iowa's numeric water quality criteria requires that data show full support of the previously impaired beneficial use for two consecutive Integrated Report cycles. These data must be generated from monitoring studies and programs consistent with Iowa's credible data law and must be in sufficient quantity to be used with Section 305(b) water quality assessment procedures (see Table 8). Special conditions for delisting impairments include the following:

- Chlorophyll a and Secchi depth: For Iowa lakes, median-based TSI values for both chlorophyll a and Secchi depth must be 63 or less for two consecutive IR cycles before a lake can be removed from the state's Section 303(d) list (IR Category 5) (see Attachment 3 of this methodology for more information). A TSI value of 63 indicates a chlorophyll a concentration of approximately 27 micrograms per liter (µg/L) and a Secchi depth of approximately 0.8 meters.

- Indicator bacteria: For segments with contact recreation uses assessed as impaired by indicator bacteria, and assuming that sufficient and credible new data are available, the recreation season geomean levels of *E. coli* must all be less than the applicable state water quality criterion for two consecutive listing cycles prior to delisting. Two consecutive listing cycles for Iowa's streams/rivers encompasses five years and seven years for lakes. Also, the percentage of samples that exceed the state's SSM *E. coli* criterion must not be significantly greater than 10% (the 10% rule) for two consecutive listing cycles. Requiring that geomeans and SSM values meet applicable water quality criteria for two consecutive listing cycles is designed to avoid impairment flip-flopping that can occur with high-variability and weather-influenced parameters such as indicator bacteria.

- Atrazine: For segments with drinking water uses assessed as impaired by atrazine, all moving annual averages must be less than the atrazine MCL for two consecutive Section 303(d) listing cycles before a delisting due to more recent data. If the atrazine impairment was based on significantly greater than 10% of the samples exceeding the atrazine MCL, delisting of the impairment requires two consecutive 303(d) listing cycles where the number of MCL violations is not significantly greater than 10%. Atrazine in surface waters, and especially in lakes, can exhibit wide fluctuation from year to year. DNR assessment/listing staff will review the historic atrazine data to determine any trends in levels and to determine whether delisting is justified.

- Biological impairments, fish and macroinvertebrates: The protocol for identifying a biological impairment based on results of IBIs for fish and/or macroinvertebrates from DNR's biological monitoring program requires two samplings within a five-year period that show biological impairment. Conversely, the protocol for delisting these biological impairments requires two samplings in a five-year period that show "full support" of aquatic life uses.

- Biological impairments, freshwater mussels: Both the listing and delisting of a biological impairment based on freshwater mussels requires only one sampling. While DNR's biological monitoring program is a routine ambient monitoring program, data for freshwater mussels are generated through special studies and one-time statewide surveys that typically do not provide for re-sampling of sites.

- Fish kill impairments: Occurrence of multiple pollutant-caused fish kills or a kills of unknown origin on an Iowa waterbody indicates a severe stress to the aquatic community and suggests that the Class B aquatic life use should be assessed as "impaired." The delisting of fish kill impairments can occur through either of the following:
    - Results of two DNR biological assessment sampling events within a five-year period that both suggest "full support" of the Class B aquatic life use of the fish kill-affected wadeable stream. The delisted stream segment is moved to IR Categories 1 or 2a ("fully supported").
    - Results of a single DNR fish kill follow-up sampling that show recovery of the impaired waterbody's fish community to levels typical for the respective Level IV ecoregion. The delisted stream segment is moved to IR subcategory 3a (not assessed).

- **Flaws in original analysis or errors in listing**. Errors in the data or flaws in assessment procedures used to list the waterbody invalidate the basis for listing. Changes in assessment methodology can be considered as correcting flaws in analysis or errors in listing.

- **New conditions.** Examples of new conditions include revised WQS, the elimination of discharges, and new control equipment such that a listed waterbody no longer meets the criteria for Section 303(d) listing.

All uses removed from Iowa's current Section 303(d) list will be summarized in a table posted at the DNR impaired waters website (https://programs.iowadnr.gov/adbnet). For any waterbody listed on the final EPA-approved previous Section 303(d) list and not included on DNR's current list, a waterbody-specific rationale for the exclusion or delisting will be incorporated into DNR's on-line assessment database (ADBNet).

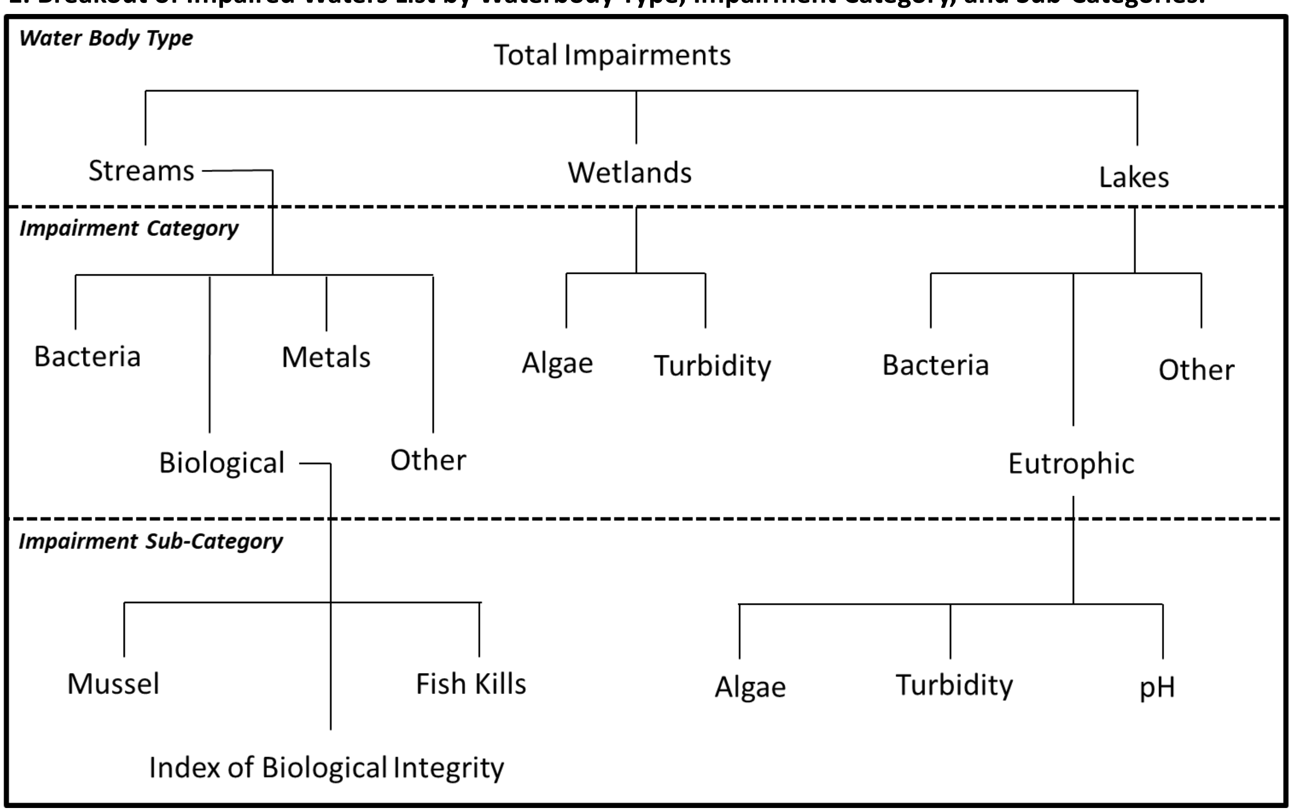
Age of data alone is not an adequate justification for omitting a previously-listed water on a new list of impaired waters. This provision is especially relevant to waterbody segments included on lists based on results of one-time surveys (e.g., results of biological assessments conducted as part of biocriteria development or faunal surveys (e.g., freshwater mussels)). For example, if a waterbody was added to Iowa's 2004 303(d) list based on a biological assessment conducted in 2002, this waterbody should remain on Iowa's subsequent 303(d) lists until (1) a TMDL is completed, (2) additional monitoring is conducted that shows "full support" of aquatic life uses, or (3) a flaw in the original data analysis or assessment is discovered.

In addition, lack of sufficient new data to develop a "monitored" assessment for a previously-listed waterbody is not adequate justification for excluding a waterbody from Section 303(d) listing. For example, if a routinely-monitored waterbody was added to Iowa's 2004 303(d) list based on a "monitored" assessment showing violations of the Iowa water quality criterion for indicator bacteria, this waterbody should remain on Iowa's impaired waters lists until (1) adequate data are available to develop a high-confidence ("monitored") assessment, (2) the newly developed assessment shows "full support" of the impaired use, or (3) there is some other "good cause" for delisting this impairment.

<u>Prioritization and scheduling of waters for TMDL development:</u>
In response to EPA's efforts to develop a new long-term vision for the Clean Water Act Section 303(d) program, DNR developed a revised system of prioritization for waterbodies included in IR Category 5. This new long term vision was developed for the 2014 IR cycle by the DNR (Berckes 2015). DNR prioritizes TMDLs with a high potential for social impact in accordance to the framework supported by EPA from the 2013 303(d) Vision (Vision). The State of Iowa focuses much of its water quality improvement efforts on nutrients and nutrient related issues. Additionally, the State of Iowa and its citizens place great value on their lake systems for recreation. As a result, the DNR focuses first and foremost on lake systems impaired for eutrophic conditions (algae, turbidity, pH).

TMDL Prioritization Methodology: To understand priorities, the 303(d) list must be looked at first. The TMDL Program's candidate pool for development derives from impaired waters in Category 5 of the IR and, potentially, high quality waters for protection. The DNR broke down impaired waters into categories to make it easier to decide which type of projects to prioritize (Figure 1).

Figure 1. Breakout of Impaired Waters List by Waterbody Type, Impairment Category, and Sub-Categories.



IR Category 5b contains biological impairments on the Impaired Waters List, with many listed as "Cause Unknown." By definition, these impairments cannot have a TMDL written without an identified pollutant as the cause of the impairment. DNR has initiated, or continued, programs to verify the freshwater mussel, fish kill, and IBI impairments; however, the causes of these impairments remain mostly unknown. Without the identification of the causes of impairment, it remains undetermined whether these impairments will require a TMDL.

Wetland impairments constitute a relatively recent addition to the Impaired Waters List and will require more investigation as to the usefulness of the TMDL process. Oxbow systems, which are essentially infant wetlands, are slowly filling; therefore, they may not be appropriate for near-term TMDL development. The lake impairments include bacteria, eutrophic, and other pollutant types. The eutrophic impairments can be further broken out to include algae, turbidity, and pH impairments.

Each of these impairment types carries a level of complexity and cost in time and money for the DNR to develop a TMDL. For example, multiple stream bacteria TMDLs in the same river basin provide an opportunity to develop many TMDLs in one document with a minimal amount of data required. Conversely, a large complex lake system using advanced modeling techniques would require more time and cost more in terms of data collection and analysis. A river basin bacteria project may produce 15 TMDLs, whereas the same amount of work effort may only produce one larger, more complex lake system TMDL.

Additionally, each type of system impacts society at various levels. Multiple efforts reveal the importance of lake watersheds to Iowans, including Iowa State University's Center for Agricultural and Rural Development (Card) research on the local economic impact of lake systems (Wan, 2021 https://www.card.iastate.edu/products/publications/pdf/21sr115.pdf). There is relatively little evidence of the potential social impact of reducing bacteria in streams.

Plotting each impairment type on a simple 2x2 plot helps prioritize TMDLs, depicted in Figure 2. The upper left quadrant of the chart includes projects that are relatively high in social impact and relatively low in complexity/cost for development. Projects that clearly fit that description include the smaller lake systems impaired for eutrophic conditions and river nitrate impairments.

Figure 2. TMDL Prioritization Grid based on Complexity/Cost and Social Impact.

		Complexity/Cost Low	***Complexity/Cost*** High
Social Impact	**High**	**Priority Group I** ***[High Priority]*** Impairments with relatively *high* social impact and relatively low complexity &/or cost for development. Example: ● Smaller Eutrophic Lake Systems ● River Nitrate	**Priority Group II** ***[Intermediate/High Priority]*** Impairments with relatively high social impact and a relatively high complexity &/or cost for development. Example: ● Larger / Complex Lake Systems ● Protection TMDLs (e.g., OIW) ● Statewide TMDL
	Low	**Priority Group III** ***[Intermediate/Low Priority]*** Impairments with relatively low social impact and a relatively low complexity &/or cost for development. Example: ● Stream Bacteria	**Priority Group IV** ***[Low Priority]*** Impairments with relatively low social impact and a relatively high complexity &/or cost for development. Example: ● Biological impairments

	• Lake Mercury impairments • Metals impairments

The upper right quadrant contains projects that hold a relatively high social impact but are more complex and may have greater data needs for TMDL development. These projects include larger and more complex lake systems, protection TMDLs for some of our high quality resources, or a statewide TMDL (e.g., beach bacteria impairments). Staffing and funding levels limit the DNR's ability to complete TMDLs in this quadrant.

Quadrant 3 contains stream bacteria projects, where there is low social impact but the cost to develop is relatively low. Finally, quadrant 4 includes projects with relatively low social impact but high complexity. Using this approach, the TMDL Program more easily decides what projects to develop that will (1) have a greater potential to be of value to the local users of the resource, and (2) provide a tool that leads to measurable water quality improvement.

Flexibility: Given that a new Impaired Waters List is issued every two years, the Vision provides a certain amount of flexibility. After each issuance of the Impaired Waters List, the TMDL program will evaluate any potential new projects to add to the priority schedule. If a new state priority manifests between now and the end of the next cycle, the TMDL Program will work with EPA in discussing a shift toward addressing that new priority. Additionally, an impairment may improve to the point of delisting and render a TMDL unnecessary. The DNR reserves the right to add or remove projects to remain consistent with the methodology for each iteration of the Impaired Waters List.

Addressing interstate inconsistencies in Section 303(d) lists:

Inconsistency in the Section 303(d) listings of border rivers and other interstate waters is a long-standing national problem (see GAO 2002). DNR faces potential listing consistency issues with the following states and rivers that border Iowa: South Dakota (Big Sioux River), Nebraska (Missouri River), Missouri (Des Moines River), and Illinois and Wisconsin (Upper Mississippi River). Thus, DNR will either (1) request and/or review the draft 303(d) lists of, or (2) consult directly with states with which Iowa shares border waters. The lists of segments reviewed for this IR cycle are summarized in Table 7 and Attachment 7.

The UMRBA's Water Quality Task Force has provided, and continues to provide, a forum for improving listing consistency for the UMR for the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin (see UMRBA-WQTF 2004). In addition to the face-to-face consultations provided in the UMRBA *Water Quality Task Force*, interstate consistency can also be addressed through viewing web-available integrated reports and Section 303(d) lists of adjacent states. For the current listing cycle, integrated reporting websites for Nebraska, South Dakota, Minnesota, and Missouri will be visited to resolve interstate listing issues as much as possible. DNR will also review the Section 303(d) listings from adjacent states for waters that either enter Iowa from Minnesota or leave Iowa into Minnesota or Missouri (e.g., the Cedar River in Mitchell County and the Chariton River in Appanoose County), or that are shared with Iowa by either state (e.g., Tuttle Lake in Emmet County).

Where the listing in another state is different than in Iowa, the DNR will review the assessment data, supporting information, and assessment methodology that support the listing in the other state. These data will be reviewed and applied to Iowa's Section 303(d) listing methodology outlined in this document. If a listing from another state for a border river is based on WQS that are consistent with the Iowa WQS, the Iowa listing will be changed to reflect that listing.

Where Section 303(d) listing decisions differ across a state line, the supporting assessment data and methodology will be requested from the appropriate state. DNR will review these data using Iowa's Section 303(d) listing methodology outlined in this document to determine whether modifications to Iowa's Section 303(d) list are justified.

This process of reviewing Section 303(d) listings for waters that border or are shared with adjacent states is designed to reduce interstate inconsistencies in Section 303(d) listings and to provide a basis for cooperation on future development of TMDLs for these interstate waters.

Public participation

A draft of this methodology is provided to the public for review and comment as part of the public comment period for the biennial Section 303(d) list. The draft methodology is available in hard copy by contacting the DNR. The draft is also available at the DNR website at https://programs.iowadnr.gov/adbnet. Comments on the draft methodology are received for a period of thirty days.

The methods used to assess water quality are always changing due both to recommendations from the EPA and changes at the state level (e.g., changes in the Iowa WQS). Thus, DNR will accept comments at any time regarding this methodology.

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Table 5. Summary of EPA's IR format as used for Iowa's 2022 IR.

DNR IR Category	EPA IR Category	Category Definition
1	1	All designated uses are met.
2	2	Some of the designated uses are met but there are insufficient data to determine if remaining designated uses are met.
3a	3	Insufficient data exist to determine whether any designated uses are met.
3b	3	Insufficient data exist to determine whether any designated uses are met but at least one use is potentially impaired based on an "evaluated" assessment. This subcategory forms the WINOFI list.
3b-c	3	Potential biological impairment on stream with watershed size within calibration range of the DNR biological assessment protocol. The aquatic life use of a stream segment within the calibrated range of the biological assessment protocol has been assessed as potentially impaired; no other uses are assessed due to lack of water quality information.
3b-u	3	Potential biological impairment on stream with watershed size outside of calibration range of the DNR biological assessment protocol. The aquatic life use of a stream segment with a watershed size outside the calibrated range of the biological assessment protocol has been assessed as potentially impaired; no other uses are assessed due to lack of water quality information.
4a	4a	Water is assessed as impaired or threatened, but a TMDL is not needed, because a TMDL has been completed.
4b	4b	Water is assessed as impaired but a TMDL is not needed because other required control measures are expected to result in attainment of WQS in a reasonable period of time.
4c	4c	Water is assessed as impaired, but a TMDL is not needed, because the impairment or threat is not caused by a "pollutant."
4d	4b	Water is assessed as impaired due to a pollutant-caused fish kill, but a TMDL is not needed, because enforcement actions were taken against, and monetary restitution sought from, the party responsible for the kill.
5a	5	Water is assessed as impaired by a pollutant stressor, and a TMDL is needed (along with IR categories 5b and 5p, the state's Section 303(d) list).
5b	5	Water is assessed as impaired or threatened based on results of biological monitoring or a fish kill investigation where specific causes and/or sources of the impairment have not yet been identified (along with IR categories 5a and 5p, the state's Section 303(d) list).
5b-t	5	Tentative biological impairment: The aquatic life use of a stream segment with a watershed size within the calibration range of the DNR biological assessment protocol is assessed as Section 303(d)-impaired based on only one of the two biological sampling events needed to confirm the existence of a biological impairment.
5b-v	5	Verified biological impairment: The aquatic life use of a stream with a watershed size within the calibration range of DNR biological assessment protocol is assessed as Section 303(d)-impaired based on results of the required two or more biological sampling events in multiple years within the previous five years needed to confirm the existence of a biological impairment.
5p	5	A presumptively-applied designated use is assessed as 303(d) impaired (along with IR categories 5a and 5b, the state's Section 303(d) list).
5*	5	Water is assessed as impaired or threatened by a pollutant stressor, and a TMDL is needed; however, the assessment for the impaired designated use was "fully supported" for one (usually current) cycle. Should the designated use be assessed as "fully supported" for the next cycle, the impairment will be delisted.

Table 6. Monitoring stations on the Iowa portion of the Upper Mississippi River and associated tributaries sampled as part of the USGS Long-Term Resource Monitoring Program (LTRMP).

Waterbody, Location	Designated Uses	Waterbody ID Number	County	LTRMP Station
Maquoketa River, near mouth	A1, BWW1, HH	IA 01-MAQ-12	Jackson	MQ02.1M
Upper Mississippi River, upstream L&D 13	A1, BWW1, HH	IA 01-NEM-70	Clinton	M525.5L
Upper Mississippi River Upper Browns Lake	A1, BWW1, HH	IA 01-NEM-6498	Jackson	M545.5B
Upper Mississippi River, L&D 12 tailwater - Bellevue	A1, BWW1, HH	IA 01-NEM-70	Jackson	M556.4A
Rock Creek, near mouth	A1, BWW2	IA 01-MAQ-2	Clinton	RK00.1M
Rock Creek, upstream PCS Nitrogen	A1, BWW2	IA 01-MAQ-3	Clinton	RK03.7M
Shrickers Slough	A1, BWW1, HH	IA 01-MAQ-1	Clinton	M508.1F
Wapsipinicon River, near mouth	A1, BWW1, HH	IA 01-WPS-332	Clinton	WP02.6M
Upper Mississippi River, downstream Sabula	A1, BWW1, HH	IA 01-NEM-70	Jackson	M532.3T
Upper Mississippi River, Buffalo Lake	A1, BWW1, HH	IA 01-NEM-70	Jackson	M540.2T
Sunfish Lake	A1, BWW1, HH	IA 01-NEM-70	Jackson	M563.9T

Table 7. Comparison of DNR's assessment reaches for the Upper Mississippi River to those agreed upon in 2004 by the Upper Mississippi River Basin Association (UMRBA) as part of the memorandum of understanding on interstate assessment reaches developed by the UMRBA Water Quality Task Force.

DNR Waterbody ID Number	Waterbody Description	Length (miles)	UMRBA Assessment Reach	Segment Description	Length (miles)*	Hydrologic Unit Code (HUC)
IA 03-SKM-884	Iowa/Missouri state line (Des Moines River) to Sugar Creek near Ft. Madison	17.3	Flint-Henderson	Des Moines River to Iowa River	74.8	07080104
IA 03-SKM-885	Sugar Creek to Skunk River	19.5				
IA 02-ICM-618	Skunk River to water supply intake at Burlington	8.75				
IA 02-ICM-619	Burlington water supply intake to Iowa River	29.2				
IA 01-NEM-61	Iowa River to L&D 15 at Davenport	49.3	Copperas-Duck	Iowa River to Lock & Dam 13 at Clinton	89.3	07080101
IA 01-NEM-62	L&D 15 to L&D 14 at LeClaire	10.7				
IA 01-NEM-63	L&D 14 to Wapsipinicon River	13.1				
IA 01-NEM-64	Wapsipinicon River to L&D 13 at Clinton	16.2				
IA 01-NEM-70	L&D 13 to Catfish Creek at Dubuque	54.0	Apple- Plum	Lock & Dam 13 to Lock & Dam 11	59.7	07060005
IA 01-NEM-71	Catfish Creek to L&D 11 at Dubuque	5.68				
IA 01-NEM-75	L&D 11 to L&D 10 at Guttenberg	30.9	Grant-Maquoketa	Lock & Dam 11 to Wisconsin River	46.0	07060003
IA 01-NEM-76	L&D 10 to Wisconsin River	15.1				
IA 01-NEM-77	Wisconsin River to L&D 9 at Harpers Ferry	19.0	Coon-Yellow	Wisconsin River to Root River	42.9	07060001
IA 01-NEM-78	L&D 9 to IA/MN state line	23.9				

*The length of the UMRBA assessment reaches was adjusted to correspond to the total mileage in the respective DNR assessment reaches.

Table 8. Data completeness guidelines for using results, collected during the data consideration period, to make "monitored" assessments of designated beneficial uses for water quality assessments in Iowa. "Monitored" assessments are used to place waters in Category 4 (impaired but TMDL not required) and Category 5 (impaired and TMDL required, the Section 303(d) list) of Iowa's IR.*

DESIGNATED USE	TYPE OF INFORMATION	DATA REQUIRED
Class A - Contact Recreation	Indicator bacteria (*E. coli*) data from rivers or non-beach areas of publicly-owned lakes or flood control reservoirs	Data collected monthly or more frequently during recreation season (March 15 through November 15); at least 7 temporally independent samples need to be collected per recreation season.
	Indicator bacteria (*E. coli*) data from beach areas of publicly-owned lakes and flood control reservoirs	Data collected approximately weekly during recreation seasons (March 15 through November 15); at least 7 temporally independent samples need to be collected per recreation season.
	pH data	A minimum of 10 samples is needed.
	Chlorophyll a and Secchi depth data from the DNR-sponsored statewide lake surveys	Data collected at least 3 times per summer for at least 3 years (minimum of 9 samples).
Class B - Aquatic Life	Toxic parameter data	A minimum of 10 samples is needed for "Fully Supported." A minimum of 2 samples is needed for "Not Supported."
	Conventional parameter data	A minimum of 10 samples is needed.
	Data from Iowa biological sampling	At least two valid fish index of biotic integrity (IBI) or macroinvertebrate IBI's for calibrated segments sampled during the most recent 6 complete calendar years (see Attachment 2 for more information).
	Data from DNR-sponsored statewide lake survey	Data collected at least 3 times per summer for at least 3 years (minimum of 10 samples).
	Results of fish kill investigations	Two or more fish kills on a single segment during the most recent 5 complete calendar years.
Class C - Drinking Water	Toxic parameter data	A minimum of 10 samples is needed for "Fully Supported." A minimum of 2 samples is needed for "Not Supported."
	Conventional parameter data	A minimum of 10 samples is needed.
Class HH - Fish Consumption	Data for site-specific levels of toxic contaminants in fish tissue	Two samplings showing average contaminant levels greater than the DNR/IDPH advisory level are needed for "Not Supported." One sampling showing average contaminant levels less than the DNR/IDPH advisory level is needed for "Fully Supported."
	Toxic parameter data	A minimum of 10 samples is needed.

*Data that do not meet DNR's completeness guidelines can be used to develop "evaluated" (versus "monitored") assessments.

Table 9a. Summary of Iowa water quality criteria used to make assessments of support of beneficial designated uses of Iowa surface waters for purposes of the 2022 IR. The criteria listed are only for those parameters used for the 2022 IR. For a complete list and description of Iowa water quality criteria, see the Iowa WQS. Criteria are in µg/L unless indicated otherwise.

	Designated Use							
Parameter	**Class A1, A2 and A3**	**Class BWW1**	**Class BWW2 & BWW3**	**Class BCW1**	**Class BCW2**	**Class BLW**	**Class C**	**Class HH**
dissolved oxygen (mg/L) 16-hour min. / 24-hour min.)	none	5.0 / 5.0	5.0 / 4.0	7.0 / 5.0	7.0 / 5.0	5.0 / 5.0	none	none
temperature (deg C) (added heat)	none	no increase > 3 C; increase < 1 C / hr; no increase above 32 C	no increase > 3 C; increase < 1 C / hr; no increase above 32 C	no increase > 2 C; increase < 1 C / hr; no increase above 20 C	no increase > 2 C; increase < 1 C / hr; no increase above 20 C	no increase > 2 C; increase < 1 C / hr; no increase above 32 C	none	none
pH	not < 6.5 or > 9 max. change = 0.5 units	not < 6.5 or > 9 max. change = 0.5 units	not < 6.5 or > 9 max. change = 0.5 units	not < 6.5 or > 9 max. change = 0.5 units	not < 6.5 or > 9 max. change = 0.5 units	not < 6.5 or > 9 max. change = 0.5 units	not < 6.5 or > 9 max. change = 0.5 units	none
ammonia-nitrogen (mg/L)	none	Criteria are dependent on the pH and temperature of the lake, stream or river; see Tables 3a through 3c of the Iowa WQS for criteria for Class BWW1, BWW2, BWW3, BCW1, BCW2, and BLW waters.					none	none
nitrate as N (mg/L)	none	none	none	none	none	none	10	none
nitrite as N (mg/L)	none	none	none	none	none	none	1	none
nitrate+nitrite as N (mg/L)	none	none	none	none	none	none	10	none

Parameter	Class A1, A2, A3	Class BWW1	Class BWW2 & BWW3	Class BCW1	Class BCW2	Class BLW	Class C	Class HHF/ HHFW
2,4-D	none	none	none	none	none	none	none	100
2,4,5-TP (Silvex)	none	none	none	none	none	none	10	none
Alachlor	none	none	none	none	none	none	2	none
Aldrin	none	none	none	none	none	none	none	0.00050 / 0.00049
Aluminum*	none	890 / 2500	890 / 2500	890 / 2500	none	890 / 2500	none	none
Antimony	none	none	none	none	none	none	none	640 / 5.6
Arsenic (III), inorganic	none	150 / 340	150 / 340	150 / 340	none	150 / 340	none	50 / 0.18
Atrazine	none	none	none	none	none	none	3	none
Barium	none	none	none	none	none	none	none	NA / 1000
Benzo(a)pyrene	none	none	none	none	none	none	none	0.18 / 0.038

Parameter	Class A1, A2, A3	Class BWW1	Class BWW2 & BWW3	Class BCW1	Class BCW2	Class BLW	Class C	Class HHF/HHFW
Cadmium*	none	1.2 / 5.35	1.2 / 12.5	1.2 / 3.4	none	1.2 / 5.35	5	168 / NA
Carbofuran	none	none	none	none	none	none	40	none
Chlordane	none	0.0043 / 2.4	0.0043 / 2.4	0.004 / 2.5	none	0.004 / 2.5	none	0.0081 / 0.008
Chloride (mg/L)*	none	389 / 629	389 / 629	389 / 629	389 / 629	389 / 629	250	none
Chlorpyrifos	none	0.041 / 0.083	0.041 / 0.083	0.041 / 0.083	none	0.041 / 0.083	none	none
Chromium (VI)	none	11 / 16	11 / 16	11 / 16	none	11 / 16	100	3365 / NA
Copper*	none	16.9 / 26.9	16.9 / 26.9	20 / 30	none	10 / 20	none	1000 / 1300
Cyanide	none	5.2 / 22	5.2 / 22	5 / 20	none	10 / 45	none	140 / 140
Dalapon	none	none	none	none	none	none	200	none
4,4-DDD	none	none	none	none	none	none	none	0.0022 / 0.0022
4,4-DDE	none	none	none	none	none	none	none	0.0022 / 0.0022
4,4-DDT	none	0.001 / 1.1	0.001 / 1.1	0.001 / 0.9	none	0.001 / 0.55	none	0.0022 / 0.0022
o-Dichlorobenzene	none	none	none	none	none	none	600	none
p-Dichlorobenzene	none	none	none	none	none	none	none	190 / 63
Dieldrin	none	0.056 / 0.24	0.056 / 0.24	0.056 / 0.24	none	0.056 / 0.24	none	0.00054 / 0.00052
Dinoseb	none	none	none	none	none	none	7	none
Diquat	none	none	none	none	none	none	20	none
alpha-Endosulfan	none	0.056 / 0.22	0.056 / 0.22	0.056 / 0.11	none	0.15 / 0.3	none	89 / 62
beta-Endosulfan	none	0.056 / 0.22	0.056 / 0.22	0.056 / 0.11	none	0.15 / 0.3	none	89 / 62
Endosulfan sulfate	none	0.056 / 0.22	0.056 / 0.22	0.056 / 0.11	none	0.15 / 0.3	none	89 / 62
alpha-Endsulfan + beta-Endosulfan + Endosulfan sulfate	none	0.056 / 0.22	0.056 / 0.22	0.056 / 0.11	none	0.15 / 0.3	none	89 / 62
Endothall	none	none	none	none	none	none	100	none
Endrin	none	0.036 / 0.086	0.036 / 0.086	0.05 / 0.12	none	0.036 / 0.086	none	0.06 / 0.059
E. coli (MPN/100mL)	Table 10	none	none	none	none	none	none	none
fluoride	none	none	none	none	none	none	4000	none
Glyphosate	none	none	none	none	none	none	700	none
Heptachlor	none	0.0038 / 0.52	0.0038 / 0.52	0.0038 / 0.38	none	0.0038 / 0.38	none	0.00079 / 0.00079
Heptachlor epoxide	none	0.0038 / 0.52	0.0038 / 0.52	0.0038 / 0.52	none	0.0038 / 0.52	none	0.00039 / 0.00039
Hexachlorobenzene	none	none	none	none	none	none	none	0.0029 / 0.0028

Parameter	Class A1, A2, A3	Class BWW1	Class BWW2 & BWW3	Class BCW1	Class BCW2	Class BLW	Class C	Class HHF/ HHFW
Hexachlorocyclopentadiene	none	none	none	none	none	none	none	1100 / 40
Lead*	none	5.3 / 136	5.3 / 136	5.3 / 136	none	5.3 / 136	50	None
Lindane	none	NA / 0.95	NA / 0.95	NA / 0.95	none	NA / 0.95	none	1.8 / 0.98
Mercury (II)	none	0.77 / 1.4	0.77 / 1.4	0.77 / 1.4	none	0.77 / 1.4	none	0.15 / 0.05
Methoxychlor	none	none	none	none	none	none	none	NA / 100
Nickel*	none	93 / 840	93 / 840	93 / 840	none	93 / 840	none	4600 / 610
Oxamyl (vydate)	none	none	none	none	none	none	200	none
Parathion	none	0.013 / 0.065	0.013 / 0.065	0.013 / 0.065	none	0.013 / 0.065	none	none
Pentachlorophenol (PCP)*	none	22.4 / 29.1	22.4 / 29.1	60.8 / 79.2	none	22.4 / 29.1	none	30 / 2.7
Phenols	none	50 / 2500	50 / 2500	50 / 1000	none	50 / 1000	none	1700000 / 21000
Picloram	none	none	none	none	none	none	500	none
Polychlorinated biphenyls (PCBs)**	none	0.014 / 2	0.014 / 2	0.014 / 2	none	0.014 / 2	none	0.00064 / 0.00064
Selenium	none	5 / 19.3	5 / 19.3	10 / 15	none	70 / 100	none	170 / 4200
Silver*	none	NA / 11	NA / 11	NA / 11	none	NA / 11	50	none
Simazine	none	none	none	none	none	none	4	none
Styrene	none	none	none	none	none	none	100	none
Sulfate*	none	1514000 / 1514000	1514000 / 1514000	1514000 / 1514000	none	1514000 / 1514000	none	none
Tetrachloroethene	none	none	none	none	none	none	none	33 / 6.9
Thallium	none	none	none	none	none	none	none	0.47 / 0.24
Toluene	none	50 / 2500	150 / 7500	50 / 2500	none	50 / 2500	none	15000 / 1300
Total residual chlorine (TRC)	none	11 / 19	11 / 19	10 / 35	none	10 / 20	none	none
Toxaphene	none	0.002 / 0.73	0.002 / 0.73	0.037 / 0.73	none	0.037 / 0.73	none	0.0028 / 0.0028
Uranium	none	none	none	none	none	none	30	none
Vinyl chloride	none	none	none	none	none	none	none	24 / 0.25
Xylenes, total	none	none	none	none	none	none	10,000	
Zinc*	none	210 / 210	210 / 210	210 / 210	none	210 / 210	none	26000 / 7400

*Criteria are formula based by using the respective equations in the Iowa WQS.

**Includes the sum of all congener or all isomer or homolog or Aroclor analyses

Table 9b. Determining Violations for Metals Data with Criteria-Specified Fraction or Portion.

Data Fraction or Portion	Criteria Fraction or Portion Specified in 567 IAC Chapter 61	Violation if a Sample Result is Greater than Criterion?	Violation if a Sample Result is Less than Criterion?
Dissolved	Dissolved	Yes	No
Total	Total	Yes	No
Dissolved	Total	Yes	No Determination Possible
Total	Dissolved	No Determination Possible	No
Bioavailable Aluminum	Bioavailable Aluminum	Yes	No
Total Aluminum	Bioavailable Aluminum	No Determination Possible	No
Dissolved Aluminum	Bioavailable Aluminum	Yes	No Determination Possible

Table 10. Summary of Iowa water quality criteria for indicator bacteria (*E. coli*) in surface waters designated in the Iowa WQS for either primary contact recreation, secondary contact recreation, or children's recreational use. The *E. coli* content shall not exceed the following levels when the Class A uses can reasonably be expected to occur.

	Class A1: primary contact recreational use*	**Class A2: secondary contact recreational use****	**Class A3: children's recreational use***
Geometric Mean (No. of *E. coli* organisms/100 ml of water)	126	630	126
Sample Maximum (No. of *E. coli* organisms/100 ml of water)	235	2,880	235

*Criteria apply from March 15 through November 15 (i.e., the "recreational season").
**Criteria apply year-round for OIW, ONRW, and Class A2 waters that are also designated for the Class BCW1 use; for all other segments, criteria apply from March 15 through November 15 (i.e., the "recreational season").

Table 11. General water quality criteria to protect beneficial general uses for all Iowa surface waters (from the Iowa WQS, 567 IAC 61.3(2)).

The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times, to protect livestock and wildlife watering, aquatic life, noncontact recreation, crop irrigation, and industrial, domestic, agricultural, and other incidental water withdrawal uses not protected by specific numerical criteria in the subrule 61.3(3) of the Iowa WQS:
1. All waters of the state shall be "free from" the following:
● Substances attributable to point source wastewater dischargers that will settle to form sludge deposits.
● Floating debris, oil, grease, scum and other materials from wastewater discharges or agricultural practices in amounts sufficient to create a nuisance.
● Materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor, or other aesthetically objectionable conditions.
● Substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to human, animal, or plant life.
● Substances attributable to wastewater discharges or agricultural practices in quantities which would produce undesirable or nuisance aquatic life.
2. The turbidity of a receiving water shall not be increased by more than 25 nephelometric turbidity units by any point source discharge.
3. Cations and anions guideline values to protect livestock watering may be found in the "Iowa Wasteload Allocation (WLA) Procedure," as revised on November 11, 2020.
4. The *Escherichia coli* content of water which enters a sinkhole or losing stream segment, regardless of the waterbody's designated use, shall not exceed a geometric mean of 126 organisms/100 ml or a sample maximum of 235 organisms/100 ml. No new wastewater discharges will be allowed on watercourses which directly or indirectly enter sinkholes or losing stream segments.

Table 12. Methods for determining support of the Recreation Use (Class A) for surface waters in Iowa for the 2022 IR.

Class A1 Primary Contact and Class A3 Children's Recreation Uses			
Type of waterbody	**Source of Information**	**Fully Supported**	**Not Supported**
Rivers, Streams, Lakes & Flood Control Reservoirs	Indicator bacteria data from water quality monitoring conducted in and around Iowa.	Each recreational season** geometric mean of *E. coli* samples ≤ 126 orgs/100ml AND ≤ 10% of each recreational season** samples exceed 235 orgs/100 ml (90% CL) for sample sizes ≥ 10 or 0% of each recreational season** samples exceed 235 orgs/100 ml for sample sizes = 7 to 9.	One or more recreational season** geometric mean of *E. coli* samples > 126 orgs/100ml OR more than 10% of one or more recreational season** samples exceed 235 orgs/100ml (90% CL) for sample sizes ≥ 10 per season OR ≥ 3 violations of one or more recreational season** samples exceed 235 orgs/100 ml for sample sizes = 7 to 9.
Lakes (see Attachment 3)	ISU & DNR ambient lake monitoring.	TSI values for both chlorophyll a and Secchi depth are < 65.	TSI values for either chlorophyll a or Secchi depth are ≥ 65.
Rivers, Streams, Lakes & Flood Control Reservoirs	Closure(s)* of beaches and other swimming areas.	No swimming area closures in effect during the assessment period.	One swimming area closure during the assessment period.
Rivers, Streams, Lakes & Flood Control Reservoirs	pH data from water quality monitoring conducted in and around Iowa.	≤ 10% violations in all samples (90% CL).	> 10% violations in all samples (90% CL).
Class A2 Secondary Contact Recreation Use			
Type of waterbody	**Source of Information**	**Fully Supported**	**Not Supported**
Rivers, Streams, Lakes & Flood Control Reservoirs	Indicator bacteria data from water quality monitoring conducted in and around Iowa.	Each recreational season** geometric mean of *E. coli* samples ≤ 630 orgs/100ml AND ≤ 10% of each seasons samples exceed 2,880 orgs/100ml (90% CL) for sample sizes ≥ 10 or 0% of each recreational season** samples exceed 2,880 orgs/100 ml for sample sizes = 7 to 9.	One or more recreational season** geometric mean of *E. coli* samples > 630 orgs/100ml OR more than 10% of one or more recreational season samples** exceed 2,880 orgs/100ml (90% CL) for sample sizes ≥ 10 per season OR ≥ 3 violations of one or more recreational season** samples exceed 2880 orgs/100 ml for sample sizes = 7 to 9 per season.
Rivers, Streams, Lakes & Flood Control Reservoirs	pH data from water quality monitoring conducted in and around Iowa.	≤ 10% violations in all samples (90% CL).	> 10% violations in all samples (90% CL).

*Elevated levels of indicator bacteria at beaches of Iowa's state-owned lakes can trigger the posting of a "swimming is not recommended" sign. The posting of this sign, however, does not mean that the beach is closed. DNR can, and will, close beaches in case of an emergency health risk such as a wastewater bypass, spill of a hazardous chemical, or a localized outbreak of an infectious disease (see the Beach Monitoring Program Monitoring and Advisory Implementation Plan Indicator Bacteria - State Beaches, DNR 2017).

**Criteria apply year-round for OIW, ONRW, and Class A2 waters that are also designated for the Class BCW1 use; for all other segments, criteria apply from March 15 through November 15 (i.e., the "recreational season").

Table 13. Methods for determining support of the Aquatic Life Use (Class B) for surface waters in Iowa for 2022 IR. For shallow lakes, TSI = trophic state index of Carlson (1977).

Type of waterbody	Source of Information	Fully Supported	Not Supported
Rivers, Streams, Lakes & Flood Control Reservoirs	Data from water quality monitoring conducted in and around Iowa.	≤ 1 acute or chronic toxicity criteria* violation AND acute or chronic criteria for conventional pollutants exceeded in ≤ 10% of samples (90% CL).	More than one violation of acute or chronic toxicity criteria* OR > 10% of the samples violate the acute or chronic toxicity criteria for conventional pollutants (90% CL).
Shallow Lakes (see Attachment 4)	DNR shallow lakes monitoring.	TSI values for chlorophyll a are < 65, and water clarity guidelines for protection of SAV (median TSS < 30 mg/L) are met.	TSI values for chlorophyll a ≥ 65, or water clarity guidelines for protection of SAV are not met (median TSS ≥ 30 mg/L).
Warmwater Streams and Rivers	Stream biological sampling data (see Attachment 2).	Scores for all indices of biotic integrity equal or exceed the ecoregion / subecoregion biological impairment threshold.	Scores for one or both of the indices of biotic integrity are less than the ecoregion / subecoregion biological impairment threshold.
Coldwater Streams	Stream biological sampling data (See Attachment 2).	Scores for coldwater benthic index equal or exceed the coldwater biological impairment threshold.	Scores for coldwater benthic index are less than coldwater biological impairment threshold.
Rivers, Streams, Lakes & Flood Control Reservoirs	DNR fish kill reports.		More than one pollutant-caused reported within the last five years.

*See Attachment 1: Using remarked (estimated) data for toxics for purposes of IR.

Table 14. Methods for determining support of the Drinking Water use (Class C) for surface waters in Iowa for the 2022 IR.

Type of waterbody	Source of Information	Fully Supported	Not Supported
Waterbodies designated for use as a source of potable water (=raw water source)	Toxic parameter data from water quality monitoring conducted in and around Iowa.	Average levels of all toxic metals or pesticides are less than respective human health criteria (HH) or maximum contaminant levels (MCLs).*	One or more average levels of toxic metals or pesticides are greater than respective HH criteria or MCL(s).*
Waterbodies designated for use as a source of potable water (=raw water source)	Atrazine data from water quality monitoring conducted in and around Iowa.	Each annual average level of atrazine is less than the MCL.	One or more of the annual average levels of atrazine exceed the MCL.
Waterbodies designated for use as a source of potable water (=raw water source)	Nitrate, chloride, fluoride, and pH data from water quality monitoring conducted in and around Iowa.	≤ 10% of the samples violate the nitrate, chloride, and fluoride maximum contaminant levels (MCLs) (90% CL).	> 10% of the samples violate the MCL(s) (90% CL).
Municipal drinking water (=finished water)	Public water supplies using surface waters.	No drinking water supply closures or advisories in effect; water not treated beyond reasonable levels.	Due to WQ issues: one (or more) drinking water supply advisory lasting > 30 days per year, other problems not requiring closure but affecting treatment costs, or one or more drinking water supply closures per year.

* See Attachment 1: Using remarked (estimated) data for toxics for purposes of IR.

Table 15. Methods for determining support of the Fish Consumption use (Class HH) for surface waters in Iowa for the 2022 IR.

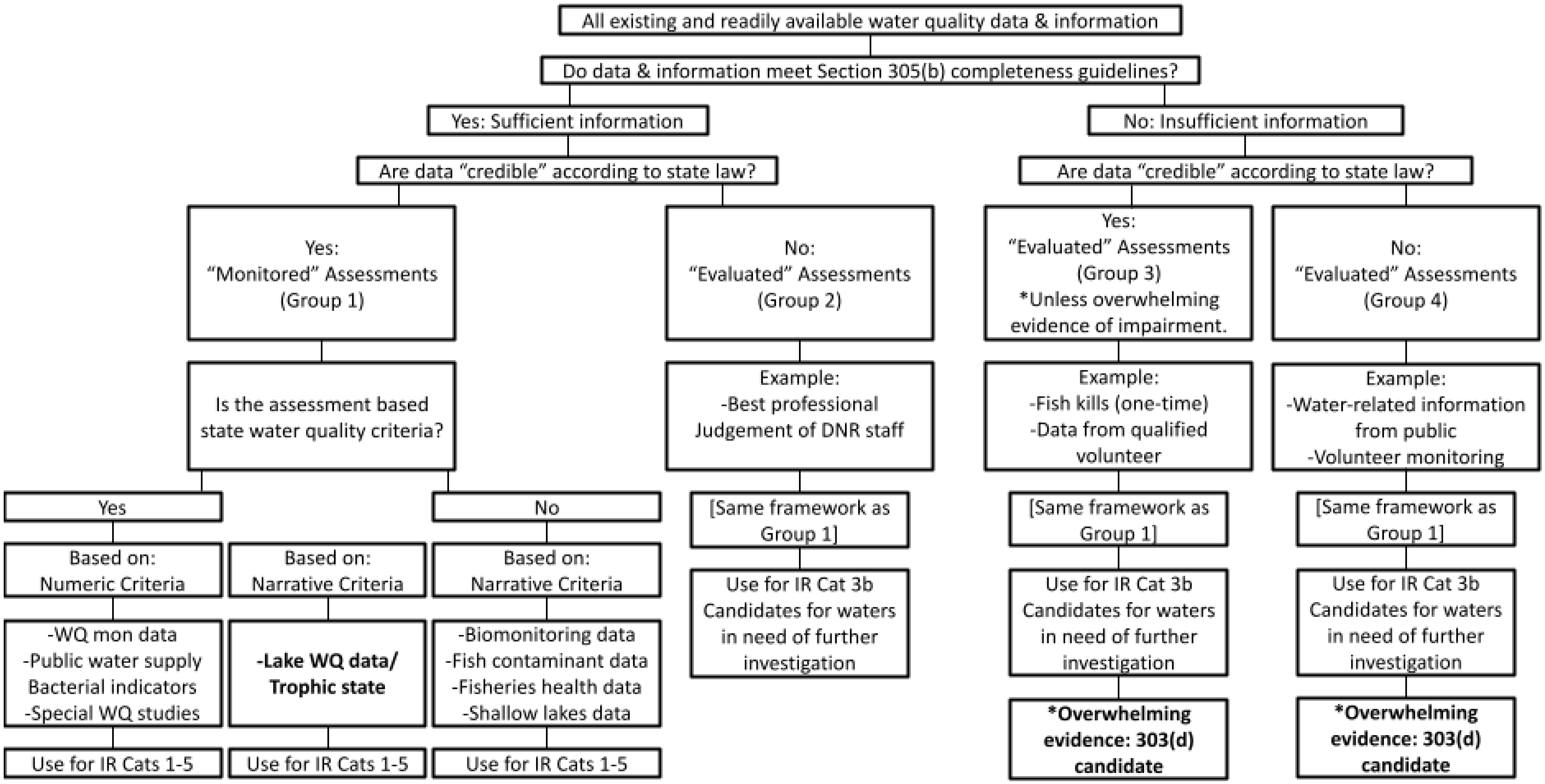
Type of Waterbody	Source of Information	Fully Supported	Not Supported
Rivers, Streams, Lakes & Flood Control Reservoirs	Monitoring of levels of toxic contaminants in fish tissue.	Results of monitoring show that levels of contaminants do not justify issuance of a consumption advisory.	Levels of one or more toxics have exceeded the respective DNR/IDPH advisory levels in two consecutive samplings and a "one meal/week" advisory or a "do not eat" advisory is in effect.
	Data from water quality monitoring conducted in and around Iowa.	Average levels of all toxic metals or pesticides are less than respective human health criteria (HH).*	One or more average levels of toxic metals or pesticides are greater than respective human health criteria (HH).*

* See Attachment 1: Using remarked (estimated) data for toxics for purposes of IR.

Table 16. Sample size and number of exceedances required to determine an impaired beneficial use (10% rule) to maintain a greater than 90% Confidence Level (CL) as reported by Lin et al. (2000) (Table excerpted from NDEQ 2006).

Sample Size (n)	Number of observations exceeding required to define an impaired use	Confidence Level	Sample Size (n)	Number of observations exceeding required to define an impaired use	Confidence Level
10	3	0.930	56	10	0.951
11	3	0.910	57	10	0.945
12	4	0.974	58	10	0.940
13	4	0.966	59	10	0.933
14	4	0.956	60	10	0.927
15	4	0.944	61	10	0.920
16	4	0.932	62	10	0.913
17	4	0.917	63	10	0.905
18	4	0.911	64	11	0.948
19	5	0.965	65	11	0.943
20	5	0.957	66	11	0.938
21	5	0.948	67	11	0.932
22	5	0.938	68	11	0.926
23	5	0.927	69	11	0.920
24	5	0.915	70	11	0.913
25	5	0.902	71	11	0.906
26	6	0.960	72	12	0.947
27	6	0.953	73	12	0.942
28	6	0.945	74	12	0.937
29	6	0.936	75	12	0.931
30	6	0.927	76	12	0.926
31	6	0.917	77	12	0.920
32	6	0.906	78	12	0.913
33	7	0.958	79	12	0.907
34	7	0.952	80	13	0.946
35	7	0.945	81	13	0.942
36	7	0.937	82	13	0.937
37	7	0.929	83	13	0.931
38	7	0.920	84	13	0.926
39	7	0.911	85	13	0.920
40	7	0.900	86	13	0.914
41	8	0.952	87	13	0.908
42	8	0.946	88	13	0.901
43	8	0.939	89	14	0.941
44	8	0.932	90	14	0.937
45	8	0.924	91	14	0.932
46	8	0.916	92	14	0.927
47	8	0.907	93	14	0.921
48	9	0.954	94	14	0.915
49	9	0.948	95	14	0.910
50	9	0.942	96	14	0.903
51	9	0.936	97	15	0.941
52	9	0.929	98	15	0.937
53	9	0.922	99	15	0.932
54	9	0.914	100	15	0.927
55	9	0.906			

Figure 3. Use of Water Quality Data and Information for Iowa's IR.

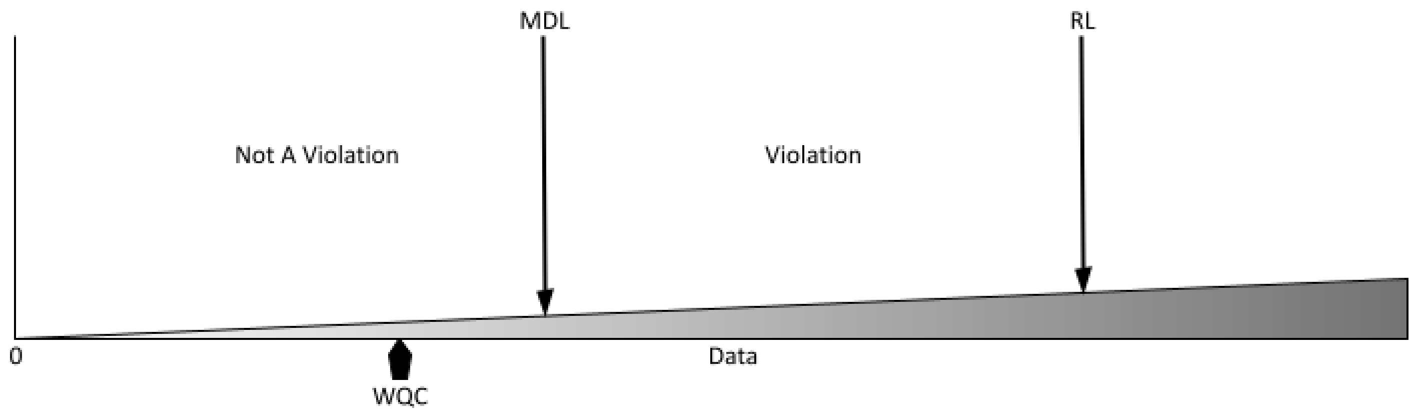


Attachment 1

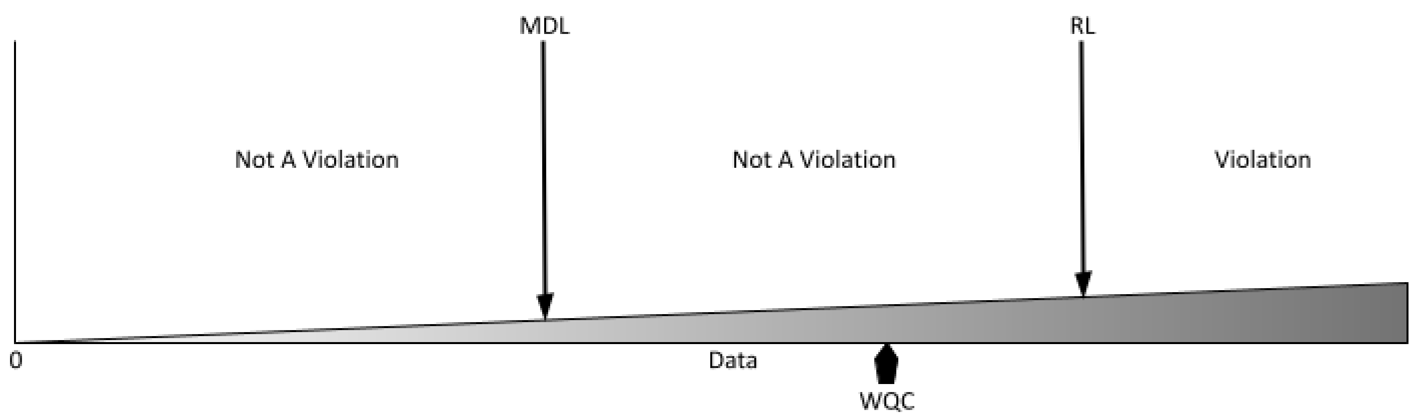
Using Toxics Estimated Data for Integrated Report Assessments

Prior to the 2014 Integrated Reporting cycle, all estimated data values were considered as valid data and were compared to water quality criteria for the purpose of identifying Section 303(d) impairments. Estimated data are those data that fall between the Method Detection Level (MDL) and the Reporting Level (RL). Based on information from USGS (Oblinger et al. 1999) and on comments from Iowa Department of Natural Resources (DNR) staff that existing impairments for toxic metals had been incorrectly identified, DNR IR staff changed how estimated data values were used for IR assessments.

The only scenario where estimated data values are used is if the water quality criterion (WQC) is below the MDL. Any data values reported between the MDL and the RL (or above the RL) will be considered as violations of the WQC.



If the WQC is between the MDL and the RL, only those data values above the RL will be considered violations. The data values between the MDL and the RL (estimated values) will not be considered violations of the WQC. The data values may or may not be above the WQC and in this situation, the estimated values are of relatively low confidence (Oblinger et al*.* 1999).



Attachment 2

Guidelines for Determining Aquatic Life Use Support using Stream Biological Sampling Data for the IR

Introduction

Since the late 1980s, EPA has encouraged states to develop and adopt narrative and biological criteria (biocriteria) for surface waters. Biocriteria are narrative or numeric expressions that describe the best attainable biological integrity (reference condition) of aquatic communities inhabiting waters of a given designated aquatic life use (EPA 1990a). Supported by a water quality planning grant from the EPA Region 7, geographers of the EPA Corvallis Environmental Research Laboratory collaborated with Iowa Department of Natural Resources (DNR) staff to revise and subdivide the ecoregions in Iowa (Figure 2-1, see also Omernik et al. 1993; Griffith et al. 1994). As part of this effort, a list of candidate stream reference sites in Iowa was generated. Reference sites are located on the least impacted streams within an ecoregion or subecoregion. Reference sites can thus serve as benchmarks to which water quality-impaired streams can be compared. A pilot reference site sampling study was conducted in 1994 to develop standardized data collection procedures for assessing the quality of aquatic habitat and for sampling benthic macroinvertebrate and fish communities (Wilton 1996). Approximately 100 reference sites were sampled during the initial reference site sampling period 1994-1998; an additional 75 sites were sampled with the biocriteria sampling protocol as part of test site sampling and sampling for watershed projects. These data, as well as more recent reference site sampling data from 1999-2004, were used to develop and calibrate indicators of stream biological integrity (Wilton 2004) and biological assessment criteria used in assessments of aquatic life use support for the 2006 Section 305(b) report and all subsequent reports.

The warmwater (WW) bioassessment indicators were calibrated for assessing support of Class BWW1 and Class BWW2 WW aquatic life uses in wadeable stream segments. The WW indicators were not calibrated for small headwater general use streams, Class BWW3 streams or non-wadeable WW rivers having watershed drainage areas > 500 mi^2. In the absence of specifically calibrated indicators for these types of WW lotic systems, the current WW indicators and criteria have been applied; however, these assessments are considered "evaluated" rather than "monitored" to reflect a greater degree of uncertainty in the assessment conclusions. A Coldwater Benthic Index (CBI) that was developed in 2012, which along with trout reproduction data from the DNR Fisheries Bureau, is used for determining the level of support for the Class BCW1 aquatic life use in designated coldwater (CW) streams of northeastern Iowa. For smaller Class BCW2 systems, the current CW indicators and criteria are applied; however, these assessments are considered "evaluated" rather than "monitored" to reflect a greater degree of uncertainty in the assessment conclusions. DNR is currently developing indicators for both small WW headwater and CW streams and large WW rivers for use in aquatic life use assessments.

Uses designated for individual stream and river reaches in Iowa were updated by the DNR in 2006 and approved by EPA in 2008. These updated uses are summarized in Iowa's Surface Water Classification document. Definitions of designated uses (e.g., Class BWW1, Class BWW2, and Class BCW1) are presented in the Iowa Water Quality Standards.

The DNR uses a WW Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI), a WW Fish Index of Biotic Integrity (FIBI), and a Coldwater Benthic Index (CBI) to summarize biological sampling data. The BMIBI, FIBI and CBI combine several quantitative measurements, or "metrics", that provide a broad assessment of stream biological conditions. A metric is a characteristic of the biological community that can be measured reliably and responds predictably to changes in stream quality. The BMIBI and FIBI each contain twelve metrics, and the CBI contains nine metrics that relate to species diversity, relative abundance of sensitive and tolerant organisms, and the proportion of individuals belonging to specific feeding and habitat groups. The metrics are numerically ranked, and their scores are totaled to obtain an index rating from 0 (poor) - 100 (optimum). Qualitative scoring ranges for the BMIBI and FIBI of poor, fair, good, and excellent have been established that reflect the biological community characteristics found at each level (Table 2-1 (a) and (b)). The qualitative scoring ranges of the CBI are still in development. These qualitative ranges are general interpretative guidelines only. To assess support of the aquatic life use, sample site IBI scores are compared against Biological Impairment Thresholds (BIT) (Table 2-2), which more specifically reflect reference conditions defined by ecoregion, thermal class, and habitat class.

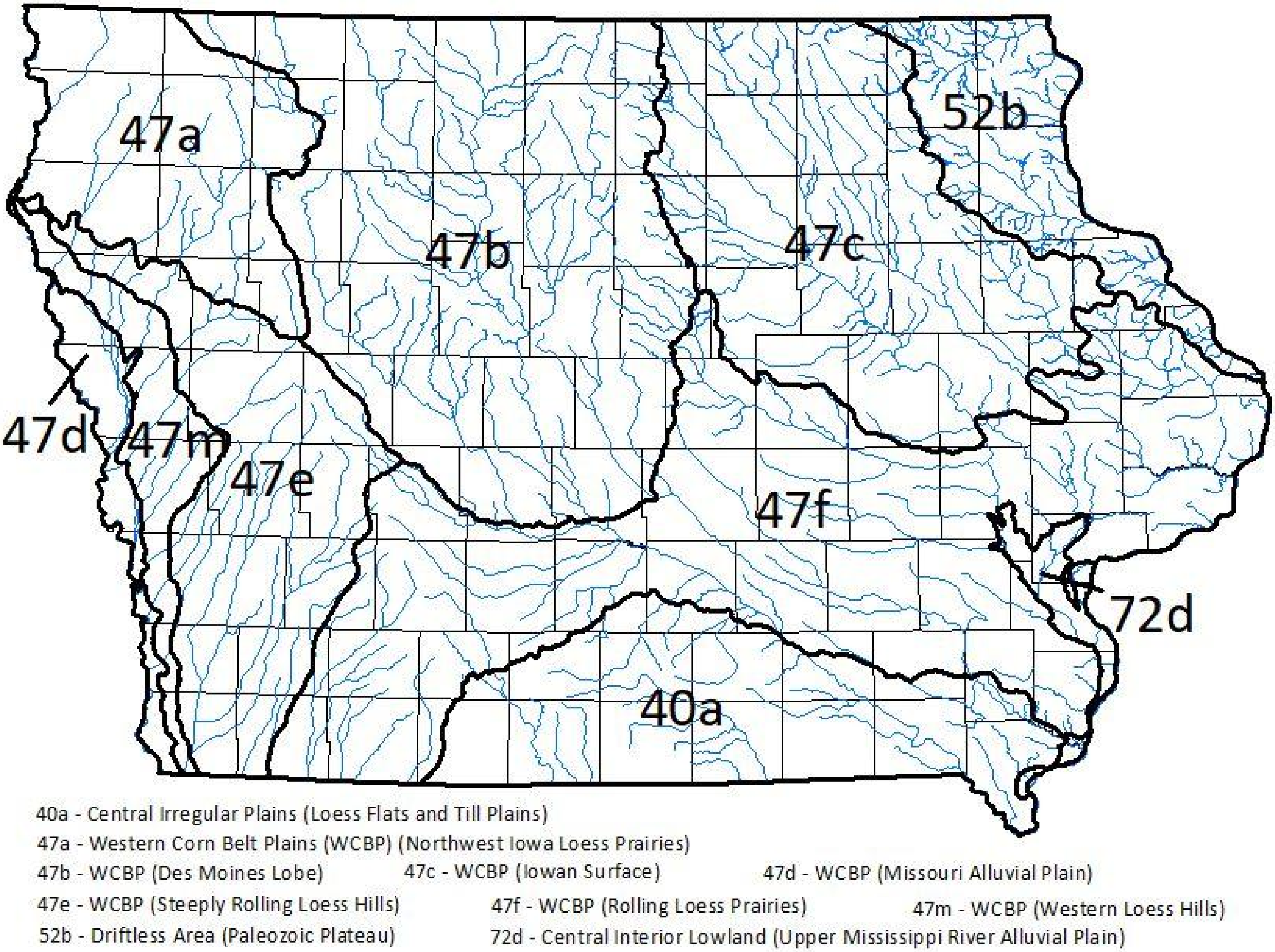


Figure 2-1. Level IV ecological regions (ecoregions) of Iowa (after Chapman et al. 2002).

<u>Determining Support of Aquatic Life Uses:</u>
The primary types and sources of data are: a) benthic macroinvertebrate and fish assemblage data collected as part of the DNR/SHL stream biocriteria project, and b) fish assemblage data collected by staff of the DNR Fisheries Bureau. Before making assessments, data completeness and quality are evaluated. "Comparable" data are considered as having completeness and quality that is comparable to biocriteria project data used to develop reference biotic indexes and impairment criteria. These data were collected using the proper sampling methodology and are used to make aquatic life use assessments. "Tentative" data are considered as having lesser or uncertain levels of completeness and quality documentation. These data are not used to make aquatic life use assessments but will continue to be used to develop follow-up sampling plans and for other internal uses.

To determine the level of aquatic life use support for a stream sampling site, the BMIBI, FIBI and/or CBI scores from that stream are compared against index levels measured at reference stream sites located in the same ecological region or thermal class. WW reference sites are also stratified by habitat class and benthic macroinvertebrate (BM) sampling gear in two ecoregions where statistically significant differences have been found between reference sites having abundant coarse (rock) substrates and riffle habitat versus those lacking these habitat characteristics. The 25th percentile values of the reference site BMIBI, FIBI and CBI scores within a given combination of ecoregion, thermal class, habitat class and BM sampling gear are used as the BIT for IR assessment purposes (Table 2-2). Use of the reference 25th percentile as an impairment threshold is consistent with biocriteria development guidance (EPA 1996), and has demonstrated efficacy in state bioassessment programs (Yoder and Rankin 1995). Biotic index performance evaluation in Iowa found little or no

overlap of index interquartile ranges between reference sites and test (impacted) sites, which suggests that reference 25th percentile levels are appropriate for assessing biological impairment.
Generally, a stream is considered biologically impaired if one or both of its index scores are significantly lower than the BIT. An uncertainty adjustment value (UAV) equal to 8 BMIBI and CBI points or 7 FIBI points is applied in cases where single sample data are used to assess the aquatic life use. The UAV reflects the typical year-to-year IBI scoring variation observed among least disturbed reference sites throughout Iowa. It is used to identify stream segments that are within a reasonable margin of error from the lower 25th percentile of reference site IBI scores. Segments assessed using the UAV may be considered a higher priority for follow-up sampling in order to better determine the status of the aquatic life use.

"Monitored" assessments are those for which comparable data are available to assess "calibrated" stream segments, which are defined by: a) Class BCW1 aquatic life use designation or b) Class BWW1 or BWW2 segments that have a watershed drainage area of ~25 to $\leq$ 500 square miles. In both cases, at least two samples must be collected in multiple years in a five year period during the most recent six year period to be considered "monitored". "Evaluated" assessments are generally of two kinds: 1) cases in which at least two samples have not been collected in multiple years and/or were not collected in the most recent six year period; 2) cases where biotic index data are used to assess "uncalibrated" segments (i.e., general use, Class BCW2, Class BWW3 or non-wadeable river segments having watershed drainage area > 500 mi^2).

<u>Aquatic Life Use Support Guidelines:</u>
The following guidelines are used to make aquatic life use status recommendations on the basis of biological sampling data only. In many cases, water quality monitoring data are also available to evaluate aquatic life use status from the perspective of chemical and physical water quality standards attainment. In these cases, a weight of evidence approach is taken to make adjustments and assign the most appropriate aquatic life use status category.

Monitored "Fully Supported" Assessments:
- Comparable data from calibrated WW or CW segments with at least two valid BMIBI or CBI scores and/or at least two valid FIBI scores. The samples were collected in multiple years in a five year period in the most recent six year period and all scores (or simple majority of scores) met or exceeded the BIT(s).

Evaluated "Fully Supported" Assessments:
- Comparable data from calibrated WW or CW segments with at least two valid BMIBI or CBI scores and/or at least two valid FIBI scores. The samples were <u>not</u> collected in multiple years and/or were not collected in a five year period during the most recent six year period and all scores (or simple majority of scores) met or exceeded the BIT(s).; <u>*OR,*</u>
- Comparable data from calibrated WW or CW segments that consisted of only one valid BMIBI or CBI and/or FIBI score, and the single score(s), plus the applicable UAV met or exceeded the BIT; <u>*OR,*</u>
- Comparable data from uncalibrated segments with at least one valid BMIBI score and/or FIBI score and the score(s) or simple majority of the scores met or exceeded the BIT(s). In cases of single IBI scores, the applicable UAV will be applied.

Monitored "Not Supported" Assessments:
- Comparable data from calibrated WW or CW segments with at least two valid BMIBI or CBI scores and/or at least two valid FIBI scores. The samples were collected in multiple years in a five year period during the most recent six year period and all scores (or simple majority of scores) of one or more IBIs (CBI, BMIBI, or FIBI) <u>did not</u> meet or exceed the BIT(s).

Evaluated "WINOFI" Assessments:
- Comparable data from calibrated WW or CW segments with at least two valid BMIBI or CBI scores and/or at least two valid FIBI scores. The samples were <u>not</u> collected in multiple years and/or <u>not</u> in a five year period during the most recent six year period and all scores (or simple majority of scores) of one or more IBIs (CBI, BMIBI, or FIBI) <u>did not</u> meet or exceed the BIT(s).; <u>*OR,*</u>
- Comparable data from calibrated WW or CW segments with only one valid BMIBI or CBI and/or FIBI score, and the single score(s) plus the applicable UAV <u>did not</u> meet or exceed the BIT(s); <u>*OR,*</u>

- Comparable data from uncalibrated segments with at least one valid BMIBI score and/or FIBI score, and the score(s) or simple majority of the scores did not meet or exceed the BIT(s). In cases of single IBI scores, the applicable UAV will be applied.

For a detailed flow chart on how the biological aquatic life use assessments are completed, see Figure 2-2.

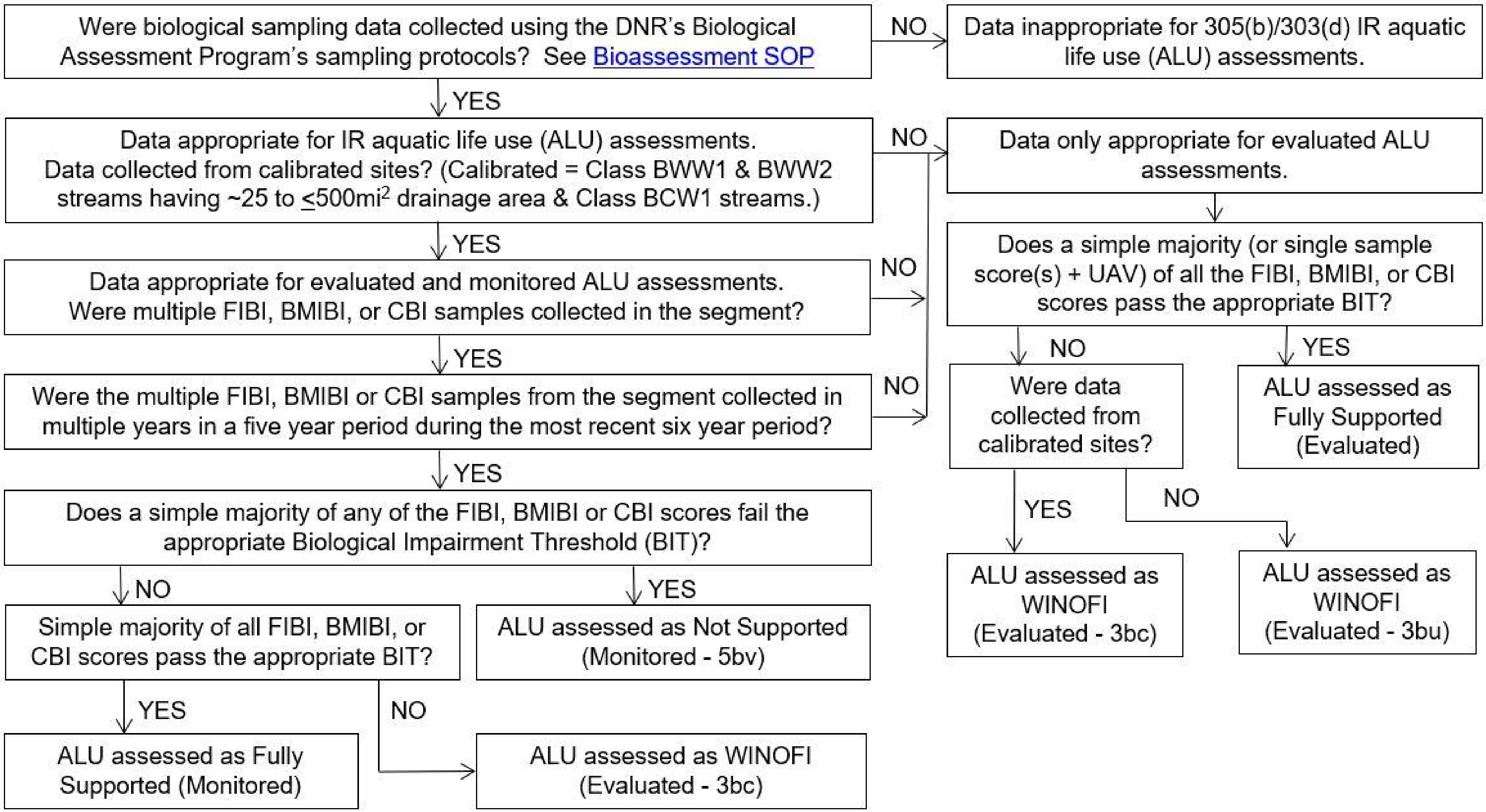


Figure 2-2. Biological assessment flowchart detailing how the DNR biological assessment methodology is used when completing IR aquatic life use assessments.

Causes and Sources:

Historically, DNR tried to assign causes and sources based on the limited water quality and habitat data collected at that same time as the biological data. This was a purely qualitative approach based on best professional judgment. However, that process was discontinued because of the complexity of the causes and sources of aquatic life use impairments. Presently, all aquatic life use impairments, based on biological data, are assigned "unknown" cause and "unknown" source, with one exception: habitat. In 2015, the DNR developed the Fish Habitat Indicators for the Assessment of Wadeable, Warmwater Streams document (http://publications.iowa.gov/21408/). This document contains a new quantitative habitat index, and comparison approach, that is used to determine if the physical habitat in the sampling reach is suppressing the fish community (FIBI score) enough that the segment is unable to pass the standard ecoregion BIT. DNR first used this FIBI/habitat approach for the 2016 IR cycle.

Abbreviations and Terms

BIT - Biological Impairment Threshold;
BMIBI - Benthic Macroinvertebrate Index of Biotic Integrity;
CBI - Coldwater Benthic Index;
EPT - Ephemeroptera, Plecoptera, Trichoptera
FFG - Functional Feeding Group
FIBI - Fish Index of Biotic Integrity;
UAV - Uncertainty Adjustment Value (8 pts. BMIBI, 8 pts. CBI, 7 pts. FIBI);
Calibrated - BCW1 stream segments or BWW1 or BWW2 stream segments that have a watershed drainage area of ~25 mi^2 to ≤ 500 mi^2.
Uncalibrated - general use, Class BWW3 or Class BCW2 segments, or large river segments having watershed drainage area of ~< 25 mi^2 or > 500 mi^2.
Comparable - Data considered as having completeness and quality that is comparable to biocriteria project data used to develop reference biotic indices and impairment thresholds.
Tentative - Data considered as having lesser or uncertain levels of completeness and quality documentation.

Table 2-1. (a). Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) qualitative scoring ranges.

Biological Condition Rating	Characteristics of Benthic Macroinvertebrate Assemblage
76-100 (Excellent)	High numbers of taxa are present, including many sensitive species. EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa are very diverse and dominate the benthic macroinvertebrate assemblage in terms of abundance. Habitat and trophic specialists, such as scraper organisms, are present in good numbers. All major functional feeding groups (FFG) are represented, and no particular FFG is excessively dominant. The assemblage is diverse and reasonably balanced with respect to the abundance of each taxon.
56-75 (Good)	Taxa richness is slightly reduced from optimum levels; however, good numbers of taxa are present, including several sensitive species. EPT taxa are fairly diverse and numerically dominate the assemblage. The most-sensitive taxa and some habitat specialists may be reduced in abundance or absent. The assemblage is reasonably balanced, with no taxon excessively dominant. One FFG, often collector-filterers or collector-gatherers, may be somewhat dominant over other FFGs.
31-55 (Fair)	Levels of total taxa richness and EPT taxa richness are noticeably reduced from optimum levels; sensitive species and habitat specialists are rare; EPT taxa still may be dominant in abundance; however, the most-sensitive EPT taxa have been replaced by more-tolerant EPT taxa. The assemblage is not balanced; just a few taxa contribute to the majority of organisms. Collector-filterers or collector-gatherers often comprise more than 50% of the assemblage; representation among other FFGs is low or absent.
0-30 (Poor)	Total taxa richness and EPT taxa richness are low. Sensitive species and habitat specialists are rare or absent. EPT taxa are no longer numerically dominant. A few tolerant organisms typically dominate the assemblage. Trophic structure is unbalanced; collector-filterers or collector-gatherers are often excessively dominant; usually some FFGs are not represented. Abundance of organisms is often low.

Table 2-1 (b). Fish Index of Biotic Integrity (FIBI) qualitative scoring guidelines.

71-100 (Excellent)	Fish (excluding tolerant species) are fairly abundant or abundant. A high number of native species are present, including many long-lived, habitat specialist, and sensitive species. Sensitive fish species and species of intermediate pollution tolerance are numerically-dominant. The three most abundant fish species typically comprise 50% or less of the total number of fish. Top carnivores are usually present in appropriate numbers and multiple life stages. Habitat specialists, such as benthic invertivore and simple lithophilous spawning fish are present at near optimal levels. Fish condition is good; typically less than 1% of the total number of fish exhibit external anomalies associated with disease or stress.
51-70 (Good)	Fish (excluding tolerant species) are fairly abundant to very abundant. If high numbers are present, intermediately tolerant species or tolerant species are usually dominant. A moderately high number of fish species belonging to several families are present. The three most abundant fish species typically comprise two-thirds or less of the total number of fish. Several long-lived species and benthic invertivore species are present. One to several sensitive species are usually present. Top carnivore species are usually present in low numbers and often one or more life stages are missing. Species that require silt-free, rock substrate for spawning or feeding are present in low proportion to the total number of fish. Fish condition is good; typically less than 1% of the total number of fish exhibit external anomalies associated with disease or stress.
26-50 (Fair)	Fish abundance ranges from lower than average to very abundant. If fish are abundant, tolerant species are usually dominant. Native fish species usually equal ten or more species. The three most abundant species typically comprise two-thirds or more of the total number of fish. One or more sensitive species, long-lived fish species or benthic habitat specialists such as Catostomids (suckers) are present. Top carnivore species are often, but not always present in low abundance. Species that are able to utilize a wide range of food items including plant, animal and detrital matter are usually more common than specialized feeders, such as benthic invertivore fish. Species that require silt-free, rock substrate for spawning or feeding are typically rare or absent. Fish condition is usually good; however, elevated levels of fish exhibiting external anomalies associated with disease or stress are not unusual.
0-25 (Poor)	Fish abundance is usually lower than normal or, if fish are abundant, the assemblage is dominated by a few or less tolerant species. The number of native fish species present is low. Sensitive species and habitat specialists are absent or extremely rare. The fish assemblage is dominated by just a few ubiquitous species that are tolerant of wide-ranging water quality and habitat conditions. Pioneering species, introduced species, and short-lived fish species are typically the most abundant types of fish. Elevated levels of fish with external physical anomalies are more likely to occur.

Table 2-2. Biological Impairment Thresholds (BIT) used for the assessment of rivers and streams in Iowa's Integrated Report.

Warmwater Streams and Rivers		
Ecoregion:	**FIBI**	**BMIBI**
40a - Central Irregular Plains	33	41
47 - Western Corn Belt Plains (WCBP) Subregions:		
47(a) - WCBP /Northwest Iowa Loess Prairies	43	54
47(b) - WCBP / Des Moines Lobe		
(Stable Riffle Habitat*)	53	62
(No Stable Riffle Habitat)	32	62
47(c) - WCBP / Iowan Surface		
(Stable Riffle Habitat - FIBI, Natural Substrate Sampling - BMIBI)	65	70
(No Stable Riffle Habitat - FIBI, Artificial Substrate Sampling - BMIBI)	44	52
47(d) - WCBP / Missouri Alluvial Plain	-	-
47(e) - WCBP / Loess Hills and Rolling Loess Prairies	31	54
47(f) - WCBP / Southern Iowa Rolling Loess Prairies		
(Mississippi River Drainage System)	36	51
(Missouri River Drainage System)	31	54
52b - Paleozoic Plateau (Driftless Area)	52	61
72d - Central Interior Lowland	36	51
Coldwater Streams	**CBI**	
Statewide CW streams (primarily located in 52b and 47c ecoregions).	60	

*Stable riffle habitat = ≥10% riffle macrohabitat, ≥10% cobble substrate and ≥30% total coarse substrate. See Figure 2-1 for ecoregion map.

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Attachment 3

Guidelines for the use of the Trophic State Index to Identify Lake Water Quality Impairments in Iowa's IR

Iowa DNR
Water Quality Monitoring & Assessment Section
Water Quality Bureau

Introduction

Prior to 2000, relatively little water quality monitoring was conducted on Iowa lakes. Lake surveys in Iowa typically involved sampling in only summer seasons of one year at roughly ten-year intervals (see Bachmann 1965, Bachmann et al. 1980, and Bachmann et al. 1994). This amount of data, although providing a snapshot of lake water quality given the climatic conditions of the specific year of sampling, was not particularly useful for developing a more accurate characterization of lake-specific water quality over the long-term. In addition, due to the general lack of historical data, accurate identification of long-term trends in water quality parameters at most Iowa lakes was not possible. Diagnostic/feasibility studies at Iowa lakes (e.g., Bachmann et al. 1982, Downing et al. 2001), have included more intensive water quality monitoring, but such studies have been conducted on relatively few lakes and are of a relatively short duration (from one to two years). Due to this general lack of data, historical assessments of lake water quality in Iowa, such as those used for Section 305(b) reporting and Section 303(d) listing, had been based primarily on the best professional judgment of Iowa Department of Natural Resources (DNR) fisheries biologists. The nearly total reliance on best professional judgment, while a valid assessment technique, resulted not only from the lack of routine ambient monitoring at Iowa lakes but also from the lack of state water quality criteria for the parameters that are most likely to indicate lake water quality impairments (e.g., nutrients (nitrogen and phosphorus), chlorophyll, turbidity, and impacts due to the accumulation of sediment in lake basins). Previous (pre-2000) Section 305(b) lake assessments that were based on best professional judgment were supplemented with lake monitoring data to the extent that this information was available (e.g., Bachmann et al. 1982, Bachmann et al. 1994).

Beginning in 2000, however, the first routine ambient monitoring program for Iowa lakes was initiated. This statewide lake survey of 131 publicly-owned Iowa lakes was funded by DNR and was conducted by ISU from 2000 through 2007 and from 2009 through to present, and was conducted by the State Hygienic Laboratory at the University of Iowa (SHL) from 2005-2008. This study was designed to be a long-term study capable of providing multiple years of data that can be used to better characterize lake water quality than was possible with the limited data from previous surveys. This ambient lake monitoring program is ongoing.

Similar to Iowa's previous Integrated Reports (IR) cycles, the lake assessment methodology for Iowa's current IR involves the use of data from the statewide lake surveys during the assessment period (Table 1) with Carlson's (1977) trophic state index (TSI) to identify lakes that do not fully meet the narrative criteria in Section 61.3(2) of the Iowa Water Quality Standards (WQS). This general approach has been used for all of Iowa's IR since 2002. The existence of any lake impairments suggested by a TSI value will be reviewed and corroborated by DNR Fisheries Bureau staff. This approach is consistent with Iowa's credible data law and allows assessment of water quality impacts due to parameters that currently lack numeric criteria in the Iowa WQS. The use of TSI values for chlorophyll and Secchi depth serves as an interim method of assessing lake water quality in Iowa until numeric criteria for nutrient parameters (phosphorus and nitrogen) and their response variables (chlorophyll a and turbidity) are adopted into the Iowa WQS.

Assessment Rationale

The concept of "trophic state" has long been used by limnologists to classify lakes and is based on the chemistry and biology of lakes. Although a number of approaches exist for classifying lakes according to trophic state, and although a number of variations exist regarding how "trophic state" is defined, the use of this framework has the advantages of historical usage, general acceptance of the trophic state concept (e.g., "eutrophic" indicates nutrient enrichment), and an improved ability to describe lake condition versus a description using a single variable or number (e.g., total phosphorus concentration). Table 3-1 describes the general framework of the lake trophic state concept. For a discussion on the development and variety of trophic state indices, see Chapter 2 (*The Basis for Lake and Reservoir Nutrient Criteria*) in EPA (2000) (see http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/lakes/index.cfm).

Carlson's (1977) TSI is a numeric indicator of the continuum of the biomass of suspended algae in lakes and thus reflects a lake's nutrient condition and water transparency. The level of plant biomass is estimated by calculating the TSI value for chlorophyll a. TSI values for total phosphorus and Secchi depth serve as surrogate measures of the TSI value for chlorophyll. The focus on turbidity in general, and chlorophyll in particular, seems appropriate for assessing the degree to which Iowa lakes support their designated Class A1 (primary contact recreation) use. Carlson's TSI provides a convenient and well-established method for identifying turbidity-related impacts to Iowa lakes. As described in a subsequent paper by Carlson (1991), turbidity, and especially turbidity related to large populations of suspended algae, is a key indicator of the degree to which a lake supports primary contact uses:

> *[plant] biomass is a proximate measure of the problems that plague lakes. Probably few citizens complain about the productivity of their lake and fewer yet lodge complaints about phosphorus concentrations. A biomass-related trophic state definition places the emphasis of the classification on the problem rather than on any potential cause*.

Because of this direct linkage between the perceived level of water quality and turbidity, TSI values for chlorophyll a and Secchi depth will be used as guidelines to identify Iowa lakes that do not meet Iowa's narrative WQS protecting against "aesthetically objectionable conditions". Both chlorophyll a and Secchi depth appear applicable to Iowa's narrative water quality criterion protecting against aesthetically objectionable conditions in Iowa surface waters (IAC Current, 61.3(2)). DNR Fisheries Bureau staff will be contacted to corroborate that the aesthetically objectionable conditions suggested by the TSI values do, in fact, exist. Because aesthetics are more closely associated with recreational uses than to aquatic life uses of Iowa lakes, impairments based on violations of these narrative criteria are typically applied to Class A1 (primary contact recreation) uses for purposes of IR assessments and listings.

For two reasons, TSI values for total phosphorus are not used as the primary basis for assessing support of either primary contact recreation uses or aquatic life uses:

- *TSI's for total phosphorus are poor predictors of impairment due to either Secchi depth or chlorophyll a:* The typical use of the TSI for total phosphorus to measure trophic state (and the level of water quality) presumes that the relationship between total phosphorus and chlorophyll a will, more or less, hold for the lake being assessed. The production of chlorophyll in Iowa's natural lakes and impoundments, however, is sometimes limited by nutrients other than phosphorus (e.g., nitrogen) and/or high levels of non-algal turbidity in the water column. Other information suggests that phosphorus is seldom a limiting nutrient in Iowa's nutrient-rich lakes. The result is that lakes with very high levels of total phosphorus that suggest hypereutrophic conditions sometimes have levels of chlorophyll a and Secchi depth that suggest relatively good water quality (i.e., in the middle to lower eutrophic range). As examples, the Iowa lakes in Table 3-2 are those that had TSI values for total phosphorus in the hypereutrophic range (i.e., greater than 70) but that had TSI values for chlorophyll a and Secchi depth less than the impairment trigger of TSI=65. Examples of lakes in Iowa with historically high TSI values for total phosphorus but low values for chlorophyll a and Secchi depth include West Lake Osceola (Clarke County), Saylorville Reservoir (Polk County), and Red Rock Reservoir (Marion County). Thus, while these lakes have very high levels of total phosphorus that might suggest impairment of designated uses, the levels of chlorophyll a are relatively low and Secchi depths are relatively high and thus do not suggest impairment. Because of this lack of correlation between TSI values for total phosphorus and TSI values for the response variables that define the aesthetically objectionable conditions, TSI values for total phosphorus are not used as the primary basis for determining the level of use support or for identifying water quality impairments at Iowa lakes.

- *The* Iowa WQS *lack water quality criteria-narrative or numeric-that are relevant to impacts of total phosphorus in surface waters*. When developing this assessment procedure, careful consideration of Iowa's numeric and narrative criteria in the Iowa WQS showed that none of these criteria are directly relevant to levels of phosphorus in the water column of a lake. That is, phosphorus is not a toxic substance at ambient levels seen in Iowa waters. In addition, high levels of phosphorus in Iowa lakes do not necessarily lead to either nuisance aquatic life or aesthetically objectionable conditions. For example, lakes with growths of aquatic macrophytes in littoral zone areas can have high levels of phosphorus but have low levels of chlorophyll a and have good water transparency.

For lakes where assessment information from the DNR Fisheries Bureau is available, TSI values were also used to supplement assessments of the designated Class B aquatic life uses based on best professional judgment of DNR fisheries biologists. According to biologists in the DNR Fisheries Bureau, algal blooms can also cause impairments to aquatic life uses of Iowa lakes through interference with some spawning activities of nest building species, e.g., Bluegill, Bullhead spp., Crappie spp., and Largemouth Bass) and lowered levels (sags) of dissolved oxygen that, in extreme cases, can cause fish mortality.

Identifying Water Quality Impairments at Iowa Lakes Based on TSI

For purposes of developing water quality assessments Carlson's (1977, 1984, 1991) TSI values were calculated using the data generated from approximately 130 Iowa lakes as part of ISU surveys from the current assessment period (Table 1). Overall (five-year) median values were used to calculate TSI values for total phosphorus, chlorophyll a, and Secchi depth for each lake. The identification of an impairment of the primary contact uses was based on TSI values for chlorophyll a and/or Secchi depth. The TSI values for the indicator variable of total phosphorus are used primarily to interpret discrepancies between TSI values for chlorophyll a and Secchi depth.

Relevant state water quality criteria

The Iowa WQS (567 IAC Chapter 61) do not contain numeric criteria for nutrients (e.g., nitrogen or phosphorus), chlorophyll, or turbidity that apply to Class A1 uses. Thus, the assessments of the degree to which these parameters might impair the Class A1 uses are based on a comparison of lake-specific TSI values to the following narrative criteria for general use waters as defined in Section 61.3(2) of the Iowa WQS:

> Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor, or other aesthetically objectionable conditions.
>
> Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life;

Examples of *aesthetically objectionable conditions* include poor water transparency caused by blooms of algae or high levels of non-algal turbidity that make the lake less desirable (aesthetically unpleasing) for primary contact recreation. Cyanobacteria blooms can also cause *aesthetically objectionable conditions* due to their ability to create unpleasant floating scums on the water surface or unpleasant odors, both of which can limit the primary contact recreation uses at a lake. In addition, cyanobacteria can be considered a form of *nuisance aquatic life* due to their ability to produce toxins that can adversely affect aquatic life and the uses of the lake for watering by livestock and wildlife. In severe cases, levels of these toxins in lake water can affect human health.

DNR is aware that some of the *aesthetically objectionable conditions* and/or *undesirable or nuisance aquatic life* at the lakes assessed as "impaired" may not be attributable to either wastewater discharges or agricultural practices. For example, a number of lakes assessed as "impaired" based on TSI values are very shallow (mean depth less than 2 meters) natural lakes of glacial origin with very low watershed-to-surface area ratios. The turbidity-related water quality problems at these lakes, whether caused by algae or suspended inorganic sediments, are due primarily to lack of sufficient water depth to prevent internal nutrient recycling and sediment re-suspension due to either bottom-feeding fish (e.g., Common Carp) and/or wind/wave action. Regardless, the levels of turbidity (whether of algal or non-algal origin) at these lakes constitute limitations to the use of these lakes for their designated beneficial uses. Thus, these lakes are appropriate for addition to the state list of impaired waters.

Data sources

The primary data source for assessing the degree to which Iowa lakes support their designated primary contact uses is chlorophyll a and Secchi depth values generated for approximately 130 Iowa lakes sampled as part of the ISU surveys from the current assessment period. Data for inorganic suspended solids and total phosphorus from these surveys were also used to interpret TSI values and to provide a more complete assessment of lake water quality. Information from the DNR Fisheries Bureau on recent water quality conditions/problems, the status of fish populations, and on lake history was used where appropriate to supplement assessments based on TSI values for chlorophyll a and/or Secchi depth and to verify the existence of any "aesthetically objectionable condition" suggested by TSI values. In addition, information on lake phytoplankton communities from the ISU and SHL surveys was used to determine the amount and proportion of cyanobacteria in the water column. The amount of cyanobacteria was used to determine potential impairments due to nuisance aquatic life.

Data requirements for listing

Data quantity

In 1990, in order to improve the accuracy and confidence level of Section 305(b) water quality assessments, DNR developed "data completeness guidelines" for using results of routine water quality monitoring. With the advent of Section 303(d) listing in the late 1990s, these state guidelines were used to identify the numbers of samples needed for water quality assessments that could support Section 303(d) listings (i.e., *monitored* assessments). Assessments based on less than the recommended number of samples are considered "evaluated"; these assessments are of lower confidence than "monitored" assessments and are thus not appropriate for Section 303(d) impaired waters listing but are appropriate for Section 305(b) water quality reporting. In order to account for the year-to-year variability in lake water quality, state limnologists participating in the EPA Region 7 nutrient criteria regional technical assistance group (RTAG) (IA, KS, MO, NE) recommend in 2001 that the combined data from at least three years of monitoring conducted from three to five times per year should be used to characterize lake water quality and to identify water quality impairments. This recommendation has been incorporated into DNR's data completeness guidelines. Thus, for purposes of Iowa's current IR, overall median water quality values from the five-year period from the current assessment period (approximately 15 samples) will be used to calculate TSI values to determine the existence of an impairment. As is typical in all monitoring networks, special circumstances occasionally prevent either sample collection (e.g., adverse weather conditions) or the reporting of data (e.g., laboratory accidents). For purposes of identifying candidate lakes for Iowa's impaired waters list, only those lakes with at least 10 samples each for chlorophyll a and Secchi depth over the five-year period will be considered to meet DNR's data completeness guidelines. Assessments for lakes with fewer than 10 samples for this period will be considered "evaluated" and thus will not be used to identify candidate lakes for impaired waters listing. Other lake water quality datasets appropriate for calculating TSI values will be reviewed to determine compliance with DNR's data completeness guidelines.

Data quality

As specified in the 2001 Iowa Code, Section 455B.194, subsection 1, (Iowa's credible data law) the department shall use credible data when determining whether any water of the state is to be placed on or removed from any Section 303(d) list (Category 5 of the IR). In addition, Iowa's credible data law specifies that data more than five years before the end of the current IR data consideration period are presumed under state law to be "not credible" unless DNR identifies compelling reasons as to why the older data are credible. Data generated by the ISU lake survey and through the SHL lake monitoring network meet all requirements of Iowa's credible data law and can thus be used to add waters to Iowa's impaired waters list. Other datasets appropriate for calculating TSI values will be reviewed to determine compliance with Iowa's credible data law.

Threshold TSI values

Similar to Iowa's five previous IR cycles, a TSI value of greater than or equal to 65 for either chlorophyll a or Secchi depth will be used to identify candidate lakes for Category 5 of Iowa's current IR (see Table 3-1 for a description of the IR categories). This threshold is similar to that used by the Minnesota Pollution Control Agency (MPCA) for lakes in the Western Corn Belt Plains ecoregion of southern Minnesota (MPCA 2005). Nearly the entire state of Iowa lies in this same ecoregion, the exceptions being (1) the portion of south-central and southeastern Iowa in the Central Irregular Plains ecoregion and (2) the portion of northeastern Iowa in the Driftless Area ecoregion. Lakes with TSI values greater than or equal to 65 are likely to have nutrient or sediment-related water quality problems that contribute to excessive turbidity (algal or non-algal) that impair the Class A1 uses and are thus potential candidates for Section 303(d) listing.

Assessment categories ("monitored" and "evaluated")

Prior to recent revisions to guidance for state compliance with Sections 305(b) and 303(d) of the Clean Water Act (EPA 2003, 2005), EPA (1997) recommended that states identify water quality assessments as one of two types: evaluated or monitored. "Evaluated" assessments are those based on data older than five years or other than site-specific ambient monitoring data (e.g., questionnaire surveys of fish and game biologists [=best professional judgment] or predictive modeling using estimated input values) and thus are of relatively low confidence. In contrast, "monitored" assessments are based primarily on recent, site-specific ambient monitoring data and thus are of relatively high confidence. DNR has historically not considered waterbodies identified as impaired based on evaluated (lower confidence) assessments as candidates for the state's Section 303(d) list. DNR has, however, historically considered waterbodies identified as impaired based on monitored (higher confidence) assessments as candidates for the state's Section 303(d) list. In order to maintain continuity with past assessment procedures, and due to the usefulness of EPA's (1997) recommendation, DNR continues to (1) identify each assessment of lake water quality as either evaluated or monitored and (2) consider only lakes with recent site-specific data ("monitored" assessments) as candidates for Section 303(d) listing. Similar to listings for other types of waterbodies, however, once a lake is added to the state's Section 303(d) list, the lake will remain on the list until new data or some other good cause suggests that the lake should be removed from Iowa's list. Age of data is not an acceptable reason for removing waters from the state's Section 303(d) list.

Use support categories

The following are detailed descriptions of the use support categories used for Section 305(b) lake assessments. This approach is the same as that used for previous IR cycles in Iowa. The TSI values associated with each of these use support categories are summarized in Table 3-3. Any impairments (i.e., "aesthetically objectionable conditions") suggested by TSI values for chlorophyll a and/or Secchi depth are verified by DNR field (Fisheries) staff.

Not Supported and "monitored": candidate for Section 303(d) listing:

If the overall lake-specific median summer TSI value for either chlorophyll a or Secchi depth is greater than or equal to 65, then the lake should be assessed as "not supported" designated use, and the lake should be considered as a candidate for Section 303(d) listing. These lakes are likely to have severe turbidity-related impacts, of either algal or non-algal origin that (1) interfere with designated uses for primary contact recreation and (2) constitute an aesthetically objectionable condition that violates narrative criteria for general use waters as defined in Section 61.3(2) of the Iowa WQS. The TSI threshold value for chlorophyll a and/or Secchi depth is the lower limit that identifies "hypereutrophic" lakes (Table 3-1). Thus, this threshold value provides strong evidence of a water quality impairment.

WINOFI "evaluated": not candidates for Section 303(d) listing:

If the overall lake-specific median summer TSI value for either chlorophyll a or Secchi depth is greater than or equal to 65, but the TSI value(s) is based on less than sufficient data (<9 samples), then the lake should be assessed as "WINOFI" designated use but should not be considered a candidate for Section 303(d) listing. These lakes may have turbidity-related impacts, of either algal or non-algal origin, that may interfere with designated uses for primary contact recreation and/or aquatic life. Thus, while the TSI values for Iowa lakes in this category *may* be impaired for Class A1 use, insufficient data are available for developing Section 305(b) assessments having the high degree of confidence needed to justify Section 303(d) listing. These lakes will be placed into IR Category 3b and will thus be added to Iowa's list of WINOFI. Note: due to the existence of sufficient data for chlorophyll a and Secchi depth from lakes in Iowa's ambient lake monitoring program, TSI-based "evaluated" (lower confidence) assessments are rare.

Fully Supported; "evaluated" or "monitored": not candidates for Section 303(d) listing

Lakes with overall summer median TSI values for chlorophyll a and Secchi depth less than 65 are assessed as "fully supported" their designated use for primary contact recreation. These lakes have moderately-good (TSI approaching 65) to sometimes exceptional (TSI < 55) water quality with only brief episodes of marginal water quality conditions. The TSI threshold values for both chlorophyll a and Secchi depth in this category range from the middle range between eutrophic and hyper-eutrophic lakes to the upper range of mesotrophic lakes. Thus, the range of lake quality in this assessment category is considerable.

Delisting Water Quality Impairments Based On TSI

For lakes on Iowa's Section 303(d) list of impaired waters (IR Category 5), median-based TSI values for both chlorophyll a and Secchi depth must be 63 or less for two consecutive IR cycles before a lake can be removed from this list. A TSI value of 63 indicates a chlorophyll a concentration of approximately 27 µg/L and a Secchi depth of approximately 0.8 meters. The requirement to have two consecutive IR cycles where a previously-impaired lake's TSI values are 63 or less is designed to ensure that a long-term and relatively stable improvement in lake water quality has occurred before delisting the impairment.

Management and Accessibility of Assessments

The Section 305(b) assessments of the degree of support of the primary contact recreation (Class A1) and aquatic life (Class BLW or BWW) uses for the lakes sampled as part of the DNR's lake monitoring programs are entered into DNR's Section 305(b) assessment database (ADBNet).

Table 3-1. Changes in temperate lake attributes according to trophic state (modified from EPA 2000, Carlson and Simpson 1996, and Oglesby et al. 1987).

TSI Value	Attributes	Primary Contact Recreation	Aquatic Life (Fisheries)
50-60	eutrophy: anoxic hypolimnia; macrophyte problems possible	[none]	warmwater fisheries only; percid fishery; bass may be dominant
60-70	Cyanobacteria (blue-green algae) dominate; algal scums and macrophyte problems occur	weeds, algal scums, and low transparency discourage swimming and boating	Centrarchid fishery
70-80	hyper-eutrophy (light limited). Dense algae and macrophytes	weeds, algal scums, and low transparency discourage swimming and boating	Cyprinid fishery (e.g., Common Carp and other rough fish)
>80	algal scums; few macrophytes	algal scums, and low transparency discourage swimming and boating	rough fish dominate; summer fish kills possible

Table 3-2. Iowa lakes with overall median TSI values for total phosphorus greater than 70 (=hypereutrophic) that have TSI values for chlorophyll a and Secchi depth that do <u>not</u> suggest impairment of primary contact recreation (i.e., TSI values of less than 65). TSI values are based on data from the Iowa State University and the State Hygienic Laboratory surveys of 134 Iowa lakes from 2000 through 2010 (N approximately equal to 44); lakes are ranked by the TSI value for total phosphorus.

Lake Name	County	TSI for total phosphorus	TSI for chlorophyll a	TSI for Secchi depth
Saylorville Reservoir	Polk	81	56	61
Red Rock Reservoir	Marion	78	50	64
West Lake (Osceola)	Clarke	71	60	62

Table 3-3. Summary of ranges of TSI values and measurements for chlorophyll a and Secchi depth used to define Section 305(b) use support categories for Iowa lakes.

Level of Support	TSI value	Chlorophyll a (µg/L)	Secchi Depth (m)
Fully supported	<65	<33	>0.7
Not supported (monitored or evaluated: candidates for Section 303(d) listing)	≥65	≥33	≤0.7

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Attachment 4
Methodology for Assessing Iowa's Shallow Natural Lakes Class BLW Aquatic Life Use

Iowa DNR
Water Quality Monitoring & Assessment Section
Water Quality Bureau

Introduction

Iowa Department of Natural Resources (DNR) has historically relied on the professional judgment of DNR biologists to assess Iowa's shallow lakes and wetlands due to the lack of (1) monitoring data, (2) appropriate water quality criteria and (3) an assessment protocol. Although assessed for purposes of Section 305(b) reporting, Iowa's wetlands and shallow lakes have typically not been identified as candidates for Section 303(d) impaired waters listing. That is, without water quality monitoring data, and without an assessment protocol to objectively identify the degree to which a shallow lake or wetland supported its designated aquatic life use, DNR was unable to develop high-confidence assessments that would support a Section 303(d) listing.

In 2006, the DNR Watershed Monitoring and Assessment Section initiated routine water quality monitoring on several shallow lakes and wetlands in north-central and northwest Iowa. For the assessment period (Table 1), data generated for total suspended solids and chlorophyll a from Iowa's shallow natural lakes of glacial origin were again used with guidelines for wetland assessment from the Upper Mississippi River Conservation Committee's (UMRCC) Water Quality Technical Section (UMRCC 2003) using total suspended solids (TSS) and Carlson's (1977) trophic state index (TSI) for chlorophyll a to identify the degree to which these shallow lakes support their designated Class BLW aquatic life uses. Information from DNR field staff on the status of aquatic macrophytes and aquatic macroinvertebrates at the shallow lakes monitored will be used to supplement the water quality assessments developed.

Assessment Rationale

High levels of TSS impact the ability of a shallow lake to support the growth of submersed aquatic vegetation (SAV). Because submersed aquatic vegetation is critical to the health of shallow lake ecosystems, the elimination of SAV can degrade habitat quality such that undesirable aquatic species such as cyanobacteria, Common Carp (*Cyprinus carpio*), and Fathead Minnows (*Pimephales promelas*) dominate the ecosystem.

The concept of "trophic state" has long been used by limnologists to classify lakes and is based on the chemistry and biology of lakes. Although a number of approaches exist for classifying lakes according to trophic state, and although a number of controversies exist regarding how "trophic state" is defined, the use of this framework has the advantages of historical usage, general acceptance of the trophic state concept (e.g., "eutrophic" indicates nutrient enrichment), and an improved ability to describe lake condition versus a description using a single variable or number (e.g., total phosphorus concentration). Table 4-1 describes the general framework of the lake trophic state concept. For a discussion on the development and variety of trophic state indices, see Chapter 2 (*The Basis for Lake and Reservoir Nutrient Criteria*) in EPA (2000) (see http://WW2.epa.gov/nutrient-policy-data/criteria-development-guidance-lakes-and-reservoirs*).*

Carlson's (1977) TSI is a numeric indicator of the continuum of the biomass of suspended algae in lakes and thus reflects a lake's nutrient condition and water transparency. The level of plant biomass is estimated by calculating the TSI value for chlorophyll a. TSI values for Secchi depth serve as surrogate measures of the TSI values for chlorophyll. Carlson's trophic state index provides a convenient and well-established method for identifying turbidity-related impacts to Iowa lakes and thus seems appropriate for assessing the degree to which Iowa's shallow lakes support their designated Class BLW aquatic life uses.

Because of the direct linkage between and turbidity and attainment of aquatic life goals, a TSI value for chlorophyll a will be used to identify shallow lakes in Iowa that do not fully support their designated Class BLW aquatic life uses. For the following reason, the TSI value for Secchi depth will not be used to evaluate the attainment of aquatic life goals of shallow lakes. Due to the depth of these shallow lakes, TSI values for Secchi depth can be misleading. In some instances, the Secchi disk remains visible at the bottom of the lake and the depth of the lake is recorded as the Secchi depth. In these instances, the water clarity may be sufficient to support the Class BLW uses, but the index value is limited by the depth of the lake. Thus, total suspended solids will be used as an indicator of water clarity to determine whether or not the Class BLW uses are impaired in these shallow systems.

DNR field staff will provide available information from surveys for aquatic macrophytes, aquatic macroinvertebrates, and fish populations to supplement the assessment and to corroborate any impairment of aquatic life uses that is identified. DNR field staff will be contacted to ensure that the TSI-based assessment is consistent with their knowledge of the particular shallow lake.

The connection of TSS and chlorophyll a (as interpreted by the TSS) at shallow lakes to the Iowa Water Quality Standards (WQS) is the attainment of the designated Class BLW aquatic life use. This use is defined as follows:

> Lakes and wetlands (Class BLW). These are artificial and natural impoundments with hydraulic retention times and other physical and chemical characteristics suitable to maintain a balanced community normally associated with lake-like conditions.

The goal of Iowa's shallow lakes management strategy is to use techniques such as lake draw-downs and biomanipulation to shift the lake from a turbid, algae-dominated system with little or no rooted aquatic vegetation and a poor-quality sport fishery to a clear-water, macrophyte-dominated state that supports a balanced warmwater aquatic community of fish, aquatic macroinvertebrates, and aquatic vegetation (macrophytes) (Iowa DNR 2008). This total suspended solids and TSI-based assessment method, with its focus on water clarity to promote growth of submersed aquatic vegetation, provides an objective measure of the relative success of DNR's management strategy.

This methodology applies only to shallow lakes and not to wetlands. For purposes of this Integrated Report (IR) cycle, shallow lakes are defined as lakes with maximum depths typically greater than seven feet but less than 15 feet. Shallow lakes typically do not stratify thermally in summer. Abundant rooted aquatic vegetation (macrophytes), including submergent and emergent vegetation, may cover much of a shallow lake. Shallow lakes can support a variety of beneficial uses including boating, fishing, waterfowl production, hunting, aesthetics, and limited swimming. Wetlands have maximum depths typically less than seven feet, often have minimal open water in summer, and are typically not managed as sport fisheries but for waterfowl and wildlife production, hunting, and aesthetics. Wetlands are not managed for swimming uses and lack swimming beaches. Due to limitations in DNR's assessment database (*ADBNet*), Iowa's shallow lakes are placed in the "wetland" category.

Identifying Water Quality Impairments at Shallow Lakes

Overview

For purposes of developing water quality assessments for the IR cycle, the TSS concentration and Carlson's (1977) TSI were used with the three years of data generated for Iowa shallow lakes as part of DNR surveys from assessment period (Table 1). Overall (three-year) summer-season median value for total suspended solids and the TSI value for chlorophyll a were used for each lake. The identification of impairments of the Class BLW aquatic life uses was based on the resulting median total suspended solids concentration and median-based TSI value for chlorophyll a.

Relevant state water quality criteria

The Iowa WQS (567 IAC Chapter 61) do not contain numeric criteria for nutrients (e.g., nitrogen or phosphorus), chlorophyll, or turbidity that apply to Class BLW aquatic life uses. Thus, the assessments of the degree to which the Class BLW uses supported are based on a determination of whether this use is impaired by turbidity as interpreted through the TSI (Carlson 1977) and the UMRCC (2003) benchmarks to protect growth of SAV. The assessments of the degree to which turbidity might impair the Class BLW uses of shallow lakes are based on a comparison of lake-specific TSI values to the following narrative criteria for general use waters as defined in Section 61.3(2) of the Iowa WQS:

Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life;

Examples of *undesirable or nuisance aquatic life* include cyanobacteria blooms, blooms of sestonic algae, and dominance by populations of undesirable fish species (e.g., Common Carp). Cyanobacteria can be considered a form of *nuisance aquatic life* due to their ability to produce toxins that can adversely affect aquatic life and the uses of the lake for watering by livestock and wildlife. In severe cases, levels of these toxins in lake water can affect human health.

DNR is aware that the presence of *undesirable or nuisance aquatic life* at the shallow lakes assessed as "impaired" may not be attributable to either wastewater discharges or agricultural practices. The turbidity-related water quality problems at these shallow lakes, whether caused by algae or suspended inorganic sediments, are due primarily to a dominance of nuisance aquatic life (e.g., Common Carp) that prevents the growth of rooted aquatic vegetation that is needed to stabilize shoreline sediments and improve water clarity. Without rooted aquatic vegetation, nutrient-rich sediments are easily resuspended into the water column by either bottom-feeding fish and/or wind/wave action. Regardless, high levels of turbidity (whether of algal or non-algal origin) at these lakes can limit the ability of the lake to support their designated aquatic life uses. Thus, these lakes are appropriate for addition to the state list of impaired waters.

Data Sources

Data for TSS and chlorophyll a collected by DNR staff from the assessment period (Table 1) will be used. DNR field staff will also provide information on the status of aquatic macrophyte, macroinvertebrate, and fish communities at the shallow lakes assessed.

Data requirements for listing

Data quantity

In 1990, in order to improve the accuracy and confidence level of water quality assessments, DNR developed "data completeness guidelines" for using results of routine water quality monitoring for Section 305(b) reporting. These state guidelines identify the numbers of samples needed for water quality assessments that can support Section 303(d) listings (i.e., a *monitored* assessment). Assessments based on less than the recommended number of samples are considered "evaluated"; these assessments are of relatively lower confidence than "monitored" assessments and are thus not appropriate for Section 303(d) impaired waters listing but are appropriate for Section 305(b) water quality reporting.

In order to account for the year-to-year variability in lake water quality, state limnologists participating in the EPA Region 7 nutrient criteria regional technical assistance group (RTAG) (IA, KS, MO, NE) recommend in 2001 that the combined data from at least three years of monitoring conducted from three to five times per year should be used to characterize lake water quality and to identify water quality impairments. This recommendation has been incorporated into DNR's data completeness guidelines.

Thus, for purposes of Iowa's Integrated Report (IR), overall summer-season median water quality values from the three-year assessment period (Table 1) will be used to calculate overall median TSS concentrations and chlorophyll TSI values to determine the existence of a turbidity-related impairment. Only those shallow lakes with at least nine samples for TSS, chlorophyll a and Secchi depth over the assessment period (Table 1) will be considered to meet DNR's data completeness guidelines. Assessments for shallow lakes with fewer than nine samples for this period will be considered "evaluated" (i.e., of lower confidence) and thus will not be used to identify candidate lakes for Section 303(d) impaired waters listing.

Data quality

As specified in the 2001 Iowa Code, Section 455B.194, subsection 1, (Iowa's credible data law) the department shall use credible data when determining whether any water of the state is to be placed on or removed from any Section 303(d) list (Category 5 of the IR). In addition, Iowa's credible data law specifies that data more than five years before the end of the Section 305(b) assessment period (Table 1) are presumed under state law to be "not credible" unless DNR identifies compelling reasons as to why the older data are credible. Data generated by the DNR staff as part of the assessment period (Table 1) shallow lakes surveys meet all requirements of Iowa's credible data law and can thus be used to add shallow lakes to Iowa's impaired waters list.

Threshold total suspended solids value

Based on guidelines proposed by the Upper Mississippi River Conservation Committee's Water Quality Technical Section (UMRCC 2003), an overall growing season median concentration of TSS equal to or greater than 30 mg/L will be used to identify candidate shallow lakes for Section 303(d) listing and addition to Category 5 of Iowa's IR (see Table 2 for a description of the IR categories). (Note: the original recommended TSS threshold for SAV was 25 mg/L; this threshold was subsequently revised to 30 mg/L (John Sullivan, Wisconsin DNR (retired), personal communication.) Shallow lakes with TSS concentrations greater than or equal to 30 mg/L are likely to have impeded growth of SAV. A lack of SAV can degrade habitat quality such that undesirable aquatic species such as cyanobacteria, Common Carp, and Fathead Minnows dominate. The presence of nuisance/undesirable aquatic species constitutes an impairment of the Class BLW aquatic life uses and therefore makes lakes with a TSS concentration equal to or greater than 30 mg/L candidates for Section 303(d) listing. Shallow lakes with TSS concentrations approaching, but not exceeding, 30 mg/L will also be considered candidates for Section 303(d) listing if data suggest a worsening water quality trend that threatens full support.

Threshold TSI values for chlorophyll

Similar to the approach for assessing lake water quality that Iowa has used since the 2004 IR cycle, a TSI value of equal to or greater than 65 for chlorophyll a will be used to identify candidate shallow lakes for Section 303(d) listing and addition to Category 5 of Iowa's IR. Lakes with TSI values greater than or equal to 65 are likely to have nutrient water quality problems that contribute to excessive turbidity (algal) that impair the Class BLW aquatic life uses and are thus potential candidates for Section 303(d) listing. Shallow lakes with TSI values approaching, but not exceeding, 65 will also be considered candidates for Section 303(d) listing if data suggest a worsening water quality trend that threatens full support. This methodology is similar to that used by the Minnesota Pollution Control Agency for lakes in the Western Corn Belt Plains ecoregion of southern Minnesota (MPCA 2005). All of Iowa's natural lakes of glacial origin lie within this ecoregion. As explained under *Assessment Rationale*, the TSI value for Secchi depth will not be used to evaluate the attainment of aquatic life goals. Due to the depth of these shallow lakes, TSI values for Secchi depth can be misleading. In some instances, the Secchi disk remains visible at the bottom of the lake. In these instances, the depth of the lake is recorded as the Secchi depth. The water clarity, therefore, may be sufficient to support the Class BLW uses, but the index value is limited by the depth of the lake. This makes the Secchi depth TSI value, an unreliable indicator of water clarity conditions. Total suspended solids will be used as an indicator of water clarity to determine whether or not the Class BLW uses are impaired in these shallow systems.

Assessment categories ("monitored" and "evaluated")

Prior to recent revisions to guidance for state compliance with Sections 305(b) and 303(d) of the Clean Water Act (EPA 2003, 2005), EPA (1997) recommended that states identify water quality assessments as one of two types: evaluated or monitored. Evaluated assessments are those based on data older than five years or other than site-specific ambient monitoring data (e.g., questionnaire surveys of fish and game biologists [=best professional judgment] or predictive modeling using estimated input values) and thus are of relatively low confidence. In contrast, monitored assessments are based primarily on recent, site-specific ambient monitoring data and thus are of relatively high confidence. DNR has historically not considered waterbodies identified as impaired based on evaluated (lower confidence) assessments as candidates for the state's Section 303(d) list. DNR has, however, historically considered waterbodies identified as impaired based on monitored (higher confidence) assessments as candidates for the state's Section 303(d) list. In order to maintain continuity with past assessment procedures, and due to the usefulness of EPA's (1997) recommendation, DNR continues to (1) identify each assessment of lake water quality as either evaluated or monitored and (2) only consider lakes with recent site-specific data ("monitored" assessments) as candidates for Section 303(d) listing.

Use support categories

The following are detailed descriptions of the use support categories used for Section 305(b) shallow lake assessments. The TSS concentrations associated with each of these support categories are summarized in Table 4-2. The chlorophyll a TSI values associated with each of these use support categories are summarized in Table 4-3. This assessment methodology is summarized in Table 4-4. Any impairments suggested by TSS concentrations or TSI values for chlorophyll a are verified by DNR field staff.

Not Supported and "monitored": candidate for Section 303(d) listing

If the overall shallow lake-specific summer-season median TSS concentration based on at least nine samples is greater than or equal to 30 mg/L, or the summer-season median TSI value for chlorophyll a based on at least nine samples is greater than or equal to 65, then the lake should be assessed as "not supported" its designated aquatic life uses, and the lake should be considered as a candidate for Section 303(d) listing. These lakes are likely to have moderate to severe turbidity-related impacts, of either algal or non-algal origin that prevent the shallow lake from supporting its Class BLW aquatic life use. TSI values from 65 and above are in the middle to upper range between eutrophic and hypereutrophic lakes. The TSS concentration for this use support category is utilized by the Upper Mississippi River Conservation Committee's Water Quality Technical Section as a threshold to sustain SAV in the Upper Mississippi River. The chlorophyll a threshold values for this use support category (65 and above) are those used by the Minnesota Pollution Control Agency to identify Section 303(d)-impaired lakes in southern Minnesota (MPCA 2005). As such, these thresholds are appropriate for identifying impairments in Iowa lakes.

Waters in need of further investigation (WINOFI) "evaluated": not candidates for Section 303(d) listing:

If the overall shallow lake-specific median total suspended solids concentration is greater than or equal to 30 mg/Lor the summer TSI value for chlorophyll a is greater than or equal to 65, but the TSS and TSI values are based on less than sufficient data (i.e., less than nine samples over the three-year period), then the shallow lake should be assessed as "WINOFI" designated uses but should not be considered a candidate for Section 303(d) listing. These shallow lakes possibly have turbidity-related impacts, of either algal or non-algal origin, that may interfere with support of designated uses for aquatic life. Thus, while the TSS concentration and/or TSI value for Iowa lakes in this category *may* be impaired for Class BLW uses, insufficient data are available for developing Section 305(b) assessments having the high degree of confidence needed to justify Section 303(d) listing. These shallow lakes will be placed into IR categories 2b or 3b and will thus be added to Iowa's WINOFI list.

Shallow lakes with overall summer-season median TSS concentrations based on at least nine samples of less than 30 mg/L or TSI values for chlorophyll a based on at least nine sample of less than 65, but that demonstrate adverse trends in any of these parameters such that impairment is likely for the next IR cycle, will be considered "fully supported/threatened (impaired)" and considered candidates for addition to IR Category 5 (Section 303(d) list). Because, however, sufficient data do not currently exist to determine the existence of water quality trends at Iowa's shallow lakes, identification of adverse trends will likely not be possible for the current IR cycle.

Fully Supported; "monitored": not candidates for Section 303(d) listing:

If the overall shallow lake-specific summer-season median TSS concentrations are less than 30 mg/L and TSI values for chlorophyll a are less than 65 in the absence of any adverse water quality trend, and the overall median is based on based on at least nine samples, then the lake should be assessed as "fully supported" its designated aquatic life uses. The assessment type should be considered "monitored" (i.e., of higher confidence), and the water should be placed into Categories 1 or 2a of the IR. The TSI threshold values for chlorophyll a in this category range from the middle range between eutrophic and hyper-eutrophic lakes to the upper range of mesotrophic lakes.

Fully Supported; "evaluated": not candidates for Section 303(d) listing:

If the overall lake-specific summer-season median TSS concentration is less than 30 mg/L and TSI values for both chlorophyll a or Secchi depth are less than 65 in the absence of any adverse water quality trend, and the overall medians are based on fewer than nine samples, then the lake should be assessed as "fully supported" of its designated aquatic life uses. The assessment type, however, should be indicated as "evaluated" (i.e., of lower confidence).

Delisting TSI and SAV water quality impairments at shallow lakes
For shallow Iowa lakes assessed as Section 303(d) impaired to be delisted and/or considered "fully supported" of its designated aquatic life uses, two conditions must be met:

- The overall (three-year) median-based summer season TSI values for chlorophyll a must be 63 or less for two consecutive IR cycles before a shallow lake can be removed from the state's Section 303(d) list (IR Category 5). A TSI value of 63 indicates a chlorophyll a concentration of approximately 27 µg/L and a Secchi depth of approximately 0.8 meters. The requirement to have two consecutive IR cycles where a previously-impaired lake's TSI values are 63 or less is designed to ensure that a long-term improvement in lake water quality has occurred before delisting.

- The overall (three-year) median-based summer season level of TSS must be less than 30 mg/L for two consecutive IR cycles before a shallow lake can be removed from the state's Section 303(d) list (IR Category 5). Median levels of TSS less than 30 mg/L have been shown to be protective of growth of SAV, and SAV is crucial to shallow lake water quality and ecosystem function (UMRCC 2003). The delisting requirement to have median TSS levels below the impairment threshold of 30 mg/L for two consecutive IR cycles is designed to ensure that a long-term improvement in lake water quality has occurred before delisting.

If either of these conditions is not met, the shallow lake will remain impaired or will be included in IR Category 5 (the state's Section 303(d) list).

Management and Accessibility of Assessments
The Section 305(b) assessments of the degree of support of the Class BLW uses for the shallow lakes sampled as part of the DNR survey are entered into DNR's ADBNet.

Table 4-1. Changes in temperate lake attributes according to TSI (modified from EPA 2000, Carlson and Simpson 1996, and Oglesby et al. 1987).

TSI Value	Attributes	Primary Contact Recreation	Aquatic Life (Fisheries)
50-60	eutrophy: anoxic hypolimnia; macrophyte problems possible	[none]	warmwater fisheries only; percid fishery; bass may be dominant
60-70	Cyanobacteria (blue-green algae) dominate; algal scums and macrophyte problems occur	weeds, algal scums, and low transparency discourage swimming and boating	Centrarchid fishery
70-80	hyper-eutrophy (light limited). Dense algae and macrophytes	weeds, algal scums, and low transparency discourage swimming and boating	Cyprinid fishery (e.g., Common Carp and other rough fish)
>80	algal scums; few macrophytes	algal scums, and low transparency discourage swimming and boating	rough fish dominate; summer fish kills possible

Table 4-2. Assessment and impairment thresholds for aquatic life uses of shallow lakes in Iowa based on TSS concentrations. Median, summer-season TSS concentrations are calculated for each lake.

Total Suspended Solids Concentration	Rationale for threshold selection:	Assessment Decision:
< 30 mg/L	Water quality is sufficient to support growth of SAV (UMRCC 2003).	Full support: TSS concentrations indicate full support of aquatic life uses and Clean Water Act goals.
≥ 30 mg/L	A TSS concentration of 30 mg/L or greater is used by the UMRCC Water Quality Technical Section to indicate that SAV is inhibited. The inhibition of SAV leads to undesirable or nuisance aquatic life.	Not Supported / Impaired: Water clarity is sufficiently poor that aquatic life uses can be considered moderately impaired.

Table 4-3. Assessment and impairment thresholds for aquatic life uses of shallow lakes in Iowa based on TSI values. TSI values are calculated using an overall three-year summer-season median value for chlorophyll a and Secchi depth.

TSI value	Chlorophyll a (median during growing season)	Rationale for threshold selection:	Assessment Decision:
< 65	< 33 ppb	Water quality is sufficient to support growth of aquatic macrophytes (UMRCC 2003).	Full support: TSI values less than 65 indicate full support of aquatic life uses and Clean Water Act goals.
≥ 65	≥ 33 ppb	A TSI value of 65 is used by state of Minnesota as an impairment threshold for chlorophyll a and Secchi depth in shallow lakes in the southern part of the state (Heiskary and Wilson 2005). TSI values 65 or greater indicate generally poor water transparency such that growth of aquatic macrophytes is suppressed or eliminated.	Not Supported / Impaired: Water clarity is sufficiently poor that aquatic life uses can be considered moderately impaired.

Table 4-4. Summary of methodology for assessing support of Class BLW aquatic life uses in Iowa's shallow lakes. Based on at least nine samples collected over a three-year monitoring period, the concentration of TSS is the three-year growing season median. The TSI value for chlorophyll a is based on the overall three-year median concentration of chlorophyll a during the growing season.

Parameter:	**Fully** Supported	**Not** Supported
Total Suspended Solids:	< 30 mg/L	≥ 30 mg/L
	And	*Or*
Chlorophyll a TSI:	TSI < 65	TSI ≥ 65
Candidate for 303(d) listing?	**No**	**Yes**

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Attachment 5
Methodology for Identifying Recovery of Iowa Stream Fish Communities from Fish Kills

Water Quality Monitoring & Assessment Section and
Watershed Improvement Section,
Water Quality Bureau,
Iowa Department of Natural Resources

Introduction

The following protocol is designed to provide the biological information needed to determine whether a fish community impacted by fish kill events have recovered from those events. This protocol defines thresholds for numbers of fish species (species richness) and fish abundance (catch per unit effort or fish density) that indicate a stream fish community is similar to non-fish kill impacted fish communities in a given ecoregion or watershed. Fish communities in fish kill-impaired stream segments that meet or exceed both these thresholds will be considered to have recovered from the fish kill events, and the associated stream segment will be moved from an impairment category of Iowa's Integrated Report (IR) (IR Categories 5 or 4) to a non-impairment category (IR Category 3a).

Background

Based on the results an DNR study of fish kill recovery (Wilton 2002) that showed some streams recover relatively quickly from a fish kill event (within a few months), DNR's adoption of EPA's recommendation suggested that at least some fish kill-impaired stream segments would remain identified as Section 303(d) impaired (in IR Category 5) long after the full recovery of aquatic life in the affected waterbody had occurred.

Development of DNR's fish kill follow-up protocol

In late 2010, DNR staff began discussions on a procedure for follow-up sampling in fish kill-impaired stream segments. A fish kill follow-up biological sampling protocol was proposed for wadeable streams that, while based on DNR's bioassessment protocol, could be performed by existing DNR central office staff over a relatively short time frame without contract employee support, thus reducing the staff resources, cost, and time needed to conduct this monitoring. Because this sampling protocol does not include all aspects of DNR's bioassessment protocol (Iowa DNR 2015) and the sampling results cannot be used for comparison to ecoregion reference conditions, the decision was made to consider any stream showing recovery from a fish kill event as "not assessed" (IR Category 3a) as opposed to "fully supported" of the aquatic life use (IR Categories 1 or 2). Thus, if fish kill follow-up sampling suggested recovery from fish kill events, the impairment would be delisted and moved to the non-impairment category of Iowa's Integrated Report (IR 3a) indicating that there are insufficient data to assess support of the designated use.

DNR staff met with EPA Region 7 staff in July 2011 to discuss this proposal for fish kill follow-up sampling and the delisting of fish kill impairments. Region 7 staff were generally supportive of the DNR proposal.

The following is an overview of the DNR fish kill follow-up sampling protocol:

- Fish kill segments in Categories 5 and 4 are targeted for follow-up sampling to determine the composition and abundance of the fish community. Field sampling is conducted during the July 15-October 15 biomonitoring timeframe as defined by the DNR bioassessment protocol (Iowa DNR 2015).
- Sample locations are located within the stream assessment segment identified as affected by the fish kill(s).
- As recommended by the DNR bioassessment protocol, the length of stream sampled is set at 30 times the estimated average stream width.
- Fish are sampled in one pass with backpack electrofishing equipment with the size of the sampling crew varying from 2 to 4 depending on stream width. The DNR general rule is one probe for every 15 feet of stream width.
- All fish collected are identified to species, counted, and returned to the stream. Unknown specimens are preserved for later identification.
- Field sheets from fish kill follow-up sampling sessions are scanned and stored on the department's network drive. All calculations and associated comparisons from each sampling event are also stored on the network drive as are the photographs taken to document the field work conducted.

Identifying recovery from the fish kill event(s)

Two components of the fish community are measured and compared to benchmark values to determine the degree to which the results of fish kill follow-up sampling indicate recovery from a fish kill event(s): fish species richness (SR) and fish abundance.

- Comparison of observed to expected fish species richness

  Delisting threshold: If 50% or more of the regionally expected fish species are present at the fish kill follow-up site, the SR of the fish community will be considered to have recovered from the fish kill event(s).

  Expectations for fish SR in Iowa streams have previously been developed for purposes of Section 305(b) reporting (Iowa DNR 2002; Table 5-1). The 50% SR threshold value has been used historically by DNR for IR assessments and listings based on fish survey data (Iowa DNR 2001) and on freshwater mussel survey data (Iowa DNR 2005). Given the large variability in SR between watersheds and even between streams within a watershed or ecoregion, the 50% threshold is an appropriate threshold for expected SR.

  If less than 50% of the expected fish species are present, the fish community is considered to not meet regional expectations thus suggesting an ongoing impact from the fish kill event(s).

- Comparison of fish abundance (i.e., catch per unit effort or fish density) to benchmark values established through other DNR biological sampling projects.

  Delisting threshold: If the fish abundance at the fish kill follow-up site (reported as number of fish per 500 feet of stream) equals or exceeds the 25th percentile of the Level IV ecoregion fish abundance estimates from the 2002-2006 Iowa REMAP project, the fish abundance of the stream segment will be considered to have recovered from the fish kill event(s). The selection of the 25th percentile delisting threshold is based on the common use of the 25th percentile as an ecoregion reference benchmark. Use of the reference 25th percentile as an impairment threshold is consistent with biocriteria development guidance (EPA 1996), and has demonstrated efficacy in state bioassessment programs (Yoder and Rankin 1995).

Fish kill impairment delisting decisions

If the fish community fails to meet either the SR threshold or the fish abundance threshold, the stream segment will remain assessed as "impaired" and will remain in IR impairment categories 4 or 5. These stream segments will be considered for additional fish kill follow up sampling and or monitoring with the DNR Bioassessment protocol to help determine the magnitude of potential aquatic life use impairment.

Fish communities that meet regional expectations for both SR and abundance are considered to have recovered from the fish kill event(s). The associated impaired stream assessment segments will be removed from IR impairment categories (4 or 5). Because this fish kill follow-up monitoring protocol does not include all aspects of DNR's biological assessment protocol (Iowa DNR 2015), recovery of the fish community from kill event(s) does not necessarily indicate "full support" of the aquatic life use. Rather, this protocol is designed to determine whether the fish kill-impacted stream fish community is now similar to other non-fish kill-affected fish communities in a given ecoregion or watershed. Thus, assessment segments identified as recovered are most appropriate for placement in IR Category 3a (insufficient information is available to determine whether the designated use is supported).

DNR update to the Fish kill Follow-up Protocol (FKFP) for the 2020 IR cycle and beyond

Beginning with the 2020 IR cycle, DNR reviewed all fish kills on stream segments to determine if biological sampling data were collected on those segments as part of the Iowa Biological Monitoring and Assessment Program, Fisheries Bureau interior stream sampling, UAA sampling, or SHL special project sampling. DNR evaluated the data using the "Identifying recovery from the fish kill event(s)" procedure described above. Should the stream segment be impaired both biologically (failing to meet FIBI and/or BMIBI BITs) and for the fish kill, the fish kill impairment will be removed if the fish community has shown recovery (passing FKFP evaluation) but the biological impairment would remain if the benthic macroinvertebrates are impaired or the fish community fails the BIT but passes the FKFP evaluation. DNR will repeat this process for every future IR cycle.

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Table 5-1. Expected non-game fish taxa and game fish species of wadeable warmwater streams in Iowa's ecoregions and subecoregions. Expected fish taxa for each region were based on distribution information in Harlan et al. (1987). Subregion 47f (Southern Iowa Rolling Loess Prairies) is split into Missouri River (47f-Mo) and Mississippi River (47f-MS) sections due to zoogeographic differences; Subregion 72 (Interior River Lowlands) is split into groups of moderate gradient (72m) and low-gradient (72l) streams due to ecological differences. Ecoregions and subecoregions are defined according to Omernik 1993.

Ecoregion / Subecoregion → Fish Taxa ↓	40a	47a	47b	47c	47d	47e	47f-MO	47f-MS	52b	72m	72l
Campostoma spp. (Central or Largescale Stoneroller)	X	X	X	X					X	X	
Cyprinella spp. (Red or Spotfin Shiner)	X	X	X	X	X	X	X	X		X	
Common Shiner		X	X	X					X	X	
Hornyhead Chub										X	
Golden Shiner											X
Notropis spp. (esp., Bigmouth or Sand Shiner)	X	X	X	X	X	X	X	X	X	X	X
Southern Redbelly Dace									X		
Pimephales spp. (esp., Fathead or Bluntnose Minnow)	X	X	X	X	X	X	X	X	X	X	X
Suckermouth Minnow	X						X	X			
Flathead Chub						X					
Rhinichthys spp. (Western Blacknose or Longnose Dace)			X	X					X		
Creek Chub	X	X	X	X	X	X	X	X	X	X	
White Sucker or Northern Hog Sucker			X	X				X	X	X	
Ictaluridae spp. (Catfishes e.g., Black Bullhead, Yellow Bullhead, or Channel Catfish)	X	X	X	X	X	X	X	X		X	X
Redfin Pickerel											X
Blackstripe Topminnow											X
Centrarchidae spp. (Sunfish excluding lake species)	X	X	X	X	X	X	X	X		X	X
Darter Species (esp., Johnny or Fantail Darter)	X	X	X	X				X	X	X	
Expected Number of taxa:	9	9	11	11	6	7	7	9	9	11	7

Attachment 6
Methodology for Identifying Aquatic Life Impairments based on results of Continuous Monitoring for Dissolved Oxygen

Water Quality Monitoring & Assessment Section and
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Water Quality Bureau,
Iowa Department of Natural Resources

Background

Iowa Department of Natural Resources (DNR) staff have historically used monthly grab sample data for dissolved oxygen (DO) generated by routine ambient monitoring networks for purposes of Section 305(b) water quality assessments and for Section 303(d) impaired waters listings. Impairments of designated aquatic life uses have been identified when monitoring results have shown that significantly greater than 10% of the grab-sample data collected over a three-year period for streams and rivers (approximately 36 samples) and a five-year period for lakes (approximately 15 samples) violated Iowa's quality criteria for DO. In recent years, an increasing amount of continuous monitoring for DO has occurred; this trend is expected to continue. This methodology was developed in 2014 and describes the approach and procedures for using results of continuous monitoring for DO for both Iowa's Section 305(b) assessments and Section 303(d) listings. This methodology is consistent with the Iowa Water Quality Standards (WQS); Table 6-1) and with Iowa's existing assessment/listing methodology for DO based on results of grab sample monitoring and use of the 10% rule (see Iowa DNR 2013).

Monitoring Rationale

Continuous DO monitoring will be targeted at critical conditions of low stream flow and high water temperatures that typically occur in mid to late summer (e.g., July and August) in Iowa streams. Results of previous grab-sample and continuous DO monitoring have shown mid to late summer to be the most likely times of year when levels of DO are likely to violate water quality criteria and adversely impact aquatic communities. Conversely, results of previous monitoring have not shown impairments due to low DO in Iowa streams and rivers during the higher flows and cooler water temperatures typical of other seasons of the year.

Data quality

All data used to identify Section 303(d) impairments in Iowa must meet requirements of Iowa's credible data law (https://www.legis.iowa.gov/docs/code/455B.194.pdf):

- "*Credible data*" means scientifically valid chemical, physical, or biological monitoring data collected under a scientifically accepted sampling and analysis plan, including quality control and quality assurance procedures.
- Data dated more than five years before the department's date of listing or other determination under section 455B.194, subsection 1 (Iowa's credible data law), shall be presumed not to be credible data unless the department identifies compelling reasons as to why the data is credible.

Data quantity

In order to use results of continuous DO monitoring for purposes of identifying Section 303(d) impairments, monitoring needs to have been conducted over at least one four-week (28-day) period during mid to late summer (e.g., July and August) in each of two different years within the five-year data collection period (see Table 1). For any 28-day monitoring period, a minimum data interval of two consecutive weeks (14 days) is needed to adequately assess DO levels during critical (late summer) periods. DNR staff will evaluate stream flow levels, air temperatures, and/or precipitation patterns that existed during deployment in order to determine whether monitoring equipment was deployed during the target conditions.

Table 6-1. Iowa's dissolved oxygen criteria for protecting designated aquatic life uses as specified in the Iowa WQS.

Classification:	**BCW1**	**BCW2**	**BWW1**	**BWW2**	**BWW3**	**BLW**
Waterbody Type:	*Coldwater streams*		*Warmwater streams/rivers*			*Lake/wetland*
Minimum for 16 hours of a 24-hour period	7.0	7.0	5.0	5.0	5.0	5.0*
Minimum during a 24-hour period	5.0	5.0	5.0	4.0	4.0	5.0*

*applies only to the upper layer of stratification in lakes

Identifying violations of Iowa's DO criteria using continuous data for DO

A violation of Iowa's DO criteria based on continuous monitoring data will be identified if results of continuous monitoring show that either of the following conditions has occurred:

- Levels of DO fail to meet the 16-hour criterion for more than 8 hours of a 24-hour period. In the context of continuous monitoring for DO, a violation would be a day where levels of DO failed to remain above the 16-hour criterion for at least 16 hours.
- Levels of DO fail to meet the 24-hour criterion. In the context of continuous monitoring for DO, a violation of this criterion would be a day (24-hour period) when the DO falls below the 24-hour criterion.

Identifying impairments of aquatic life uses based on continuous monitoring data for DO

Based on a 28-day deployment of continuous DO monitoring equipment, a Section 303(d) impairment of designated aquatic life uses will be identified if any of the following conditions occurs during each of two 28-day monitoring periods during different years within a five-year period:

- Significantly greater than 10% (the 10% rule) of the days monitored have levels of DO that fail to meet the 16-hour criterion for more than 8 hours of the 24-hour period.
    - Impairment based on this provision in the absence of impairment due to violations of the 24-hour criterion would suggest potential chronic impacts to the aquatic community.

- Significantly greater than 10% of the days monitored have levels of DO that fail to meet the 24-hour minimum DO criterion.
    - Impairments based on this provision would suggest relatively short-term and more severe impacts to the aquatic community from low DO.

As is done for other applications of the 10% rule for grab sample data in Iowa's assessment/listing methodology, guidelines developed by Lin et al. (2000) will be used to determine whether the number of days in violation of Iowa's DO criteria represent a significant exceedance of the 10% rule with a greater than 90 percent confidence. This approach is based on the binomial method for estimating the probability of committing Type I errors (incorrectly identifying an impairment where no impairment exists) and Type II errors (incorrectly assessing an impaired water as "fully supported") (see Table 16). DNR first used this binomial-based approach for identifying impairments based on violations of the 10% rule for the 2006 IR cycle and has continued to use this approach.

Identifying waters in need of further investigation

As provided for in Iowa's credible data law, Iowa's list of waters in need of further investigation (WINOFI) is not part of the Section 303(d) process in Iowa but includes waterbody segments where limited information suggests, but does not credibly demonstrate, a water quality impairment. The state's WINOFI list is comprised of those waterbody segments assessed (evaluated) as potentially "impaired"; that is, the assessment of a designated use in these waterbodies as "impaired" is based on less than complete information; thus, the assessment is of relatively low confidence and is not appropriate for addition to the list of Section 303(d) waterbodies. These potentially-impaired water segments are thus placed in subcategories 2b and 3b of the Integrated Report which comprises the list of waters in need of further investigation. The following circumstances will result in waters with continuous DO-based violations of water quality criteria being placed on Iowa's list of WINOFI.

- The frequency of DO violations during a 28-day monitoring period in one year, as interpreted for continuous monitoring data, suggests impairment of the designated aquatic life uses, but results from a second 28-day period in a subsequent year of a five-year period are not yet available.

- Although the violation frequency of DO criteria is significantly greater than the 10% impairment threshold, too few data were available to meet Iowa's data quantity guidelines for identifying Section 303(d) impairments.
- Although the violation frequency of DO criteria is significantly greater than 10% impairment threshold, the continuous data for DO were generated without an approved quality assurance/work plan in-place.
- Due to insufficient data, there is less than 90% confidence that the 16-hour and/or 24-hour criteria are not violated significantly more than 10% of the time.

Water segments on the WINOFI list require additional monitoring to determine whether addition to Iowa's Section 303(d) list of impaired waters is appropriate.

Overwhelming evidence of impairment

Situations exist where reliable information can accurately indicate a Section 303(d) impairment of designated beneficial uses even though this information does not meet DNR's data quantity and/or data quality requirements for Section 303(d) listing. Such waterbodies would be considered for addition to Iowa's Section 303(d) list based on overwhelming evidence of impairment. If results of continuous monitoring for DO do not meet either DNR's data quantity or data quality requirements, but these data suggest significant water quality degradation, these data can be used to consider a waterbody for Section 303(d) listing. For example, if a stream waterbody is monitored for less than the required number of days to support a Section 303(d) listing decision, but the violation frequencies are well into the impairment range (e.g., > 25% of days with violations of the 24-hour DO criterion), then this waterbody can be considered for addition to Iowa's Section 303(d) list. Another example is when the frequency of DO violations during a 28-day monitoring period in one year is > 25%, but results from a second 28-day period in a subsequent year of a five-year period are not yet available. Any decision to invoke overwhelming evidence of impairment based on continuous DO data will be supported by a detailed rationale in Iowa's water quality assessment database (ADBNet) that includes an evaluation of the quality and quality of data available. If data quality or data quantity are judged to be suspect, DNR will either add the waterbody to the list of waters in need of further investigation or consider the waterbody to be "not assessed.".

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Attachment 7

Addressing Interstate Inconsistencies in Section 303(d) Lists

The following is a comparison of DNR's assessment segments with adjacent states (Nebraska, South Dakota, Minnesota, and Missouri) assessment segments not addressed by the UMRBA memorandum.

Nebraska (http://deq.ne.gov/NDEQProg.nsf/OnWeb/TMDL):

DNR Waterbody ID Number	Waterbody Description	Length (miles)	Nebraska Assessment Reach ID	Segment Description	Length (miles)*	Hydrologic Unit Code (HUC)
IA 06-WEM-1707	Missouri River, IA/MO state line to confluence with Platte River West of Glenwood in Mills County	41.6	MT1-10000: Missouri R.	Missouri R., downriver from confluence with Platte R.	41.6	10240001
IA 06-WEM-1708	Missouri R., from Platte River to Council Bluffs WS intake	23.3	NE1-10000: Missouri River	Missouri River, upriver from Platte River to Big Sioux River	135.4	10230006
IA 06-WEM-1709	Missouri R., from Council Bluffs WS intake to Boyer River	15.4				
IA 06-WEM-1715	Missouri River, from Boyer River to Little Sioux River	33.3				
IA 06-WEM-1720	Missouri River, from Little Sioux River to Elm Creek	20.8				10230001
IA 06-WEM-1721	Missouri River, from Elm Creek to Omaha Creek Ditch	25				
IA 06-WEM-1722	Missouri River, from Omaha Creek Ditch to Big Sioux R.	17.6				

South Dakota (https://danr.sd.gov/OfficeOfWater/SurfaceWaterQuality/waterqualitystandards/integratedreports.aspx):

DNR Waterbody ID Number	Waterbody Description	Length (miles)	South Dakota Assessment Reach ID	Segment Description	Length (miles)*	Hydrologic Unit Code (HUC)
IA 06-BSR-1520	Big Sioux River, mouth to Broken Kettle Creek, Plymouth County	16.9	SD-BS-R-BIG_SIOUX_17	Big Sioux River, mouth to Broken Indian Creek, Plymouth County	58.1	10230001
IA 06-BSR-1521	Big Sioux River, Broken Kettle Creek to Brule Creek near Richland, SD	18.4				
IA 06-BSR-1522	Big Sioux River, from Brule Creek to Indian Creek, Plymouth County	22.8				
IA 06-BSR-1523	Big Sioux River, from Indian Creek to Rock River	23.7	SD-BS-R-BIG_SIOUX_16	Big Sioux River, from Indian Creek to near Alcester	23.7	10230001
IA 06-BSR-1524	Big Sioux River, from Rock River to Beaver Creek near Canton, SD	22.2	SD-BS-R-BIG_SIOUX_15	Big Sioux River, near Alcester to Fairview	22.2	10170203
IA 06-BSR-1525	Big Sioux River, from Beaver Creek to Ninemile Creek	22.5	SD-BS-R-BIG_SIOUX_14	Big Sioux River, near Fairview to Ninemile Creek	22.5	10170203
IA 06-BSR-1526	Big Sioux River, from Ninemile Creek to IA/MN line	9.3	SD-BS-R-BIG_SIOUX_13	Big Sioux River, Ninemile Creek to near Brandon	9.3	10170203

*The assessment reach lengths were adjusted to correspond to the total mileage in the respective DNR assessment reaches.

Minnesota (https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list):

DNR Waterbody ID Number	Waterbody Description	Length (miles)	Minnesota Assessment Reach ID	Segment Description	Hydrologic Unit Code (HUC)
IA 01-NEM-78	Mississippi River, Lock & Dam 9 near Harpers Ferry (Allamakee County) to IA/MN State Line	26.3	07060001-509	Mississippi River, Root River to MN/IA border	07060001
IA 02-CED-479	Cedar River, from Rock Creek near Orchard (Floyd County) to IA/MN State Line	30.6	07080201-516	Cedar River, Elk Creek to MN/IA border	07080201
IA 02-CED-579	Little Cedar River, from Stacyville Dam (Mitchell County) to IA/MN State Line	9.5	07080201-518	Little Cedar River, Headwaters to MN/IA border	07080201
IA 02-CED-594	Otter Creek, from mouth (Mitchell County) to IA/MN State Line	5.4	07080201-517	Otter Creek, Headwaters to MN/IA border	07080201
IA 02-SHL-787	Shell Rock River, from confluence with Rose Creek (Cerro Gordo County) to IA/MN State Line	24.3	07080202-501	Shell Rock River, Albert Lea Lake to Goose Creek	07080202
IA 02-WIN-831	Winnebago River, from confluence with Pike Run (Winnebago County) to IA/MN State Line	15.3	07080203-501	Lime Creek, Bear Lake to MN/IA border	07080203
IA 04-BLU-964	Blue Earth River, from confluence with Tributary (Kossuth County) to IA/MN State Line	10.4	07020009-645	Blue Earth River, Middle Branch, MN/IA border to -94.104 43.514	07020009
IA 04-BLU-965	West Branch Blue Earth River, from confluence with Tributary (Kossuth County) to IA/MN State Line	6.0	07020009-643	Blue Earth River, West Branch, MN/IA border to 15th St	07020009
IA 04-UDM-1228	Des Moines River, from School Creek at Estherville (Emmet County) to IA/MN State Line	12.1	07100002-501	Des Moines River, JD 66 to MN/IA border	07100002
IA 06-BSR-1538	Rock River, from Kanaranzi Creek (Lyon County) to IA/MN State Line	5.8	10170204-501	Rock River, Elk Creek to MN/IA border	10170204
IA 06-BSR-1800	Little Rock River, from Argo Slough (Lyon County) to IA/MN State Line	16.6	10170204-513	Little Rock River, Little Rock Creek to MN/IA border	10170204
IA 06-BSR-1547	Kanaranzi Creek, Mouth (Lyon County) to IA/MN State Line	7.4	10170204-517	Kanaranzi Creek, Norwegian Creek to MN/IA border	10170204
IA 06-BSR-1546	Mud Creek, from mouth (Lyon County) to IA/MN State Line	25.1	10170204-525	Mud Creek, Headwaters to MN/IA border	10170204
IA 06-LSR-1641	Ocheyedan River, from Little Ocheyedan River (Osceola County) to IA/MN State Line	21.5	10230003-501	Ocheyedan River, Ocheda Lake to MN/IA border	10230003
IA 06-LSR-1668	Little Sioux River, West Fork, from mouth (Dickinson County) to IA/MN State Line	13.7	10230003-509	Little Sioux River, West Fork JD 13 to MN/IA border	10230003
IA 06-LSR-1579	Little Sioux River, from West Fork Little Sioux River (Dickinson County) to IA/MN State Line	8.9	10230003-515	Little Sioux River, Unnamed Creek to MN/IA border	10230003
IA 01-WPS-6416	Wapsipinicon River, from North Line of S20 T100N R15W (Mitchell County) to IA/MN State Line	3.9	07080102-507	Wapsipinicon River, -92.6732 43.5073 to MN/IA border	07080102

Missouri (https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters):

DNR Waterbody ID Number	Waterbody Description	Length (miles)	Missouri Assessment Reach ID	Segment Description	Hydrologic Unit Code (HUC)
IA 05-NSH-1412	Nishnabotna River, IA/MO Line to (Fremont County) to confluence of East Nishnabotna and West Nishnabotna Rivers (Fremont County)	5.4	0227.00	Nishnabotna River (Atchison)	10240004
IA 06-WEM-1707	Missouri River, IA/MO State Line (Fremont County) to confluence with Platte River West of Glenwood (Mills County)	41.6	0226.00	Missouri River (Atchison/ Jackson)	10240001
IA 04-FOX-994	Fox River, IA/MO State Line to confluence with an Unnamed Tributary (Davis County)	22.5	0038.00	Fox River (Clark)	07110001
IA 05-GRA-1351	Thompson River, IA/MO State Line to confluence with Long Creek (Decatur County)	29.0	0549.00	Thompson River (Harrison)	10280102
IA 05-GRA-1350	East Fork Medicine Creek, IA/MO State Line to Tributary S24,T68N,R22W (Wayne County)	9.6	0623.00	Little Medicine Creek (Mercer/ Grundy)	10280103
IA 05-GRA-1356	Weldon River, IA/MO State Line to Mormon Pool (Decatur County)	21.6	0560.00	Weldon River (Mercer/ Grundy)	10280102
IA 05-NOD-1388	Nodaway River, IA/MO State Line To East Nodaway River (Page County)	4.4	0279.00	Nodaway River (Nodaway/ Andrew)	10240010
IA 05-GRA-1350	East Fork Medicine Creek, IA/MO State Line to Tributary S24,T68N,R22W (Wayne County)	9.6	0619.00	Medicine Creek (Putnam/ Grundy)	10280103
IA 05-GRA-1349	Locust Creek, IA/MO State Line to Tributary S15,T67N,R20W (Wayne County)	1.6	0606.00	Locust Creek (Putnam/ Sullivan)	10280103
IA 05-GRA-1375	East Fork Grand River, IA/MO State Line to Gooseberry Creek (Ringgold County)	15.6	0457.00	East Fork Grand River (Worth/ Gentry)	10280101
IA 05-GRA-1378	Middle Fork Grand River IA/MO State Line to Tributary S13,T68N,R30W (Ringgold County)	12.2	0468.00	Middle Fork Grand River (Worth/ Gentry)	10280101
IA 05-PLA-1467	Platte River IA/MO State Line to Tributary S36,T68N,R32W (Taylor County)	6.3	0312.00	Platte River (Worth/ Platte)	10240012

Attachment 8

Iowa DNR Integrated Report Impairment Causes Interpretations

Information is also included on the historical use of the individual cause categories for water quality assessments in Iowa and on the existence of numeric criteria in the Iowa Water Quality Standards (WQS). NA = "not applicable". Information is taken from several published and on-line sources (see "References, Attachment 5") as well as from Iowa Department of Natural Resources (DNR) staff experience from identifying these causes of impairment for Iowa waters.

Cause Category	Historically Used?	Numeric Criteria?	Description
ammonia (un-ionized)	yes	yes	Ammonia refers to the concentration of ionized (NH_4^+) and un-ionized ammonia (NH_3) in water. Ammonia is formed during bacterial decomposition of organic matter and is delivered to streams and rivers from wastewater discharges and from nonpoint sources. The primary source of ammonia dissolved in water comes from bacterial mineralization of dead plants and animals (Cole 1979). (Mineralization is the conversion of an element from an organic to an inorganic form as a result of microbial decomposition.) Impairments related to measured concentrations of ammonia in Iowa waters are rare. Most ammonia impairments are tied to fish kills caused by delivery of animal waste to streams; these impairments are based on the presumed presence of high levels of ammonia in the high-strength animal waste generated by animal feeding operations to which fish kills are often attributed.
arsenic	yes	yes	Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Inorganic arsenic compounds are mainly used to preserve wood. Copper chromated arsenate (CCA) is used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards. Inorganic arsenic is a known human carcinogen (source: ATSDR (https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=19&toxid=3). Arsenic impairments in Iowa waters are due to violations of Iowa's human health criterion designed to protect against adverse health impacts from consuming arsenic in water and fish. This criterion (0.18 parts per billion (ppb) is well below what is believed to be the natural background concentration of arsenic in Iowa surface waters and groundwaters (~1 to 2 ppb) and is far below the EPA's maximum contaminant level of no more than 10 parts per billion in drinking water.
atrazine	yes	yes	A common pesticide (corn herbicide) that is in the triazine family of herbicides. The only criterion for atrazine in the Iowa WQS is the maximum contaminant level of 3 ppb to protect drinking water (Class C) uses.
cause unknown	yes	NA	Causes of impairment are identified as "unknown" where results of water quality monitoring suggest an impact, but no cause of the impact is apparent. Most often, this cause category is used when results of biological monitoring identify an impact to biotic integrity but do not suggest a specific cause of the impact. In such cases, follow-up monitoring is often needed to determine the specific cause or causes of the impairment.
chloride	no	yes	Chloride (Cl^-) is a naturally-occurring negatively-charged dissolved constituent of water and is one of several similar ions that combine to constitute "total dissolved solids." Chloride is a major ion commonly found in streams and wastewater. Chloride may get into surface water from several sources, including wastewater from certain industries, wastewater from communities that soften water, road salting, agricultural runoff, and produced water from oil and gas wells. Levels of chloride in Iowa surface waters are relatively low with a median concentration of 22 mg/L in the approximately 8,500 samples collected from 2000 through 2009 as part of DNR's ambient stream/river water quality

			monitoring network (Iowa DNR 2010). Only 10% of these samples have had chloride levels greater than 39 mg/L; the maximum concentration in these samples was 170 mg/L. The Iowa WQS identifies a chloride criterion of 250 mg/L to protect surface waters used as a source of a municipal water supply (i.e., Class C waters). Results of water quality monitoring to date have not shown levels of chloride in surface waters that suggest impairment of Class C uses. Iowa's hardness-based aquatic life standards are (assuming a hardness of 200 mg/L) are a chronic criterion of 389 mg/L and an acute criterion of 629 mg/L. Chloride levels in Iowa waters are sufficiently low that violations of Iowa's aquatic life criteria for chloride are very rare.
chlorine	yes	yes	Chlorine and chloramines are widely used in treatment of potable water supplies and wastewater treatment plant effluents and are used in a variety of industrial applications, including power generating facilities and paper mills. Although the Iowa WQS contain numeric criteria to protect aquatic life uses from adverse impacts of total residual chlorine, analytical difficulties have precluded analysis for total residual chlorine as part of ambient surface water monitoring since 1999. Currently, the only scenario that would lead to identification of chlorine as the cause of an impairment is the accidental release of chlorine to surface waters such that a fish kill occurs (e.g., as would potentially occur following a water main break).
cyanide	no	yes	Cyanide enters air, water, and soil from both natural processes and industrial activities. Cyanide is usually found joined with other chemicals to form compounds. Examples include hydrogen cyanide, sodium cyanide and potassium cyanide. Certain bacteria, fungi, and algae can produce cyanide. Cyanide and hydrogen cyanide are used in electroplating, metallurgy, organic chemicals production, photographic developing, manufacture of plastics, fumigation of ships, and some mining processes. Most cyanide in surface water will form hydrogen cyanide and evaporate. Cyanide in water does not build up in the bodies of fish (source: http://www.atsdr.cdc.gov/tfacts8.pdf). Detectable levels of cyanide are extremely rare in Iowa waters; there are no water quality impairments, historical or current, attributed to cyanide.
dioxins	no	yes	Dioxins and dioxin-like compounds are by-products of various industrial processes, and are commonly regarded as highly toxic compounds that are environmental pollutants and persistent organic pollutants. Dioxins are not intentionally produced and have no known use. They are the by-products of various industrial processes (i.e., bleaching paper pulp, and chemical and pesticide manufacture) and combustion activities (i.e., burning household trash, forest fires, and waste incineration). The defoliant Agent Orange, used during the Vietnam War, contained dioxins. Dioxins are found at low levels throughout the world in air, soil, water, sediment, and in foods such as meats, dairy, fish, and shellfish. The highest levels of dioxins are usually found in soil, sediment, and in the fatty tissues of animals. Much lower levels are found in air and water. Sources: Wikipedia (http://en.wikipedia.org/wiki/Dioxins_and_dioxin-like_compounds) and ATSDR (https://wwwn.cdc.gov/TSP/substances/ToxChemicalListing.aspx?toxid=29). In Iowa, dioxins have been detected in samples of fish tissue but occur at extremely low levels (in the low parts per trillion range) and pose no known risk to human health or the aquatic environment.
excessive algal growth / chlorophyll a	yes	no	Chlorophyll is the pigment in plants that is essential for photosynthesis whereby carbon dioxide and water are converted to carbohydrates and oxygen; chlorophyll a is a form of chlorophyll that is common to all types of freshwater algae (e.g., green algae, cyanobacteria, and diatoms). For purposes of water quality assessment, chlorophyll a is used as a surrogate measure of growth of algae in the water column. "Excessive algal growth" refers to an unusually large concentration of algal organisms (planktonic or benthic) that can adversely affect either the

			aesthetic quality of the surface water for water-based recreation or the ability of the waterbody to support the expected types and numbers of aquatic biota (see explanation for "turbidity" below). Scenarios that can lead to impairments due to "excessive algal growth" include the following: (1) large populations of Common Carp that increase water column nutrient levels through feeding and spawning activities such that algal blooms occur, (2) populations of Grass Carp that, through removal of littoral zone vegetation and feeding activities, lead to increased water column nutrient levels such that algal blooms occur, and (3) excessive growth of attached algae (periphyton) or attached filamentous algae on coarse substrates in stream riffle areas.
exotic species	yes	no	For purposes of Section 305(b) water quality assessments in Iowa, "exotic species" refers to a form "introduced into an area or ecosystem outside its historic or native geographic range; this includes both foreign (i.e., exotic) and transplanted species, and is used synonymously with "alien," "nonnative," and "introduced." Examples of exotic species in Iowa include Common Carp, Grass Carp, and the plant purple loosestrife. Scenarios that can lead to impairments due to "exotic species" include the following: (1) re-suspension of sediment and nutrients in a shallow lake by a large population of Common Carp such that turbidity and/or algal populations are increased to nuisance levels; (2) elimination of aquatic macrophytes from the littoral zone of a lake by Grass Carp such that the lake shifts from a clear-water to a turbid, phytoplankton-dominated (green) lake; and (3) the replacement of native wetland vegetation (e.g., grasses, sedges, cattails) with the exotic invasive purple loosestrife, thus degrading the habitat quality of the wetland for waterfowl and nutritional value of the wetland for wildlife.
flow alterations	yes	no	"Flow alterations" refer to human-related deviations from natural seasonal flow regimes that can adversely affect native biota. Flow alterations can result from several activities including water withdrawal for irrigation or water supplies, regulation of stream flow at dams, and drainage projects that lead to localized lowering of water tables such that lake/wetland water levels are adversely affected.
habitat alterations (other than flow alterations)	yes	no	"Habitat alterations" refer to manmade changes in the physical habitats of surface waters such that native aquatic biota may be adversely affected. When assessing impairments to Iowa surface waters for Section 305(b) reporting, "habitat alterations" refers primarily to impacts from (1) stream channelization (i.e., channel straightening), (2) removal of riparian vegetation, (3) pasturing of the riparian zone, and/or (4) streambank destabilization. All of these alterations tend to decrease the value of streams and rivers as high quality habitats for use by aquatic life through removal of important naturally-occurring habitat types (e.g., pools, riffles, sand bars, and snags). In addition, the alteration of aquatic habitat tends to increase the severity of impacts from other sources of pollution on aquatic life, especially the effects of siltation during low-flow periods.
metals	yes	yes	A general category that includes the following toxic metals: aluminum, antimony, arsenic, asbestos, beryllium, cadmium, chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, thallium, zinc. All but aluminum are identified as "priority pollutants" under Section 307a of the Clean Water Act. Levels of toxic metals in Iowa waters are low. Impairments of Iowa waters for metals occur infrequently and tend to occur in rivers. Impairments are usually related to violations of chronic criteria to protect aquatic life uses from toxic metals. The occurrence of acutely toxic levels of toxic metals in Iowa surface waters is extremely rare.
nitrate	yes	yes	High levels of nitrate in drinking water can lead to infant methemoglobinemia (blue baby syndrome). This condition occurs as a result of ingestion of high levels of nitrate followed by the metabolism of nitrate to ammonia in the infant's digestive system. The conversion of nitrate to ammonia produces nitrite which can oxidize the iron atom in hemoglobin such that it cannot carry oxygen. The lack of oxygen can give blood and oxygen-deficient tissues a bluish

			color. To protect against this condition, the EPA recommends that nitrate levels in water delivered by a public water supply to consumers should not exceed a maximum contaminant level (MCL) of 10 mg/L as nitrogen. The Iowa WQS identify this 10 mg/L MCL as the water quality criterion to protect surface waters used as a source of a municipal water supply. At concentrations seen in surface waters, nitrate is not believed to be toxic to aquatic life; thus, there are no water quality criteria in the Iowa WQS that apply to aquatic life uses.
nitrogen	yes	no	Nitrogen is an essential nutrient, is very abundant in the earth's atmosphere, and-like phosphorus-is implicated in eutrophication of surface waters such than excessive production of plant biomass occurs. Being considerably more abundant that phosphorus, nitrogen is much less often identified as a limiting (critical) nutrient in the eutrophication process. In water, nitrogen occurs in several forms (oxidation states) including nitrate, nitrite, and ammonia. Total nitrogen is defined as the sum of ammonia, nitrate, nitrite, and total Kjeldahl nitrogen (a measure of organic forms of nitrogen; e.g., in proteins). Total nitrogen is the measure most often proposed as an indicator of nutrient enrichment in surface waters and is the form proposed for inclusion into state WQS as a nutrient criterion. In Iowa waters, nitrate usually accounts for the majority of total nitrogen. Levels of total nitrogen in Iowa waters and in waters of other Corn Belt states are high relative to those in other states and are high relative to nutrient benchmark values for total nitrogen that have developed by nutrient criteria workgroups over the last decade (approximately 1 part per million for both rivers and lakes).
noxious aquatic plants	yes	no	"Noxious aquatic plants" refers to excessive growths of aquatic macrophytes or algae (e.g., Cyanobacteria also known as blue-green algae) that are known to interfere with recreational uses and be potentially harmful to human health as well as to the health of aquatic biota. Scenarios that can lead to impairments due to "noxious aquatic plants" include the following: dominance of a lakes' phytoplankton community by Cyanobacteria.
nutrients	yes	no	High levels of plant nutrients (primarily, nitrogen and phosphorus) indicate the potential for water quality problems in surface waters that result from excessive production of plant biomass. In lakes, high levels of nutrients can lead to excessive growth of aquatic plants, especially algae, which can interfere with recreational uses of a lake (e.g., boating, swimming, and fishing). Excessive plant growth can also lead to oxygen depletion of lake water through respiration related to bacterial decomposition of plant material and other organic matter that accumulates on the lake bottom. Severe cases of oxygen depletion can lead to fish kills. High levels of plant nutrients are generally attributed to agricultural nonpoint source pollution, to background levels in soil, and to naturally-occurring conditions, especially the internal nutrient recycling that occurs in the shallow glacial lakes of northern Iowa. Urban point sources and urban runoff, however, also contribute excessive amounts of nutrients to Iowa lakes with urban watersheds. Both the origin of high levels of plant nutrients and the nutrient concentrations that can impair aquatic life uses of Iowa's surface waters are poorly understood. Due to the natural fertility of Iowa's soils, levels of plant nutrients were likely relatively high prior to settlement in the mid-19th century (Menzel 1983). Application of fertilizers, however, especially for row crop agriculture, has increased nutrient levels in the state's surface waters over that during pre-settlement times. The threshold levels at which plant nutrients cause problems in Iowa's surface waters have not yet been identified. Thus, the Iowa WQS does not contain water quality criteria for either levels of phosphorus or nitrogen related to protection for primary contact recreation (Class A) or for aquatic life (Class B) beneficial uses. Since 2004, DNR has used a trophic state index to identify nutrient-related water quality problems in lakes due to poor water clarity caused by large populations of algae that are aesthetically objectionable and that thus

			suggest impairment of recreational uses. Algal impairment based on the trophic state index is the most commonly identified impairment at Iowa lakes.
oil and grease	no	no	"Oil and grease" refers to adverse impacts to public water supplies or aquatic biota due to the presence of oils of petroleum or non-petroleum origin. Scenarios that can lead to impairments due to "oil and grease" include the following: (1) a fish kill caused by a spill of fuel oil and (2) adverse impacts to aquatic life resulting from contact of surface waters with coal tar waste.
organic enrichment / low dissolved oxygen	yes	yes	Impairments due to organic enrichment occur when the amount of organic material delivered to the waterbody exceeds the capacity of the stream to mineralize and assimilate this organic material with the result that levels of dissolved oxygen can fall below water quality criteria designed to protect aquatic life uses. In the absence of excessive inputs of oxygen-demanding organic material-as commonly measured through biochemical oxygen demand or "BOD"-streams, rivers, and lakes can process organic material without serious consequences to either chemical water quality or aquatic life. When inputs of organic materials exceed the stream or river's assimilative capacity, however, degradation of water quality will occur. The high rates of bacterial respiration resulting from the excessive amounts of organic material can lower the level of dissolved oxygen below that needed to support aquatic life. Most of the lakes with impacts due to organic enrichment are the relatively shallow natural lakes in north-central and northwest Iowa. Wind action at shallow lakes in summer tends to circulate lake water at all depths, thus resuspending sediments and nutrients that have settled to the bottom of the lake back into the water column. The increased levels of nutrients in the water column can increase plant production, usually in the form of algae. Continued resuspension of sediment and nutrients can lead to poor water transparency due to high levels of planktonic algae or due to high concentrations of suspended sediment. The relatively high levels of biological productivity in these lakes can lead to depletion of dissolved oxygen, and fish kills can occur. In temperate climates such as Iowa's, deeper lakes tend to thermally stratify during summer: a relatively cold and stagnant bottom layer of the lake (hypolimnion) becomes isolated from the relatively warm and wind-circulated surface layer (epilimnion) by a middle layer with a temperature gradient (metalimnion or thermocline). As summer progresses, bottom layers of stratified eutrophic lakes tend to become increasingly nutrient-rich and oxygen-poor. The isolation of this bottom layer, however, prevents movement of the poor-quality water to the surface layer of the lake. This isolation tends to improve the water quality of the surface layer of a lake that is used by aquatic life and is used for water-based recreation (e.g., swimming and water skiing). Water quality studies on Iowa lakes have shown that lakes with average depths greater than 13 feet tend to establish and maintain thermal stratification in summer and thus have better water quality than do shallower lakes (Bachmann et al. 1994).
other inorganics	no	yes	"Other inorganics" is a general cause category for inorganic substances that are not already included in a cause category.
pathogens (pathogen indicators)	yes	yes	"Pathogens," in the context of Section 305(b) reporting, actually refers to concentrations of typically non-pathogenic indicator bacteria (e.g., fecal coliforms or *E. coli*) in surface water samples. Iowa surface waters that support swimming, water skiing, and other primary body contact recreation that involves considerable risk of ingesting surface water are designated for one of several types of Class A (swimmable) use in the Iowa WQS. Levels of fecal coliform bacteria and *E. coli* are monitored by DNR in rivers and lakes designated for Class A uses to *indicate* the health risks to persons using these waters for water-based recreation. Although typically not pathogenic, pathogen indicators such as fecal coliforms and *E. coli* are present in the intestines of warm-blooded animals and are

			commonly monitored by state environmental agencies to indicate the degree to which surface waters may contain waterborne pathogens (e.g., *Salmonella* and *Shigella*) that can cause disease in humans. "Pathogen indicators" (bacteria) is the most frequently identified impairment of Iowa streams and rivers. Despite the relatively high levels of indicator bacteria in Iowa streams and rivers, and despite the high numbers of impairments, reports of waterborne disease are extremely rare.
PCBs	yes	yes	Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated organic compounds (congeners). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U.S. by the trade name Aroclor. PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils (excerpted from ATSCR ToxFAQ: http://www.atsdr.cdc.gov/tfacts17.pdf). Levels of PCBs in Iowa surface waters are too low to be detected in samples collected as part of ambient water quality monitoring. PCBs, however, like many chlorinated organic compounds, do accumulate (bioconcentrate) in animal tissue. In Iowa waters, the only Section 303(d) impairment caused by PCBs is their accumulation in fish tissue to levels that indicate the need to issue a fish consumption advisory (see https://www.iowadnr.gov/environmental-protection/water-quality/water-monitoring/fish-tissue). Levels of PCBs in Iowa fish and in fish nationwide, however, have declined greatly (by a factor of 100) since the banning PCB production in the United States in 1977.
pesticides	yes	yes	"Pesticides" refers to any substance, either currently or historically, used to kill plants, insects, algae, fungi, and other organisms; includes herbicides, insecticides, algalcides, fungicides, and other substances. For purposes of the Iowa IR, this category includes priority pesticides* (as defined in Section 307a of the Clean Water Act) as well as non-priority pesticides (e.g., cyanazine, and metolachlor).
pH	yes	yes	"pH" indicates the hydrogen ion concentration in a water sample and indicates the intensity of an acid. The pH of natural waters is a measure of acid-base equilibrium achieved by the various dissolved compounds, salts, and gases. A pH of 7 is considered neutral (neither acidic nor basic). As the pH of waters decreases below 7, the waters become increasingly acidic. For example, the pH of tomatoes is 4.5, vinegar is approximately 2, and battery acid is roughly 1 pH unit. As the pH increases above 7, the waters become increasingly basic. For example, the pH of baking soda is 8.3, ammonia is 11, and lye has a pH of 13. The pH scale varies logarithmically such that water with a pH of 5 is ten times more acidic (i.e., has ten times the hydrogen ion concentration) than water with a pH of 6. The ability of surface waters to resist changes in pH is called buffering capacity and is measured by alkalinity. The alkalinity of a surface water reflects the nature of the rocks within a drainage basin and is measured as milligrams of calcium carbonate ($CaCO_3$) per liter (mg/L). Surface waters with high alkalinities resist lowering of pH values due, for example, to the addition of low-pH rainfall (acid precipitation). pH can have direct and indirect effects on aquatic life. Within a range of about pH 6.5 to 9, the direct impact to aquatic life is minimal; outside of this range, adverse physiological impacts can occur and will increase as the pH deviates from this range. pH can also have indirect impacts on aquatic life as the toxicity of certain metals to aquatic life increases at lower pH and the toxicity of ammonia increases as pH levels increase. pH levels outside of the range of 6.5 to 9.0 can also impact swimmers by causing irritation to eyes

			(FWPCA 1968). Thus, because of the potential impacts to both aquatic life and primary contact recreation uses, the Iowa WQS specify a range of pH values of 6.5 to 9.0 as protective of both aquatic life and primary contact recreation uses. Levels of pH in Iowa surface waters lean toward the basic side of neutral with lake pH values being somewhat higher than those found in rivers and streams. The median pH of over 9,000 stream/river samples collected from 2000-2009 was 8.2 units with over 90 percent of the samples greater than a pH of 7.8 units and with only 10 percent of the samples having a pH of greater than 8.6 (Iowa DNR 2010). The median pH of almost 3,000 summer-season water samples collected from Iowa lakes from 2000-2007 was 8.6 units with over 90 percent of the samples having a pH of greater than 8.0 units; 17 percent of the samples had a pH greater than 9.0 units and thus are in violation of the Iowa water quality criterion. The tendency for lake pH values to be higher than rivers likely reflects the larger populations of algae in lakes versus rivers: the removal of carbon dioxide from the water column during algal photosynthesis results in an increase in pH levels.
phosphorus	yes	no	Phosphorus is an essential nutrient for all living cells and functions in the storage and transfer of energy in living organisms and in their genetic systems. Igneous rock was the original source of phosphorus on earth; biotic sources of phosphorus (e.g., guano from sea birds) also exist. Phosphorus is highly reactive and is not found as a free element in Nature. In water, phosphorus can occur in several forms including dissolved and particulate. In addition, phosphorus concentrations in water can be reported in a number of ways depending on the type of sample analyzed (i.e., filtered versus unfiltered) and the type analytical methods used. (Sources: Wikipedia (http://en.wikipedia.org/wiki/Phosphorus) and Cole (1979)). DNR's ambient stream/river and lake monitoring networks measure and report phosphorus as "total phosphorus as P." Although an essential nutrient and although not toxic at levels found in the aquatic environment, high levels of phosphorus in water can stimulate excessive production of plant biomass (for example, algae) such that adverse water quality impacts can occur. These impacts range from reduced water clarity due to algae suspended in the water column, excessive oxygen demand from bacterial mineralization of decomposing plant material, and production of large populations of cyanobacteria (blue-green algae) that can be aesthetically objectionable as well as potentially harmful to human health. Levels of total phosphorus in Iowa surface waters tend to be high relative to levels considered to be of concern. The median level of total phosphorus in the approximately 9,500 samples collected from 2000 through 2009 as part of DNR's ambient stream/river water quality monitoring network is 200 parts per billion (ppb) (Iowa DNR 2010). Twenty-five percent of the samples had phosphorus levels greater than 340 ppb. Of the 131 Iowa lakes monitored from 2001 through 2009, 99 lakes (75%) had median phosphorus levels greater than 50 ppb. The summary statistics suggest that the majority of Iowa's rivers, streams, and lakes have levels of phosphorus above the nutrient benchmark values for total phosphorus that have developed by nutrient criteria workgroups over the last decade (approximately 50 ppb for lakes and 100 ppb for rivers). The Iowa WQS does not contain water quality criteria for either levels of phosphorus or nitrogen related to protection for primary contact recreation (Class A) or for aquatic life (Class B) beneficial uses. Thus, despite the quite high levels of phosphorus in Iowa waters, very few impairments of Iowa waters have been specifically attributed to "nutrients," "phosphorus," or "nitrogen." Given the lack of numeric nutrient criteria, DNR has used a trophic state index to identify nutrient-related water quality impacts in lakes (e.g., poor water clarity due to large populations of algae) that are aesthetically objectionable and that thus suggest impairment of recreational uses. Algal impairment based on the trophic state index is the most commonly identified impairment at Iowa lakes.

priority organics	yes	yes	"Priority organics" are toxic organic pollutants listed in Section 307a of the federal Clean Water Act: "Priority organics" includes the following pollutant groups: chlorinated benzenes, chlorinated ethanes, chlorinated phenols, other chlorinated organics, haloethers, halomethanes, nitrosamines, non-chlorinated phenols, phthalate esters, polynuclear aromatic hydrocarbons (PAHs), pesticides and metabolites*, DDT and metabolites, polychlorinated biphenyls (PCBs), and other organics. For purposes of the Iowa IR, this cause category does not include the following groups of priority organics: pesticides and metabolites, DDT and metabolites, or polychlorinated biphenyls (PCBs).
radiation (radium)	no	yes	Radiation is the energy emitted spontaneously in the process of decay of unstable atoms of radioisotopes. Sources of radiation include (1) the natural decay of primordial radioisotopes and their decay products and (2) manmade radioisotopes released into the environment beginning with testing and use of the atomic bomb in World War II. Radiation absorbed by plant and animal tissue may cause cellular and molecular damage that can adversely affect aquatic biota. Although routinely monitored in Iowa groundwater monitoring networks, monitoring for radiation (radium) is not part of surface water monitoring networks in Iowa.
siltation	yes	no	Silt delivered to streams and rivers through nonpoint source runoff and/or through streambank erosion can degrade aquatic habitat through covering of coarse substrates, through deposition in pools, and through increasing the turbidity of the water. Siltation impacts in lakes refer to the erosion of soil particles by precipitation and movement of soil particles in runoff to lake basins where accumulation of silt occurs. The amount of silt delivered to Iowa's lakes relative to lake volume is an important factor in determining the quality of a lake for fishing, swimming and for use as a source of drinking water. Sedimentation is especially a problem for man-made lakes formed by dams placed across stream channels. Water quality impacts related to high rates of siltation/sedimentation include the delivery of excessive levels of plant nutrients (primarily phosphorus) to lakes, loss of lake volume, loss of surface area, a shortened useful life of the lake, interference with reproduction and growth of certain fish species, and impairments to recreational uses such as boating and fishing. While the delivery and accumulation of sediment is often the most serious problem in man-made lakes, it is generally less of a problem in the natural lakes of north-central and northwest Iowa. Natural lakes generally have much smaller watersheds relative to lake surface area, and their watersheds have less topographic relief and lower erosion rates than do lake watersheds in other regions of the state. Man-made lakes with low sedimentation rates tend to have clearer water and more productive fisheries than do lakes receiving large amounts of sediment. The man-made lakes in Iowa with the best water quality have relatively steep sides, small watersheds, and have well-controlled watersheds with a high percentage either in approved soil conservation practices or in non-crop land uses (e.g., pasture or forest) (see Hill 1981). Ideally, a man-made lake in Iowa would have a watershed-to-surface area ratio of from 20:1 up to 40:1. As watershed size increases relative to lake area, the more likely that the lake basin will be impacted (overloaded) with sediment delivered to the lake in rainfall runoff.
sulfates	no	yes	Sulfate (SO_4^{-2}) is a naturally-occurring negatively-charged dissolved constituent of water and is one of several similar ions that combine to constitute "total dissolved solids." Sulfate may form salts with sodium, potassium, magnesium and other positively-charged ions. Sulfate is widely distributed in nature and may be present in natural waters at concentrations ranging from a few to several hundred milligrams per liter. At high levels (e.g., greater than 600 mg/L), sulfate in drinking water can have laxative effects on consumers. Levels of sulfate in Iowa surface waters are relatively low with a median concentration of 36 mg/L in the approximately 8,000 samples collected from 2000 through 2009 as part of DNR's ambient stream/river water quality monitoring network (Iowa DNR 2010). Only 10% of these

			samples have had sulfate levels greater than 96 mg/L; the maximum concentration in these samples was 400 mg/L. The Iowa WQS identify criteria to protect aquatic life from high levels of sulfate; the criteria depend on both hardness and the chloride concentrations. Although sulfate criteria depend on hardness and the chloride concentration, levels below 500 mg/L likely to not violate these criteria.
suspended solids	yes	no	"Suspended solids" refers to the organic and inorganic particulate matter suspended in the water column. High levels of suspended solids in Iowa surface waters reduce water clarity and give a turbid or cloudy appearance to the water. Such material can originate from detritus carried by streams and rivers, atmospheric fallout, biological activity, chemical reactions, and re-suspension from bottom sediments as a result of current, wind/wave action, or movements of bottom-dwelling fish. The Iowa WQS does not contain numeric aquatic life criteria for suspended solids. The Upper Mississippi River Conservation Committee's Water Quality Technical Section has identified a suspended solids threshold concentration of 30 mg/L above which turbidity in the water inhibits growth of types of submersed aquatic vegetation that are important to ecosystem function (see UMRCC 2003). DNR has used this threshold to assess the degree to which Iowa's shallow lakes support their aquatic life uses.
taste and odor	no	no	"Taste and odor" refers to the acceptability of drinking water to the user. Most taste and odor problems are related to the presence of phenolic compounds or to the presence of odor-producing organic substances produced by microorganisms or by human and industrial wastes.
thermal modifications	yes	yes	"Thermal modification" refers to a manmade deviation from natural seasonal water temperatures such that aquatic biota may be adversely affected. This deviation can include (1) addition of heat above physiological optimum levels of resident aquatic life, (2) the addition of heat such that state WQS are violated, or (3) the abrupt cessation of heated effluents during cooler seasons such that aquatic life cannot acclimate to the sudden change in ambient water temperature. Scenarios that can lead to impairments due to "thermal modifications" include the following: (1) discharge of heated effluent from power generating facilities such that ambient water temperatures violate WQS and (2) a fish kill caused by summer storm runoff with elevated water temperatures due to flow over super-heated impervious surfaces (streets, parking lots, etc.) in urban areas. Criteria for water temperature are summarized in Table 9a of this document and can also be found in the Iowa WQS.
total dissolved solids / salinity / chlorides / sulfates	no	no	"Total dissolved solids" (TDS) refers to the concentration of inorganic salts, small amounts of organic material, and other dissolved materials in the water column. The principal inorganic anions dissolved in water are carbonates, chlorides, sulfates, and nitrates; the principal cations are calcium, magnesium, sodium, and potassium. Previous version of the Iowa WQS contained a numeric criterion for TDS of 750 mg/L as part of "general water quality criteria." Recent changes in the Standards, however, have included replacement of the TDS criterion with separate criteria for chloride and sulfate with the goal of improved protection of aquatic life (see https://www.iowadnr.gov/portals/idnr/uploads/water/standards/ws_fact.pdf).
total toxics	no	no	"Total toxics" refers to the cumulative adverse impact of toxic parameters from multiple groupings on water quality and aquatic biota.
turbidity	yes	no	For purposes of Section 305(b) assessments and Section 303(d) listings, "turbidity" refers to non-algal materials suspended in the water column, especially soil particles (silt or clay), that give the water a brown, cloudy appearance. Turbidity-related impairments due to planktonic algae (i.e., "green" water) are considered to be caused by "excessive algal growth/chlorophyll a." Regardless of the cause, high levels of turbidity may suggest a water quality impairment. High levels of turbidity in surface waters, whether due to suspended algae or non-algal materials, can interfere with

			the growth and reproduction of sight-feeding game fish (e.g., Bluegill (*Lepomis macrochirus*), Largemouth Bass (*Micropterus salmoides*), and Walleye (*Sander vitreus*)), and excessive turbidity reduces the aesthetic appeal of surface waters for primary contact recreation such as swimming and water skiing. The primary sources of high turbidity in Iowa surface waters are (1) the resuspension of bottom sediments in shallow lakes through wind/wave action, (2) delivery of high amounts of silt and clay particles to the surface waters during precipitation runoff from agricultural areas, (3) contributions of silt and clay particles from erosion of stream banks or lake shorelines, or (4) bottom feeding fish (e.g., Common Carp (*Cyprinus carpio*) and Bullhead spp. (*Ameiurus* spp.) that increase turbidity through resuspension of sediment and nutrients during feeding and spawning activities. Surface waters that drain watersheds with certain types of clay-dominated soils may have chronic problems with turbidity regardless of the level of agricultural activity in the watershed. Historical evidence suggests that streams and rivers in the Missouri River drainage of southern and western Iowa had high levels of turbidity even during pre-settlement times. The presence of a turbidity tolerant fish fauna in these streams and rivers supports this assertion. Iowa surface waters with water quality problems due to high levels of turbidity are generally of three types: (1) man-made lakes in southern Iowa with relatively large watersheds having high rates of soil erosion (e.g., Bob White, Rock Creek, and Manteno lakes) and (2) shallow natural lakes of northern Iowa with high turbidities related to resuspension of silt and nutrients by bottom-feeding fish and/or wind/wave action (e.g., Ingham, Lower Gar, and North Twin lakes) and (3) streams and rivers with chronically high turbidities that may contribute to reduced aquatic diversity.
unknown toxicity	yes	NA	"Unknown toxicity" is identified as a cause of impairment when results of monitoring suggest some type of toxic impact but the identities of the substances causing toxicity are unknown. For example, results of a biological assessment that shows a complete lack of aquatic life in a stream strongly suggest the presence of toxic substances; the cause of impairment in such a case would be identified as "unknown toxicity."

* aldrin, dieldrin, chlordane, alpha-endosulfan, beta-endosulfan, endoslufan sulfate, endrin, endrin aldehyde, heptachlor, heptachlor epoxide, alpha BHC, beta BHC, gamma-BHC (lindane), delta-BHC, and toxaphene.

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