Stream Nutrient Aquatic Life Criteria
Technical Advisory Committee

Wednesday, April 7, 2010
Wallace Building, 3rd Floor Conference Room

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Nutrient Criteria for the Protection of Stream Aquatic Life

Technical Advisory Committee Meeting
April 7, 2010

Meeting Objectives

- Clarify mission & process
- Set forth work direction

Preliminary Questions

- Why stream nutrient criteria?
  - Need to address serious water quality problems caused by nutrient enrichment (eutrophication)
  - Federal & state mandates
- Why form a Technical Advisory Committee (TAC)?
  - Assure standards reflect good science
  - State law requires

Stream Biological Resources

Freshwater Mussels:

55 species

29 Species of Greatest Conservation Need (SGCN)

"Flowing water aquatic habitats had the greatest number of SGCN of any habitat class followed by herbaceous wetlands." (Iowa Wildlife Action Plan. "Securing a future for fish and wildlife – A conservation legacy for Iowans." Zohrer 2006)

Fish:

153 species

68 Species of Greatest Conservation Need (SGCN)

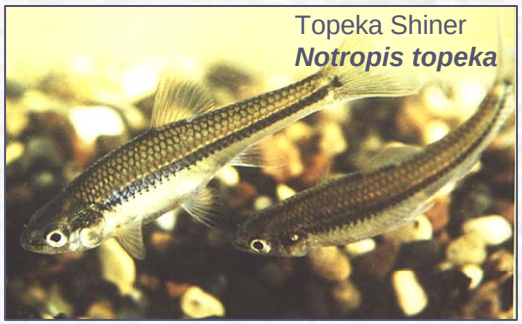


Photo by Konrad Schmidt

Nutrient Enrichment*

Nutrient (N & P) Inputs

Primary Response:

Photosynthetic productivity

Algae and aquatic plant biomass

Secondary Responses & WQ Impacts:

- ↓ Water clarity / Aesthetics
- ↑ D.O. flux / ↓ D.O. minima
- ↑ Rough fish
- ↓ Species diversity
- ↑ Habitat degradation
- ↑ Cyanobacteria / cyanotoxins
- ↑ Taste & odor compounds
- ↓ Water quality (e.g., pH, ammonia)

***potential responses to nutrient inputs when nutrient availability is limiting to algae and plants**

TAC Mission and Objectives

Assist IDNR in developing nutrient criteria for the protection of stream aquatic life designated uses

- Advise on scientific aspects of stream nutrients & nutrient effects
- Develop criteria recommendations
- Identify and clarify future technical needs

TAC Process

Characteristics:

- DNR leadership
- Objective, data-driven approach
- Consensus oriented; majority and minority views documented
- Interface with DNR standards development process

TAC Process

Steps:

1. Become familiar with water quality standards and nutrient criteria guidance
2. Review nutrient literature and available nutrient criteria benchmarks
3. Inventory, summarize and analyze Iowa-specific data
4. Define data gaps and nutrient monitoring needs
5. Construct and evaluate conceptual nutrient criteria scenarios
6. Where feasible, quantifiably define nutrient and nutrient response criteria
7. Document TAC proceedings and recommendations

TAC Process

Issues / Questions:

- How suitable is Iowa's current aquatic life designated use framework for establishing nutrient criteria?
- What other stream classes or strata should be considered in developing nutrient criteria recommendations?
- To what extent are existing nutrient criteria benchmarks applicable to Iowa streams?
- To what extent can Iowa-specific data be used to craft nutrient criteria recommendations for all aquatic life uses or sub classifications?
- How should uncertainty/variability in nutrient-biological response relationships be dealt with?

TAC Process

Issues / Questions (continued):

- How sufficient is the "cause and effect" evidence linking nutrient levels with aquatic biological assemblage indicators?
- What is the best approach for dealing with downstream nutrient impacts?
- What were the pristine or pre-settlement nutrient levels in Iowa streams?
- What are realistically achievable nutrient levels?
- How might the Department address anthropogenic-related attainability issues in developing nutrient standards and policies?

TAC Process

- Questions?
- Thoughts?

Background Info

- Water quality standards
- Nutrient criteria guidance
- Data inventory
- Literature resources

IA Water Quality Standards

Components:

- Designated Uses
- Criteria
- Anti-degradation Policy

IA Water Quality Standards

Designated Uses –

three major types or classes:

- A (primary recreational contact)
- B (aquatic life)
- C (drinking water)

IA Water Quality Standards

- Class B (aquatic life) - basis for sub-classifications:
  - Thermal characteristics
    - cold water, warm water
  - Stream size and flow
  - Ability to support game fish

B(CW-1), B(CW-2),

B(WW-1), B(WW-2), B(WW-3)

IA Water Quality Standards

Class B (aquatic life)

Questions:

- *Does the current aquatic life use classification framework provide a suitable framework for developing appropriate nutrient criteria? If not, what is missing?*

Or perhaps stated another way,

- *What are we trying to protect and how do we define it?*

Nutrient Criteria Guidance

Steps:

1. Identify water quality needs and goals with regard to managing nutrient enrichment problems
2. Classify rivers and streams first by type, and then by trophic status
3. Select variables for monitoring nutrients
4. Design a sampling program for monitoring nutrients and algal biomass in rivers and streams
5. Collect data and build database.
6. Analyze data
7. Develop criteria based on reference conditions and data analyses

(Nutrient Criteria Technical Guidance Manual – Rivers & Streams; U.S. EPA 2000)

Nutrient Criteria Guidance

Criteria Derivation Approaches:

- A) Identification of *reference reaches* for each stream class based on best professional judgment (BPJ) or percentile selections of data plotted as frequency distributions (Figure 1);
- B) Use of *predictive relationships* (e.g., trophic state classifications, models, biocriteria);
- C) Application and/or modification of *established nutrient/algal thresholds* (e.g., nutrient concentration thresholds or algal limits from published literature).

(Nutrient Criteria Technical Guidance Manual – Rivers & Streams; U.S. EPA 2000)

Nutrient Criteria Guidance

Questions:

- Where is Iowa with respect to progressing through the criteria development steps and what are the main obstacles?
- Which criteria derivation approaches should be pursued and how should we go about it?
- Which parameters should be looked at?

Iowa Stream Data Inventory

First Needs:

- Assistance identifying/describing non-DNR data sources
- Determine best use of data
- Data acquisition & management

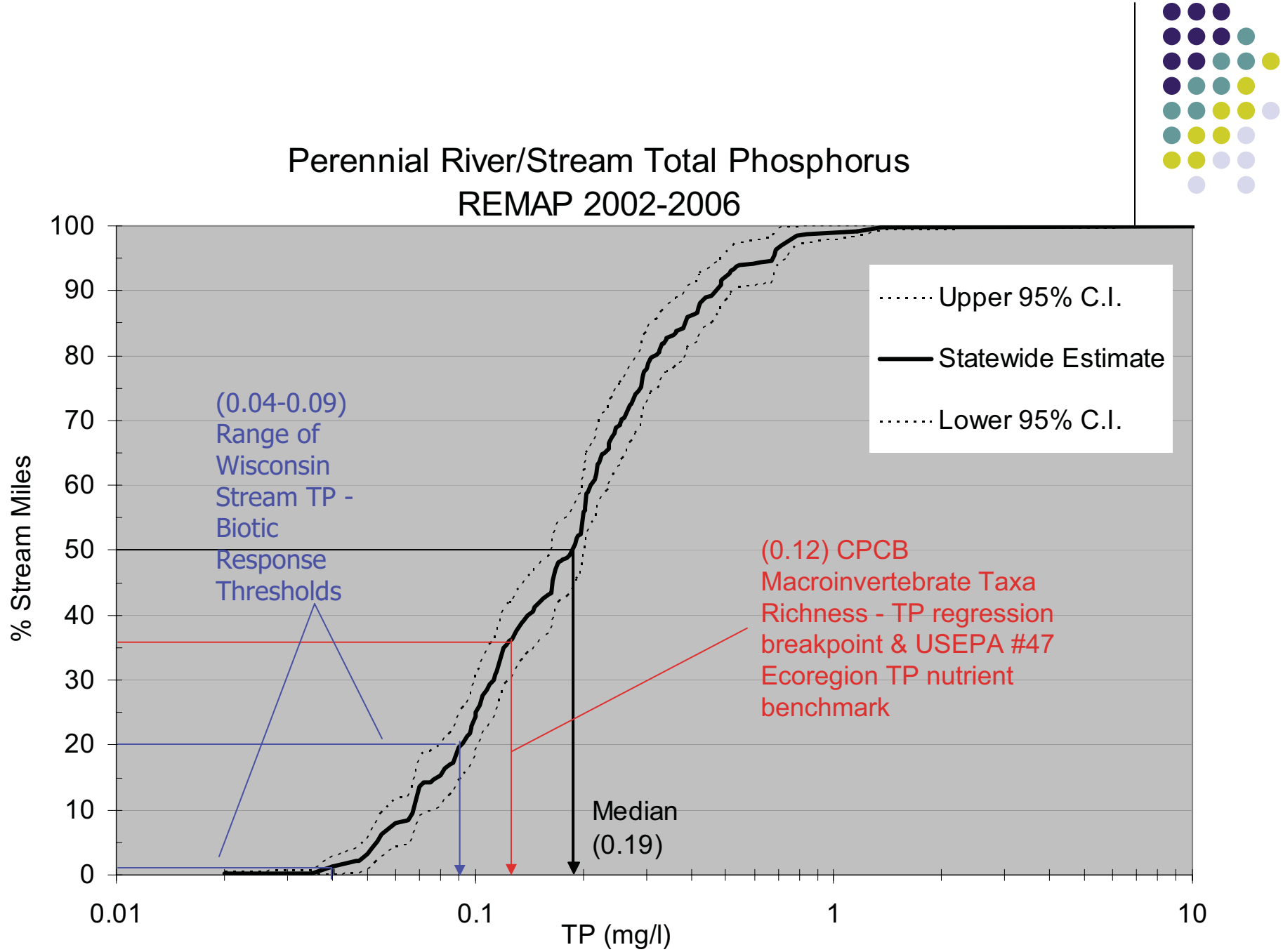
Literature Resources

Approach:

- Continue to acquire and review
- Catalogue relevant findings and benchmarks
- Develop ranking process for applicability and strength of evidence?

Moving Forward

- Short-term (1 - 2 months)
  - monitoring needs
  - data inventory / literature review
  - data analysis strategy
- TAC utilization
  - communication / meetings
  - data analysis & interpretation
  - process documentation
  - products


Perennial River/Stream Total Phosphorus
REMAP 2002-2006
% Stream Miles
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
TP (mg/l)
Upper 95% C.I.
Statewide Estimate
Lower 95% C.I.
(0.04-0.09) Range of Wisconsin Stream TP - Biotic Response Thresholds
(0.12) CPCB Macroinvertebrate Taxa Richness - TP regression breakpoint & USEPA #47 Ecoregion TP nutrient benchmark
Median (0.19)

Stream Aquatic Life Nutrient Criteria
Technical Advisory Committee

Mission and Process

Establishing a stream nutrient technical advisory committee (TAC) is not only a smart idea, it is required by §455B.176A of the Iowa Code:

"The appropriate level of protection and standards shall be determined on a scientific basis. In the development process for the water quality standards, input shall be received from a water quality standards advisory committee convened by the department. The water quality standards advisory committee shall be comprised of experts in the scientific fields relating to water quality, such as environmental engineering, aquatic toxicology, fisheries biology, and other life sciences and experts in the development of the appropriate levels of aquatic life protection and standards."

The mission of this TAC is to assist IDNR in developing nutrient criteria for the protection of stream aquatic life designated uses, which are defined within Iowa's Water Quality Standards (IAC 567:Chapter 61). The TAC will advise IDNR on important technical issues surrounding stream nutrients and develop criteria recommendations that represent the best-available scientific information. Should the TAC determine the scientific foundation is not sufficient to recommend nutrient criteria for certain designated uses or other stream sub-classifications, the TAC will describe the deficiencies and recommend steps to resolve them. While the TAC may propose explicit nutrient criteria recommendations, including numeric limits, the IDNR is responsible for determining how to utilize the recommendations in the development of water quality standards.

The TAC will be chaired by a technical designee of the IDNR. The process to develop nutrient criteria recommendations will be systematic, informed, and consensus oriented. Conflicting opinions on technical issues will be respected and noted in the TAC proceedings. It is anticipated the TAC will be active for approximately 12-15 months and will meet approximately 4 - 6 times during this time period. Given the short time frame and challenging task at hand, the TAC will need to take a very focused and goal-oriented approach. Prior to each meeting an agenda detailing the meeting objectives and desired outcomes will be distributed. Members will be asked to review information prior to each meeting in order to come fully prepared to engage in discussion. TAC members may have an opportunity to participate in the summarization, analysis, or presentation of relevant data; however, this level of participation is not required or expected. The main process steps are:

1. Become familiar with water quality standards and nutrient criteria guidance;
2. Review nutrient literature and available nutrient criteria benchmarks;
3. Inventory, summarize and analyze Iowa-specific data;
4. Define data gaps and nutrient monitoring needs;
5. Construct and evaluate conceptual nutrient criteria scenarios;
6. Where feasible, quantifiably define nutrient and nutrient response criteria;
7. Document TAC proceedings and recommendations.

As the TAC progresses through these steps, several issues or questions are likely to arise. For example:

- How suitable is Iowa's current aquatic life designated use framework for establishing nutrient criteria?
- What other stream classes or strata should be considered in developing nutrient criteria recommendations?
- To what extent are existing nutrient criteria benchmarks applicable to Iowa streams?
- To what extent can Iowa-specific data be used to craft nutrient criteria recommendations for all aquatic life uses or sub classifications?
- How should uncertainty/variability in nutrient-biological response relationships be dealt with?
- How sufficient is the "cause and effect" evidence linking nutrient levels with aquatic biological assemblage indicators?
- What is the best approach for dealing with downstream nutrient impacts?
- What were the pristine or pre-settlement nutrient levels in Iowa streams?
- What are realistically achievable nutrient levels?
- How might the Department address anthropogenic-related attainability issues in developing nutrient standards and policies?

The TAC will take a pragmatic approach in order to achieve as much progress as possible with the development of nutrient criteria recommendations. At the conclusion of the process, the TAC leader will work with the members to prepare a report of the TAC's findings and recommendations. Members will be provided at least two opportunities to review draft versions of the report before it becomes final. IDNR then will review the report and determine how to implement the TAC's recommendations. Once this determination has been made, the IDNR will inform the TAC of its plans and provide an opportunity to comment on any draft nutrient standards that are prepared. IDNR will initiate a meeting with the TAC to discuss issues relating to the implementation plans or draft standards. The IDNR will address the TAC's comments and concerns in a written responsiveness summary to be entered in the public record. Should the TAC consultation meeting result in modifications to the draft standards, these changes will be made prior to engaging stakeholders, policy-makers, and the public in the rule-making process.

Finally, TAC members should be aware that a water quality standards advisory committee is considered a "governmental body" and is subject to Iowa's open meeting law. TAC meetings will be announced to the public and open to observers. All meeting agendas, minutes, and related documents will be made accessible to the public.

IAC Environmental Protection [567]: Chapter 61
Iowa Water Quality Standards
http://www.iowadnr.gov/water/standards/files/chapter61.pdf

The Iowa Code (455B) and the Water Quality Standards (IAC 567 - Chapter 61) establish water quality goals for all waters of the state. Waters of the state are defined in Iowa Code 445B.171(36) as: *"any stream, lake, pond, marsh, watercourse, waterway, well, spring, reservoir, aquifer, irrigation system, drainage system, and any other body or accumulation of water, surface or underground, natural or artificial, public or private, which are contained within, flow through or border upon the state or any portion thereof".*

"States are tribes are responsible for setting water quality standards to protect the biological, chemical, and physical integrity of their waters" (U.S. EPA 2000). Biotic Integrity is defined as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" .

Water Quality Standards generally include three major components: 1) Designated uses; 2) Criteria (narrative and numeric); 3) Anti-degradation policy.

Designated Uses:

Iowa has two cold water and three warm water stream aquatic life designated uses that are defined in Chapter 61:

Cold water aquatic life—Type 1 (Class "B(CW1)"). Waters in which the temperature and flow are suitable for the maintenance of a variety of cold water species, including reproducing and nonreproducing populations of trout (*Salmonidae* family) and associated aquatic communities.

Cold water aquatic life—Type 2 (Class "B(CW2)"). Waters that include small, channeled streams, headwaters, and spring runs that possess natural cold water attributes of temperature and flow. These waters usually do not support consistent populations of trout (*Salmonidae* family), but may support associated vertebrate and invertebrate organisms.

Warm water—Type 1 (Class "B(WW-1)"). Waters in which temperature, flow and other habitat characteristics are suitable to maintain warm water game fish populations along with a resident aquatic community that includes a variety of native nongame fish and invertebrate species. These waters generally include border rivers, large interior rivers, and the lower segments of medium-size tributary streams..

Warm water—Type 2 (Class "B(WW-2)"). Waters in which flow or other physical characteristics are capable of supporting a resident aquatic community that includes a variety of native nongame fish and invertebrate species. The flow and other physical characteristics limit the maintenance of warm water game fish populations. These waters generally consist of small perennially flowing streams.

Warm water—Type 3 (Class "B(WW-3)"). Waters in which flow persists during periods when antecedent soil moisture and groundwater discharge levels are adequate; however, aquatic habitat typically consists of nonflowing pools during dry periods of the year. These waters generally include small streams of marginally perennial aquatic habitat status. Such waters support a limited variety of native fish and invertebrate species that are adapted to survive in relatively harsh aquatic conditions.

Protocols for determining what the appropriate aquatic life use designation should be:

- Cold Water - http://www.iowadnr.gov/water/standards/files/04cwp.pdf
- Warm Water - http://www.iowadnr.gov/water/standards/files/warmwater.pdf

Also relevent:

Human health (Class "HH"). Waters in which fish are routinely harvested for human consumption or waters both designated as a drinking water supply and in which fish are routinely harvested for human consumption. This designation is assigned to all B(WW-1) and B(CW-1) streams, and can be assigned to other aquatic life designations on a case-by-case basis.

General use segments. These are intermittent watercourses and those watercourses which typically flow only for short periods of time following precipitation and whose channels are normally above the water table. These waters do not support a viable aquatic community during low flow and do not maintain pooled conditions during periods of no flow.

The general use segments are to be protected for livestock and wildlife watering, aquatic life, noncontact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses.

Designated uses assigned to individual water bodies can be viewed in a rule-referenced document entitled, "Surface Water Classifications".
http://www.iowadnr.gov/water/standards/files/swcdoc2.pdf

Criteria:

"Criteria are elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representeing a quality of water that supports a particular use." (U.S. EPA 2000).

Narrative Criteria

61.3(2) *General water quality criteria*. The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times for the uses described in 61.3(1)*"a."*
a. Such waters shall be free from substances attributable to point source wastewater discharges that will settle to form sludge deposits.
b. Such waters shall be free from floating debris, oil, grease, scum and other floating materials attributable
to wastewater discharges or agricultural practices in amounts sufficient to create a nuisance.
c. Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor or other aesthetically objectionable conditions.
d. Such waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to human, animal, or plant life.
e. Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life.
f. The turbidity of the receiving water shall not be increased by more than 25 Nephelometric turbidity units by any point source discharge.
g. Acceptable levels of total dissolved solids (TDS) and constituent cations and anions will be established on a site-specific basis. The implementation approach for establishing the site-specific levels may be found in the "Supporting Document for Iowa Water Quality Management Plans," Chapter IV, July 1976, as revised on June 16, 2004.
h. The Escherichia coli (E. coli) content of water which enters a sinkhole or losing stream segment, regardless of the water body's designated use, shall not exceed a Geometric Mean value of 126 organisms/100 ml or a sample maximum value of 235 organisms/100 ml. No new wastewater discharges will be allowed on watercourses which directly or indirectly enter sinkholes or losing stream segments.

Numeric criteria

See Chapter 61: Tables 1, 2, 3 http://www.iowadnr.gov/water/standards/files/chapter61.pdf

Anti-degradation:
New rules and procedures effective – 2/17/2010. Former anti-degradation designations of High Quality (HQ) and High Quality Resource (HQR) waters are replaced by the four-tier protection policy and procedures. Also establishes a new designation "Tier 2 ½ - Outstanding Iowa Waters (Table 1).

61.2 Antidegradation policy. It is the policy of the state of Iowa that:
a. *Tier 1 protection*. Existing surface water uses and the level of water quality necessary to protect the existing uses will be maintained and protected.
b. *Tier 2 protection.* Where the quality of the waters exceed levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the department finds, after full satisfaction of the intergovernmental coordination and public participation provisions, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the department shall assure water quality adequate to protect existing uses fully. Further, the department shall assure the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control before allowing any lowering of water quality.
c. Tier 2 ½ protection – Outstanding Iowa waters. Where high quality waters constitute an outstanding state resource, such as waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.
d. Tier 3 protection – Outstanding national resource waters. Where high quality waters constitute an outstanding national resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected. Any proposed activity that would result in a permanent new or expanded direct source of pollutants in an Outstanding National Resource Water is prohibited.
e. The four levels of protection provided by the antidegradation policy in subsections (a) through (d) of this section shall be implemented according to procedures hereby incorporated by reference and known as the "Iowa Antidegradation Implementation Procedure," http://www.iowadnr.gov/water/standards/files/antideg_clean.pdf

Table 1. Outstanding Iowa Waters

STREAMS	DESCRIPTION	Length (Miles)
Baron Springs	Mouth (S2, T91N, R6W, Clayton Co.) to spring source (S4, T91N, R6W, Clayton Co.)	1.99
Bear Creek	From road crossing in SW ¼, NW1/4, S11, T86N, R10W, Benton Co. to E line,S25, T87N, R10W, Buchanan Co.	5.2
Bloody Run	From (W. line of Section 22, T95N, R4W, Clayton Co.) to the confluence with Unnamed Creek (NAD83) UTM Coordinates X(Easting) 645284.89 Y(Northing) 4766657.44	8.59
Brownfield Creek	Mouth (Clayton Co.) to spring source (S31, T91N, R3W, Clayton Co.)	.94
Clear Creek	Mouth (Allamakee Co.) to W. line of Section 25, T99N, R4W, Allamakee Co.	3.79
Deer Creek	Road crossing in SE¼, S35, T100N, R19W, Worth Co. to the N. line of S7, T100N, R19W, Worth Co.	7.29
Dousman Creek	Mouth (S33, T96N, R3W, Allamakee Co.) to Allamakee-Clayton Co. line	3.44
Duck Creek	From the mouth (S14, T100N, R06W Allamakee Co.) to the Iowa-Minnesota state line.	1.98
Ensign Creek (aka Ensign Hollow)	Mouth (S28, T92N, R6W, Clayton Co.) to spring source (S29, T92N, R6W, Clayton Co.)	1.05
Unnamed Creek (a.k.a. Erickson Spring Branch)	Mouth (S23, T98N, R4W, Allamakee Co.) to W. line of S23, T98N, R4W, Allamakee Co.	.91
French Creek	Mouth (Allamakee Co.) to E. line of Section 23, T99N, R5W, Allamakee Co.	5.58
Grannis Creek	Mouth (S30, T95N, R7W, Fayette Co.) to W. line of S36, T93N, R8W, Fayette Co.	3.56
Jones Creek	From the mouth (S19, T98N, R04W Allamakee Co.) to bridge crossing at Clonkitty Rd. (S14, T98N, R05W Allamakee Co.)	5.75
Kleinlein Creek	Mouth (Clayton Co.) to spring source (South Spring) (S10, T91N, R6W, Clayton Co.)	3.96
Lime Creek	From confluence with unnamed tributary in NE ¼, NW ¼, S34, T87N, R10W, Buchanan Co. to N. line of S23, T87N, R10W, Buchanan Co.	3.0
Little Paint Creek	Mouth to N. line of Section 30, T97N, R3W	1.92
Ludlow Creek	Mouth (S2, T96N, R6W, Allamakee Co.) to confluence with an unnamed tributary (S33, T97N, R6W, Allamakee Co.)	2.00
Mill Creek (aka Big Mill Creek)	Confluence with Little Mill Cr. to confluence with Unnamed Cr. (S1, T86N, R3E, Jackson Co.)	8.04
Mossey Glen Creek	Mouth (S3, T91N, R5W, Clayton Co.) to S. line of S10, T91N, R5W, Clayton Co.	1.96
North Bear Creek	Mouth (S25, T100N, R7W, Winneshiek Co.) to Iowa-Minnesota state line	6.39
Pine Creek (aka South Pine Creek)	Mouth (S26, T99N, R7W, Winneshiek Co.) to N. line of S21, T99N, R7W, Winneshiek Co.	2.80
Smith Creek (aka Trout River)	Mouth (S21, T98N, R7W, Winneshiek Co.) to S. line of S33, T98N, R7W, Winneshiek Co.	3.42
South Canoe Creek	From the mouth (S22, T99N, R08W Winneshiek Co.) to the bridge crossing at Winn Rd. (S21, T99N, R08W Winneshiek Co.)	1.90
Spring Branch Creek	Mouth (S10, T88N, R5W, Delaware Co.) to spring source (S35, T89N, R5W, Delaware Co.)	2.83
Storybook Hollow	Mouth (S7, T86N, R4E, Jackson Co.) to S. line of S12, T86N, R3E, Jackson Co	1.37
Trout Run	Mouth (S16, T98N, R4W, Allamakee Co.) through one mile reach	1.0
Twin Springs Creek	Mouth (S17, T98N, R8W, Winneshiek Co.) to springs in Twin Springs Park (S20, T98N, R8W, Winneshiek Co.)	0.61
Unnamed Creek (aka Cold Water Cr.)	Mouth (S32, T100N, R9W, Winneshiek Co.) to N. line of Section 31, T100N, R9W, Winneshiek Co.)	2.46
Unnamed Creek (aka S. Fk. Big Mill)	Mouth (S8, T86N, R4E, Jackson Co.) to W. line of S17, T86N, R4E, Jackson Co.	0.97
Village Creek	Mouth (Allamakee Co.) to W. line of S19, T98N, R4W, Allamakee Co.	13.32
Waterloo Creek	Mouth (S35, T100N, R6W, Allamakee Co.) to Iowa-Minnesota state line	9.39
West Branch French Creek	From the mouth (S23, T99N, R05W, Allamakee Co.) to the confluence with Unnamed Creek (S26, T99N, R05W, Allamakee Co.)	.67
Grand Total		**118.08**
LAKES	**Description (Section, Township, Range)**	**Size (Acres)**
Big Spirit Lake	S33, T100N, R36W	5684
West Okoboji Lake	S20, T99N, R36W	3,847

Stream Nutrient Criteria Development Guidance

Background

Water quality criteria are elements of State water quality standards, which can be expressed as constituent concentrations, levels, or narrative statements representing a quality of water that supports a particular use (EPA 2000). Section 304(a) of the Clean Water Act requires the EPA to develop and publish water quality criteria and guidance reflecting the latest scientific knowledge. As an outgrowth of the 1998 National Strategy for the Development of Regional Nutrient Criteria, the EPA has published 304(a) nutrient criteria guidance documents for lakes and reservoirs, rivers and streams, estuarine and coastal waters, and wetlands. These documents are intended to serve as a starting point for states to develop more refined nutrient criteria as part of State water quality standards.

The 1998 strategy also lead to the establishment of a Regional Technical Advisory Group (RTAG) for EPA Region VII (Iowa, Kansas, Missouri, Nebraska) that was tasked with development of refined nutrient benchmarks for lakes and reservoirs, rivers and streams, and wetlands. Meeting over a period of several years, the RTAG has been able to recommend benchmarks for lakes and reservoirs in Region VII and has developed provisional benchmarks for rivers and streams.

Links to additional information:

EPA web site for Water Quality Criteria for Nitrogen and Phosphorus Pollution
http://www.epa.gov/waterscience/criteria/nutrient/

U.S. EPA 2000. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology. Washington, D.C. 152p.
http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/index.html

Nutrient Regional Technical Advisory Group (RTAG) – EPA Region VII
http://www.cpcb.ku.edu/progwg/html/nutrientwg.htm

Nutrient Criteria Derivation Steps and Approaches

The EPA (2000) guidance document identifies the following steps in the criteria development process:

1. Identify water quality needs and goals with regard to managing nutrient enrichment problems.
2. Classify rivers and streams first by type, and then by trophic status.
3. Select variables for monitoring nutrients.
4. Design a sampling program for monitoring nutrients and algal biomass in rivers and streams.
5. Collect data and build database.
6. Analyze data.
7. Develop criteria based on reference conditions and data analyses.

With respect to criteria setting or derivation - three approaches are advocated:

A) Identification of *reference reaches* for each stream class based on best professional judgment (BPJ) or percentile selections of data plotted as frequency distributions (Figure 1);

B) Use of *predictive relationships* (e.g., trophic state classifications, models, biocriteria);

C) Application and/or modification of *established nutrient/algal thresholds* (e.g., nutrient concentration thresholds or algal limits from published literature).

The guidance document provides explanations of these approaches in *Chapter 7. Nutrient and Algal Criteria Development.*
http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/index.html

Several applications of these approaches can be found in the scientific literature. Here are a few examples::

Chambers, P.A., et al., 2008. Eutrophication of agricultural streams: defining nutrient concentrations to protect ecological condition. Water Science & Technology 58(11):2203-2210.

Dodds, W.K., 2006. Eutrophication and trophic state in rivers and streams Limnol. Oceanogr., 51(1, part 2), 2006, 671–680

Soranno, P.A., et al., 2008. A framework for developing ecosystem-specific nutrient criteria: Integrating biological thresholds with predictive modeling Limnol. Oceanogr., 53(2), 2008, 773–787.

Stevenson, R.J., et al., 2008. Algae–P relationships, thresholds, and frequency distributions guide nutrient criterion development. J. N. Am. Benthol. Soc. 27(3):783–799.

Suplee, M.W., et al., 2007. Developing Nutrient Criteria for Streams: An Evaluation of the Frequency Distribution Method. Journal of the American Water Resources Association (JAWRA) 43(2):453-472.

Wang, L., et al. 2007. Linkages between nutrients and assemblages of macroinvertebrates and fish in wadeable streams: implications to nutrient criteria development. Environ Manage. 39:194-212.

EPA guidance does not recommend any one approach over another, stating: “A weight-of-evidence approach that combines one or more of the three approaches will produce criteria of greater scientific validity” (U.S. EPA 2000).

As recently as 2009, EPA prepared draft guidance entitled “Empirical Approaches for Nutrient Criteria Derivation” for review by the Science Advisory Board Ecological Processes and Effects Committee in 2009. The draft guidance, which has not been officially released, focuses on the use of stressor-response relationships to derive nutrient criteria. Stressor-response relationships are described as relationships between

nutrient concentrations and biological response measures that can be related to stream designated uses. For more information go to:
http://yosemite.epa.gov/sab/SABPRODUCT.NSF/b5d8a1ce9b07293485257375007012b7/5972e2a88464d45e85257591006649d0!OpenDocument

Nutrient Criteria Parameters

The guidance recommends that States adopt criteria for the following primary variables:

Causal Variables:

Total Nitrogen (TN) and Total Phosphorus (TP)

Response Variables:

Chlorophyll *A* (benthic and/or sestonic) and Turbidity (or transparency)

EPA developed ecoregion-based criteria recommendations for the primary variables as a starting point at the national level. The criteria were derived using the reference reach - percentile frequency distribution method.

The guidance does indicate flexibility to consider other nutrient and secondary response variables that might be appropriate in certain types of stream environments. Nutrient parameters include the various inorganic and organic, dissolved and particulate forms of N and P.

Secondary response variables include: dissolved oxygen, pH, benthic community metabolism, and autrophic index. Other potential secondary response variables include: algal biomass (ash free dry weight), algal biomass (% bottom coverage), chlorophyll pigment ratios, algal stoichiometry (N:P), Phosphatase activity, algal species composition, grazer (secondary production) biomass, macrophyte composition, benthic macroinvertebrate assemblage multi-metric index.

Ambient & Upstream/Downstream City

Site Location statewide

 # sampling sites 90

Sample Frequency generally monthly, events collected at a few sites

Data Summary

Parameter	Count	Begin Date	End Date
Chlorophyll a, corrected for pheophytin (Water)	5149	10/4/1999	8/1/2005
Chlorophyll a, free of pheophytin (Water)	4049	3/1/2005	12/17/2009
Chlorophyll a, uncorrected for pheophytin (Water)	5152	10/4/1999	8/1/2005
Dissolved oxygen (DO)	9557	10/12/1998	12/17/2009
Flow	8301	10/12/1998	12/17/2009
Nitrogen, ammonia as N	9444	10/12/1998	12/17/2009
Nitrogen, Kjeldahl	9440	10/12/1998	12/17/2009
Nitrogen, Nitrate (NO3) as N	180	12/2/2008	2/12/2009
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	9444	10/12/1998	12/17/2009
Nitrogen, Nitrite (NO2) as N	180	12/2/2008	2/12/2009
Nitrogen, organic	1	3/18/2004	3/18/2004
pH	9592	10/12/1998	12/17/2009
Phosphorus as P	9443	10/12/1998	12/17/2009
Phosphorus, orthophosphate as P	9392	10/12/1998	12/17/2009
Solids, Total Suspended (TSS) - Total	9900	10/12/1998	12/17/2009
Solids, Total Suspended (TSS) - Volatile	2634	10/15/2002	9/4/2008
Temperature, water	9610	10/12/1998	12/17/2009
Turbidity	9396	10/12/1998	12/17/2009

REMAP Random Probabilistic Survey

Site Location Statewide

 # sampling sites 233

Sample Frequency generally two or three samples per site

Data Summary

Parameter	Count	Begin Date	End Date
Chlorophyll a, corrected for pheophytin (Water)	535	6/6/2002	8/22/2005
Chlorophyll a, free of pheophytin (Water)	134	6/20/2005	10/17/2006
Chlorophyll a, uncorrected for pheophytin (Water)	535	6/6/2002	8/22/2005
Chlorophyll A (Periphyton)	546	6/6/2002	10/17/2006
Chlorophyll A (Sediment)	547	6/6/2002	10/17/2006
Diurnal D.O./Temp & Stream Metabolism	186	6/6/2002	10/17/2006
Dissolved oxygen (DO)	664	6/6/2002	10/17/2006
Flow	661	6/6/2002	10/17/2006
Nitrogen, ammonia as N	666	6/6/2002	10/17/2006
Nitrogen, Kjeldahl	667	6/6/2002	10/17/2006
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	667	6/6/2002	10/17/2006
pH	657	6/11/2002	10/17/2006
Phosphorus as P	669	6/6/2002	10/17/2006
Phosphorus, orthophosphate as P	668	6/6/2002	10/17/2006
Solids, Total Suspended (TSS) - Total	662	6/6/2002	10/17/2006
Solids, Total Suspended (TSS) - Volatile	659	6/19/2002	10/17/2006
Temperature, water	664	6/6/2002	10/17/2006
Turbidity	667	6/6/2002	10/17/2006

TMDL Summary

Site Location statewide

 # sampling sites 160 sites representing 44 watersheds

Sample Frequency generally biweekly & monthly, events collected at several sites

Data Summary

Parameter	Count	Begin Date	End Date
Chlorophyll a, corrected for pheophytin (Water)	611	1/8/2002	7/25/2005
Chlorophyll a, free of pheophytin (Water)	251	3/14/2005	12/18/2008
Chlorophyll a, uncorrected for pheophytin (Water)	611	1/8/2002	7/25/2005
Chlorophyll A (Periphyton)	180*	6/23/2003	9/15/2008
Chlorophyll A (Sediment)	180*	6/23/2003	9/15/2008
Diurnal D.O./Temp & Stream Metabolism	60*	6/23/2003	9/15/2008
Dissolved oxygen (DO)	2296	3/6/2001	12/18/2008
Flow	2091	3/6/2001	12/8/2008
Nitrogen, ammonia as N	1946	3/6/2001	12/18/2008
Nitrogen, Kjeldahl	1936	3/6/2001	12/18/2008
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1946	3/6/2001	12/18/2008
Nitrogen, organic	5	10/23/2001	8/15/2002
pH	2023	3/6/2001	12/18/2008
Phosphorus as P	1946	3/6/2001	12/18/2008
Phosphorus, orthophosphate as P	1941	3/6/2001	12/18/2008
Solids, Total Suspended (TSS) - Total	3309	3/6/2001	12/18/2008
Solids, Total Suspended (TSS) - Volatile	72	5/2/2005	9/21/2005
Temperature, water	2296	3/6/2001	12/18/2008
Turbidity	1494	3/14/2001	12/18/2008

* Estimated: approx. 90 deployments w/ 67% success rate; 2 periphyton/sediment Chl A samples / deployment

TMDL Details

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
Mud Creek - Cedar County	Mud Creek S of Durant (4)	11700001	Monthly	M	3/2001 - 11/2001
	Mud Creek SE of Wilton (2)	11700002	Monthly	M	
	Mud Creek SE of Durant (5)	11700003	Monthly	M	
	Mud Creek S of Wilton (1)	11700004	Monthly	M	
	Mud Creek W of Durant (3)	11700005	Monthly	M	
	Mud Creek near Wilton (TMDL S1)	11700006	Five Samples	5	6/2003 - 9/2003
	Mud Creek near Wilton (TMDL S2)	11700007	Five Samples	5	
	Mud Creek near Wilton (TMDL S3)	11700008	Five Samples	5	
Middle Fork South Beaver Creek - Grundy & Hardin Counties	M.F. South Beaver Creek at Ackley (47)	11420001	Monthly	M	3/2001-11/2001, 3/2003-11/2003
	M.F. South Beaver Creek NW of Wellsburg (45)	11380003	Monthly	M	
Camp Creek - Polk County	Camp Creek N of Runnells (53)	11770001	Monthly	M	3/2001-11/2001, 3/2003-11/2003
	Camp Creek S of Mitchellville (54)	11770002	Monthly	M	
	Camp Creek near Mitchellville	11770005	One-time	1	7/21/2005
Little Floyd River - Sioux County	Little Floyd River SW of Sheldon (51)	11840001	Monthly	M	3/2001-11/2001, 3/2003-11/2003
	Little Floyd River SE of Sheldon (52)	11710001		M	
Milford Creek (Iowa Great Lakes) - Dickinson County	Milford Creek SW of Milford (49)	11300002	Monthly (2001 & 2005), Biweekly (2004)	BM	3/2001-11/2001, 5/2004-10/2004, 7/2005-9/2005
	Milford Creek Below Lower Gar Lake (50)	11300001	Monthly	M	4/2001-11/2001, 5/2002-6/2002, 7/2005-9/2005
	Upper Gar Lake Outlet to Minnewshta Lake (4)	11300003	Monthly	M	5/2002 - 6/2002
	Upper Gar Lake Inlet from East Okoboji Lake (5)	11300004		M	
	Lower Gar Lake Inlet from Minnewashta Lake (5)	11300006		M	
	Lower Gar Lake - Unnamed Northeast Tributary (6)	11300007		M	

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
	Bull Ditch nr Lower Gar Lake (7)	11300008		M	
	Lower Gar Lake - Unnamed North Tributary (9)	11300010	One-time	1	06/2002
	North Tributary of Silver Lake	11300011	Biweekly	B	3/2005 - 9/2005
	Milford Creek upstream Milford (Site 3)	11300012	Monthly	M	7/2005 - 9/2005
	Storm Drainage Ditch near Milford	11300013		M	
	Iowa Great Lakes Sanitary District Wastewater Plant Effluent	11300014		M	
	Milford Creek at 225th Ave (Site 2)	11300015		M	
Sugar Creek - Cedar County	Bennett Creek SW of Bennett (10)	11160001	Monthly	M	3/2001 - 11/2001
	Sugar Creek SE of Tipton (8)	11160002		M	
	Sugar Creek E of Tipton	11160003		M	
	Sugar Creek SW of Bennett (7)	11160004		M	
	Sugar Creek NW of Wilton (6)	11160005		M	
North Fork Maquoketa River	Coffee Creek at New Vienna (31)	11310001	Monthly	M	3/2001 - 11/2001
	North Fork Maquoketa River SW of New Vienna (29)	11310002		M	
	North Fork Maquoketa River NE of New Vienna (30)	11310003		M	
	North Fork Maquoketa River N of Dyersville (28)	11310004		M	
Rock Creek - Clinton County	Rock Creek near Camanche (55)	11230001	Monthly	M	3/2001 - 11/2001
	Rock Creek Below Wetland (56)	11230002		M	
	Rock Creek Bridge on County Road Z40 (61)	11230007		M	
	Rock Creek Above Low Moor Outfall (62)	11230008		M	
	Rock Creek at Hwy 30 (63)	11230009		M	

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
Buffalo Creek - Jones County	Buffalo Creek at Anamosa (11)	11530001	Monthly	M	3/2001 - 11/2001
	Buffalo Creek NW of Anamosa (12)	11570001		M	
	Buffalo Creek SW of Prairieburg (13)	11570002		M	
Little Cedar River	Little Cedar River at Ionia (69)	11190001	Monthly	M	4/2001 - 12/2004
Shell Rock River	Shell Rock River at Rockford (68)	11340001	Monthly	M	4/2001 - 12/2004
Dry Run Creek - Black Hawk County (NOTE: Additional sites in this watershed have been monitored through a watershed project)	Dry Run Creek at Cedar Falls (Site 1)	11070006	2005 Weekly, 2006-2008 Biweekly, Monthly in Winter	WBM	6/2005 - 6/2008
	Dry Run Creek at Cedar Falls (Site 4)	11070007		WBM	
	Dry Run Creek at Cedar Falls (Site 6D1)	11070008		WBM	
Lyons Creek - Hamilton County	Lyons Creek in Webster City (Site LC1)	11400002	Biweekly, Monthly in Winter	BM	6/2006 - 12/2008
	Lyons Creek near Webster City (Site LC2)	11400003		BM	
	Lyons Creek near Webster City (site lcr3)	11400005		BM	
Iowa River - Johnson County	Iowa River at Coralville below the Coralville Dam	11520001	Biweekly	B	3/2005, 8/2005 - 9/2005
	Iowa River at Iowa City above the Burlington Stree	11520002		B	
	Iowa River near Iowa City (Site 77)	11520003		B	8/2005 - 9/2005
	Iowa River near Iowa City (Site 79)	11520004		B	
	Iowa River in Iowa City (Site 81)	11520005		B	
Buttermilk Creek - Wright County	Buttermilk Creek near Goldfield (Site BMC1)	11990001	Biweekly, Monthly (winter) + Events	BM	12/2006 - 6/2008
	Buttermilk Creek near Goldfield (Site BMC2)	11990002	One-Time	1	9/5/2007
	Buttermilk Creek near Goldfield (Site BMC3)	11990003	Biweekly, Monthly (winter)	BM	11/2006 - 7/2008
	BMCSNAP1	11990005	One-Time	1	1/2007, 2/2007
	BMCSNAP2	11990006	One-Time	1	1/2007, 2/2007

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
	BMCSNAP3	11990007	One-Time	1	1/2007, 2/2007
	BMCSNAP4	11990008	One-Time	1	1/2007, 2/2007
Powell Creek - Buena Vista County	Powell Creek (TMDL Site 1)	11110001	Monthly	M	7/2004 - 10/2004
	Powell Creek (TMDL Site 2)	11110002		M	
	Powell Creek (TMDL Site 3)	11110003		M	
Marrowbone Creek - Calhoun County	Marrowbone Creek near Lanesboro (site mab3)	11130002	Monthly	M	7/2008 - 12/2008
	Marrowbone Creek near Lanesboro (Site MaB2)	11140003	Monthly	M	8/06, 9/07, 7/08-12/08
	Marrowbone Creek near Lanesboro (site 42)	11140004	One-Time	1	09/2010
	Marrowbone Creek	16140001	5 Samples	5	9/02, 8/06, 7/08
Silver Creek - Clayton County	Silver Creek near Monona (Site SiCr1)	11220014	Monthly, Biweekly	BM	6/2006 - 10/2008
	Unnamed Tributary to Silver Creek near Monona (Site SiCr3)	11220016	One-time	1	06/2006
	Silver Creek near Luana (Site SiCr4)	11220017	Biweekly, Monthly	BM	6/2006 - 6/2007
	Unnamed Tributary to Silver Creek near Luana (Site SiCr5)	11220018	Biweekly	B	8/2006 - 10/2008
	Unnamed Trib to Silver Creek downstream of Monona WWTP	11220020	Biweekly	B	7/2008 - 10/2008
	Creamery Effluent at Highway 52 near Luana	11220021		B	
Springbrook Creek - Guthrie County	Springbrook Creek (TMDL Site 1 - Upstream)	11390001	Weekly, Biweekly	WB	7/2004 - 9/2005
	Springbrook Creek (TMDL Site 2 - Midstream)	11390002		WB	
	Springbrook Creek (TMDL Site 3 - Downstream)	11390003		WB	
	Little Springbrook Creek	12390003	Two Samples	2	6/2003 - 7/2003
Badger Creek Lake - Madison County	Badger Creek below Badger Creek Lake (4)	11610001	Three Samples	3	4/2002 - 7/2002
	Badger Creek Lake - Unnamed Trib on County Road R16. (5)	11610002		3	
	Badger Creek nr Badger Creek Lake (6)	11610003		3	

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
	Badger Creek Lake - Unnamed Tributary on Prairieview Ave. (7	11610004		3	
	Badger Creek Lake - Unnamed Tributary on 110th St. (8)	11610005		3	
	Badger Creek Lake - Unnamed Tributary on 105th St. (9)	11610006		3	
Arbor Lake - Poweshiek County	Arbor Lake -Unnamed Northeast Tributary (1)	11790001	One-Time	1	03/2002
	Arbor Lake -Unnamed Northwest Tributary (2)	11790002		1	
	Arbor Lake - Inflow from Nyanza Lake (4)	11790004		1	
	Arbor Lake - Inflow from southeast storm sewer (5)	11790005		1	
	Arbor Lake Outlet (7)	11790007		1	
Lake Darling - Washington County	Lake Darling - Unnamed Northeast Tributary (1)	11920001	Three Samples	3	3/2002 - 8/2002
	Lake Darling - Unnamed East Tributary (2)	11920002		3	
	Honey Creek nr Lake Darling (3)	11920003		3	
	Lake Darling - Unnamed Western Tributary (4)	11920004		3	
	Lake Darling Outlet (5)	11920005		3	
Lake Meyer - Winneshiek County	Lake Meyer - Unnamed Northeast Tributary (1)	11960001	Three Samples	3	3/2002 - 6/2002
	Lake Meyer - Unnamed East Tributary (2)	11960002		3	
	Lake Meyer Outlet (3)	11960003		3	
	Calmar Storm Sewer	11960004		3	
Yeader Creek - Polk County	Yeader Creek (TMDL Site 1)	11770003	Biweekly	B	7/2004 - 7/2005
	Yeader Creek (TMDL Site 2)	11770004		1	
Trumbull Lake - Clay County	North Tributary of Trumbull Lake	11210001	Once in March, Biweekly May-Sept.	B	3/2005, 5/2005 - 9/2005
	Trumbull Lake East Tributary	11210002		B	
Yellow River - Allamakee, Winneshiek County (NOTE: Additional sites in this	Yellow River	10030002	Biweekly	B	4/2009 - 9/2009
	Hickory Creek	15030007		B	
	Bear Creek	15030006		B	

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
watershed have been monitored through a watershed project)	Mainstem 3 Yellow River	11030002		B	
	Mainstem 1 Yellow River	11030001		B	
	Mainstem 2 Yellow River	15030003		B	
	No Name at Co. Rd. W60	15030009	Biweekly, Monthly in Winter	BM	2004 - 2008
	Hecker Creek at Co. Rd. W48	15030010		BM	
	Yellow River at 107th Ave.	15960002		BM	
Lime Creek - Buchanan County	Lime Creek near Brandon (site LiCr2)	11100001	Biweekly, Monthly in Winter	BM	9/07, 7/2008 - 12/2008
	Lime Creek near Brandon (site 154)	12100002		BM	
Long Dick Creek - Hamilton County	Long Dick Creek near Ellsworth (site ldc2)	11400004	Biweekly, Monthly in Winter	BM	7/2007 - 7/2009
	site ldc1 long dick creek	12850006		BM	
Pecks Creek	Peck Creek near Osterdock (Site 326)	11220012	One-Time	1	08/2006
	Peck Creek near Osterdock (Site PeC2)	11220013		1	
Walnut Creek - Poweshiek County (NOTE: Additional Sites and Samples were collected as part of a 319	site 200 walnut creek		Biweekly, Monthly in Winter	BM	2009
	site wlnt1 walnut creek	11790008		BM	
	site wlnt2 walnut creek	11790009		BM	
	site wlnt3 walnut creek	11790010		BM	
Roberts Creek - Clayton County	Roberts Creek near Postville (site rob1)	11220022	One-Time	1	08/2008
Nutting Creek - Fayette County	Nutting Creek near Clermont (Site NuCr1)	11330001	Biweekly, Monthly in Winter	BM	6/2006 - 6/2007
Tete Des Mortes Creek - Jackson County	Tete des Morts Creek near St. Donatus (Site TMD2)	11490013	One-Time	1	08/2007
	Tete des Morts Creek nr. St. Donatus (site tmd3)	11490014		1	10/2007
Don Williams Lake - Boone County	Bluff Creek below Don Williams Lake (4)	11080001	Two Samples	2	4/02, 7/02
	Bluff Creek nr Don Williams Lake (5)	11080002		2	
	Drainage Ditch No. 107 (6)	11080003		2	
	Bluff Creek (7)	11080004		2	
Big Sioux River - Sioux, Osceola, Lyon, Plymouth	Rock River near Rock Rapids (2)	11600001	Monthly	M	3/1/2002 - 12/2003

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
Counties	Rock River at IA/MN border (3)	11600002		M	
	Mud Creek nr IA/MN border (4)	11600003		M	
	Mud Creek nr Doon (5)	11600004		M	
	Little Rock River nr Doon (6)	11600005		M	
	Little Rock River at IA/MN border (1)	11720001		M	
	Indian Creek nr Chatsworth (9)	11750001		M	
	Westfield Creek nr Westfield (10)	11750002		M	
	Broken Kettle Creek (11)	11750003		M	
	Big Sioux River near Westfield	11750004		M	
	Rock River nr Rock Valley (7)	11840002		M	
	Six Mile Creek nr Chatsworth (8)	11840003		M	
Black Hawk Creek - Black Hawk and Grundy County	Black Hawk Creek upstream 230th Street	11380005	Monthly	M	4/05 - 9/05
	Black Hawk Creek at Grundy Center	11380006		M	
	Black Hawk Creek near Holland	11380007		M	
	Holland Creek	11380008		M	
	North Fork Black Hawk Creek	11380009		M	
	Black Hawk Creek at Popp Access (17)	11070003		M	
	Black Hawk Creek at Waterloo (15)	11070005		M	
Jordan Creek - Polk County	Jordan Creek near West Des Moines	11770006	One-Time	1	07/2005
Dick Creek - Wayne County	Dick Creek near Corydon (site dick1)	11930001	Biweekly	B	7/2009 - Present
	Dick Creek near Corydon (site dick2)	11930002		B	
Brushy Creek - Carroll County			One-Time	1	2009
Willow Creek -			One-Time	1	2009

Watershed	Site Name	STORET ID	Sampling Frequency	FREQUENCY	Period of Record
White Pine Creek -			One-Time	1	2009
East Pine Creek - Winneshiek County			One-Time	1	2008
North Cedar Creek - Clayton County			One-Time	1	2008

TMDL Details

Watershed	Site Name	Parameters
Mud Creek - Cedar County	Mud Creek S of Durant (4)	Dissolved Oxygen, Flow, pH, Ammonia, Nitrate + Nitrite, TKN, Orthophosphate, Total Phosphate, TSS, Turbidity
	Mud Creek SE of Wilton (2)	
	Mud Creek SE of Durant (5)	
	Mud Creek S of Wilton (1)	
	Mud Creek W of Durant (3)	
	Mud Creek near Wilton (TMDL S1)	Dissolved Oxygen, Flow, pH, Ammonia, Nitrate + Nitrite, TKN, Orthophosphate, Total Phosphate, TSS, Turbidity, Chlorophyll
	Mud Creek near Wilton (TMDL S2)	
	Mud Creek near Wilton (TMDL S3)	
Middle Fork South Beaver Creek - Grundy & Hardin Counties	M.F. South Beaver Creek at Ackley (47)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	M.F. South Beaver Creek NW of Wellsburg (45)	
Camp Creek - Polk County	Camp Creek N of Runnells (53)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Camp Creek S of Mitchellville (54)	
	Camp Creek near Mitchellville	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Chlorophyll a
Little Floyd River - Sioux County	Little Floyd River SW of Sheldon (51)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Little Floyd River SE of Sheldon (52)	
Milford Creek (Iowa Great Lakes) - Dickinson County	Milford Creek SW of Milford (49)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Chlorophyll, Turbidity
	Milford Creek Below Lower Gar Lake (50)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity
	Upper Gar Lake Outlet to Minnewshta Lake (4)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Upper Gar Lake Inlet from East Okoboji Lake (5)	
	Lower Gar Lake Inlet from Minnewashta Lake (5)	
	Lower Gar Lake - Unnamed Northeast Tributary (6)	

Watershed	Site Name	Parameters
	Bull Ditch nr Lower Gar Lake (7)	
	Lower Gar Lake - Unnamed North Tributary (9)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	North Tributary of Silver Lake	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Chlorophyll a
	Milford Creek upstream Milford (Site 3)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Chlorophyll a
	Storm Drainage Ditch near Milford	
	Iowa Great Lakes Sanitary District Wastewater Plant Effluent	
	Milford Creek at 225th Ave (Site 2)	
Sugar Creek - Cedar County	Bennett Creek SW of Bennett (10)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Sugar Creek SE of Tipton (8)	
	Sugar Creek E of Tipton	
	Sugar Creek SW of Bennett (7)	
	Sugar Creek NW of Wilton (6)	
North Fork Maquoketa River	Coffee Creek at New Vienna (31)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	North Fork Maquoketa River SW of New Vienna (29)	
	North Fork Maquoketa River NE of New Vienna (30)	
	North Fork Maquoketa River N of Dyersville (28)	
Rock Creek - Clinton County	Rock Creek near Camanche (55)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity
	Rock Creek Below Wetland (56)	
	Rock Creek Bridge on County Road Z40 (61)	
	Rock Creek Above Low Moor Outfall (62)	
	Rock Creek at Hwy 30 (63)	

Watershed	Site Name	Parameters
Buffalo Creek - Jones County	Buffalo Creek at Anamosa (11) Buffalo Creek NW of Anamosa (12) Buffalo Creek SW of Prairieburg (13)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
Little Cedar River	Little Cedar River at Ionia (69)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity, Chlorophyll a
Shell Rock River	Shell Rock River at Rockford (68)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity, Chlorophyll a
Dry Run Creek - Black Hawk County (NOTE: Additional sites in this watershed have been monitored through a watershed project)	Dry Run Creek at Cedar Falls (Site 1) Dry Run Creek at Cedar Falls (Site 4) Dry Run Creek at Cedar Falls (Site 6D1)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll a, Flow, Dissolved Oxygen, pH
Lyons Creek - Hamilton County	Lyons Creek in Webster City (Site LC1) Lyons Creek near Webster City (Site LC2) Lyons Creek near Webster City (site lcr3)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll a, Flow, Dissolved Oxygen, pH
Iowa River - Johnson County	Iowa River at Coralville below the Coralville Dam Iowa River at Iowa City above the Burlington Stree Iowa River near Iowa City (Site 77) Iowa River near Iowa City (Site 79) Iowa River in Iowa City (Site 81)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll a, Flow, Dissolved Oxygen, pH
Buttermilk Creek - Wright County	Buttermilk Creek near Goldfield (Site BMC1) Buttermilk Creek near Goldfield (Site BMC2) Buttermilk Creek near Goldfield (Site BMC3)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll a, Flow, Dissolved Oxygen, pH, Data logger, Sediment and Periphyton Chlorophyll
	BMCSNAP1 BMCSNAP2	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity

Watershed	Site Name	Parameters
	BMCSNAP3	
	BMCSNAP4	
Powell Creek - Buena Vista County	Powell Creek (TMDL Site 1)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Powell Creek (TMDL Site 2)	
	Powell Creek (TMDL Site 3)	
Marrowbone Creek - Calhoun County	Marrowbone Creek near Lanesboro (site mab3)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity, Chlorophyll a, Data logger, Sediment and Periphyton Chlorophyll
	Marrowbone Creek near Lanesboro (Site MaB2)	
	Marrowbone Creek near Lanesboro (site 42)	
	Marrowbone Creek	
Silver Creek - Clayton County	Silver Creek near Monona (Site SiCr1)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity, Data logger, Sediment and Periphyton Chlorophyll
	Unnamed Tributary to Silver Creek near Monona (Site SiCr3)	
	Silver Creek near Luana (Site SiCr4)	
	Unnamed Tributary to Silver Creek near Luana (Site SiCr5)	
	Unnamed Trib to Silver Creek downstream of Monona WWTP	
	Creamery Effluent at Highway 52 near Luana	
Springbrook Creek - Guthrie County	Springbrook Creek (TMDL Site 1 - Upstream)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity, Chlorophyll a
	Springbrook Creek (TMDL Site 2 - Midstream)	
	Springbrook Creek (TMDL Site 3 - Downstream)	
	Little Springbrook Creek	
Badger Creek Lake - Madison County	Badger Creek below Badger Creek Lake (4)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Badger Creek Lake - Unnamed Trib on County Road R16. (5)	
	Badger Creek nr Badger Creek Lake (6)	

Watershed	Site Name	Parameters
	Badger Creek Lake - Unnamed Tributary on Prairieview Ave. (7	
	Badger Creek Lake - Unnamed Tributary on 110th St. (8)	
	Badger Creek Lake - Unnamed Tributary on 105th St. (9)	
Arbor Lake - Poweshiek County	Arbor Lake -Unnamed Northeast Tributary (1)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Arbor Lake -Unnamed Northwest Tributary (2)	
	Arbor Lake - Inflow from Nyanza Lake (4)	
	Arbor Lake - Inflow from southeast storm sewer (5)	
	Arbor Lake Outlet (7)	
Lake Darling - Washington County	Lake Darling - Unnamed Northeast Tributary (1)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Lake Darling - Unnamed East Tributary (2)	
	Honey Creek nr Lake Darling (3)	
	Lake Darling - Unnamed Western Tributary (4)	
	Lake Darling Outlet (5)	
Lake Meyer - Winneshiek County	Lake Meyer - Unnamed Northeast Tributary (1)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS
	Lake Meyer - Unnamed East Tributary (2)	
	Lake Meyer Outlet (3)	
	Calmar Storm Sewer	
Yeader Creek - Polk County	Yeader Creek (TMDL Site 1)	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Chlorophyll, Turbidity
	Yeader Creek (TMDL Site 2)	
Trumbull Lake - Clay County	North Tributary of Trumbull Lake	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Chlorophyll, Turbidity
	Trumbull Lake East Tributary	
Yellow River - Allamakee, Winneshiek County (NOTE: Additional sites in this	Yellow River	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Chlorophyll, Turbidity, Data logger, Sediment and Periphyton Chlorophyll
	Hickory Creek	
	Bear Creek	

Watershed	Site Name	Parameters
watershed have been monitored through a watershed project)	Mainstem 3 Yellow River Mainstem 1 Yellow River Mainstem 2 Yellow River No Name at Co. Rd. W60 Hecker Creek at Co. Rd. W48 Yellow River at 107th Ave.	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll, Flow, Dissolved Oxygen, pH
Lime Creek - Buchanan County	Lime Creek near Brandon (site LiCr2) Lime Creek near Brandon (site 154)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll, Flow, Dissolved Oxygen, pH, Data logger, Sediment and Periphyton Chlorophyll
Long Dick Creek - Hamilton County	Long Dick Creek near Ellsworth (site ldc2) site ldc1 long dick creek	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity, Chlorophyll a, Data logger, Sediment and Periphyton Chlorophyll
Pecks Creek	Peck Creek near Osterdock (Site 326) Peck Creek near Osterdock (Site PeC2)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll
Walnut Creek - Poweshiek County (NOTE: Additional Sites and Samples were collected as part of a 319	site 200 walnut creek site wlnt1 walnut creek site wlnt2 walnut creek site wlnt3 walnut creek	Dissolved Oxygen, Flow, Ammonia, Nitrate + Nitrite, pH, Orthophosphate, Total Phosphate, TKN, TSS, Turbidity, Chlorophyll a, Data logger, Sediment and Periphyton Chlorophyll
Roberts Creek - Clayton County	Roberts Creek near Postville (site rob1)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll, Flow, Dissolved Oxygen, pH
Nutting Creek - Fayette County	Nutting Creek near Clermont (Site NuCr1)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll, Flow, Dissolved Oxygen, pH, Data logger, Sediment and Periphyton Chlorophyll
Tete Des Mortes Creek - Jackson County	Tete des Morts Creek near St. Donatus (Site TMD2) Tete des Morts Creek nr. St. Donatus (site tmd3)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Turbidity, Chlorophyll, Flow, Dissolved Oxygen, pH
Don Williams Lake - Boone County	Bluff Creek below Don Williams Lake (4) Bluff Creek nr Don Williams Lake (5) Drainage Ditch No. 107 (6) Bluff Creek (7)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH
Big Sioux River - Sioux, Osceola, Lyon, Plymouth	Rock River near Rock Rapids (2)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH

Watershed	Site Name	Parameters
Counties	Rock River at IA/MN border (3)	
	Mud Creek nr IA/MN border (4)	
	Mud Creek nr Doon (5)	
	Little Rock River nr Doon (6)	
	Little Rock River at IA/MN border (1)	
	Indian Creek nr Chatsworth (9)	
	Westfield Creek nr Westfield (10)	
	Broken Kettle Creek (11)	
	Big Sioux River near Westfield	
	Rock River nr Rock Valley (7)	
	Six Mile Creek nr Chatsworth (8)	
Black Hawk Creek - Black Hawk and Grundy County	Black Hawk Creek upstream 230th Street	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity
	Black Hawk Creek at Grundy Center	
	Black Hawk Creek near Holland	
	Holland Creek	
	North Fork Black Hawk Creek	
	Black Hawk Creek at Popp Access (17)	
	Black Hawk Creek at Waterloo (15)	
Jordan Creek - Polk County	Jordan Creek near West Des Moines	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll
Dick Creek - Wayne County	Dick Creek near Corydon (site dick1)	Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll, Data logger, Sediment and Periphyton Chlorophyll
	Dick Creek near Corydon (site dick2)	
Brushy Creek - Carroll County		Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll, Sediment and Periphyton Chlorophyll
Willow Creek -		Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll, Sediment and Periphyton Chlorophyll

Watershed	Site Name	Parameters
White Pine Creek -		Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll, Sediment and Periphyton Chlorophyll
East Pine Creek - Winneshiek County		Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll, Sediment and Periphyton Chlorophyll
North Cedar Creek - Clayton County		Ammonia, Nitrate + Nitrite, TKN, Total Phosphate, Orthophosphate, TSS, Flow, Dissolved Oxygen, pH, Turbidity, Chlorophyll, Sediment and Periphyton Chlorophyll

Other Projects:

Balance Herbicide

Site Location Iowa, Johnson, and Washington counties
 # sampling sites 3
Sample Frequency daily
Data Summary

Parameter	Count	Begin Date	End Date
Dissolved oxygen (DO)	269	5/4/2000	8/1/2000
Nitrogen, ammonia as N	270	5/4/2000	8/1/2000
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	270	5/4/2000	8/1/2000
Phosphorus as P	268	5/4/2000	8/1/2000
Phosphorus, orthophosphate as P	249	5/4/2000	8/1/2000
Temperature, water	270	5/4/2000	8/1/2000
Turbidity	264	5/4/2000	8/1/2000

Buffalo Creek

Site Location Buchanan and Delaware counties
 # sampling sites 8
Sample Frequency biweekly
Data Summary

Parameter	Count	Begin Date	End Date
Dissolved oxygen (DO)	146	6/23/2008	12/12/2008
Flow	74	6/23/2008	12/12/2008
Nitrogen, ammonia as N	146	6/23/2008	12/12/2008
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	146	6/23/2008	12/12/2008
pH	146	6/23/2008	12/12/2008
Phosphorus as P	146	6/23/2008	12/12/2008
Temperature, water	146	6/23/2008	12/12/2008
Turbidity	146	6/23/2008	12/12/2008

Cedar River-Floyd County

Site Location Floyd County
 # sampling sites 8
Sample Frequency monthly
Data Summary

Parameter	Count	Begin Date	End Date
Nitrogen, ammonia as N	55	4/16/2008	11/18/2009
Nitrogen, Kjeldahl	42	4/16/2008	11/19/2008
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	98	4/16/2008	11/18/2009
Phosphorus as P	98	4/16/2008	11/18/2009
Phosphorus, orthophosphate as P	42	4/16/2008	11/19/2008
Solids, Total Suspended (TSS)	98	4/16/2008	11/18/2009

Cedar River-Mitchell County

Site Location Mitchell County
 # sampling sites 18
Sample Frequency monthly with some events
Data Summary

Parameter	Count	Begin Date	End Date
Nitrogen, ammonia as N	283	5/16/2006	9/9/2009
Nitrogen, Kjeldahl	282	5/16/2006	7/13/2009

Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	332	5/16/2006	11/10/2009
Phosphorus as P	332	5/16/2006	11/10/2009
Phosphorus, orthophosphate as P	282	5/16/2006	7/13/2009
Solids, Total Suspended (TSS) - Total	320	5/16/2006	11/10/2009

Cedar Rapids-Urban Water Quality

Site Location Linn County
 # sampling sites 6
Sample Frequency daily
Data Summary

Parameter	Count	Begin Date	End Date
Chlorophyll a, corrected for pheophytin (Water)	159	5/29/2002	8/18/2002
Chlorophyll a, uncorrected for pheophytin (Wate	159	5/29/2002	8/18/2002
Nitrogen, ammonia as N	16	6/16/2002	8/15/2002
Nitrogen, Kjeldahl	16	6/16/2002	8/15/2002
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	16	6/16/2002	8/15/2002
Phosphorus as P	16	6/16/2002	8/15/2002
Phosphorus, orthophosphate as P	16	6/16/2002	8/15/2002
Solids, Total Suspended (TSS) - Total	16	6/16/2002	8/15/2002

Dry Run Creek

Site Location Black Hawk County
 # sampling sites 10
Sample Frequency monthly in winter, biweekly in summer
Data Summary

Parameter	Count	Begin Date	End Date
Dissolved oxygen (DO)	514	6/16/2005	6/18/2008
Nitrogen, ammonia as N	550	6/9/2005	6/18/2008
Nitrogen, Kjeldahl	550	6/9/2005	6/18/2008
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	550	6/9/2005	6/18/2008
pH Total	368	7/7/2005	6/18/2008
Phosphorus as P	550	6/9/2005	6/18/2008
Phosphorus, orthophosphate as P	346	4/12/2006	6/18/2008
Solids, Total Suspended (TSS) - Total	346	4/12/2006	6/18/2008
Temperature, water	514	6/16/2005	6/18/2008
Transparency, tube with disk	337	3/9/2006	6/18/2008
Turbidity	346	3/9/2006	6/18/2008

Floyd Mitchell/ADW

Site Location Floyd County
 # sampling sites 3
Sample Frequency generally quarterly
Data Summary

Parameter	Count	Begin Date	End Date
Nitrogen, ammonia as N	83	1/25/1995	9/30/1998
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	174	11/14/1994	8/27/2008
Nitrogen, organic	4	7/16/1996	8/20/1996

Herbert Hoover Creek

Site Location Cedar County
 # sampling sites 4
Sample Frequency monthly
Data Summary

Parameter	Count	Begin Date	End Date
Dissolved oxygen (DO)	48	6/8/2004	7/7/2005
Nitrogen, ammonia as N	56	6/8/2004	7/7/2005
Nitrogen, Kjeldahl	44	6/8/2004	7/7/2005
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	56	6/8/2004	7/7/2005
Nitrogen, organic	12	8/9/2004	10/5/2004
Solids, Total Suspended (TSS) - Total	16	4/5/2005	7/7/2005
Temperature, water	52	6/8/2004	7/7/2005
Turbidity	56	6/8/2004	7/7/2005

Lake Delhi Watershed

Site Location Delaware County
 # sampling sites 12
Sample Frequency biweekly
Data Summary

Parameter	Count	Begin Date	End Date
Dissolved oxygen (DO)	17	4/3/2006	6/12/2006
Nitrogen, ammonia as N	42	4/3/2006	6/12/2006
Nitrogen, Kjeldahl	53	4/3/2006	6/12/2006
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	42	4/3/2006	6/12/2006
pH	17	4/3/2006	6/12/2006
Phosphorus as P	42	4/3/2006	6/12/2006
Temperature, water	16	4/3/2006	6/12/2006
Turbidity	16	4/3/2006	6/12/2006

Lake Hendricks Watershed

Site Location Howard County
 # sampling sites 11
Sample Frequency biweekly/monthly
Data Summary

Parameter	Count	Begin Date	End Date
Nitrogen, ammonia as N	238	3/21/2007	11/12/2008
Nitrogen, Kjeldahl	238	3/21/2007	11/12/2008
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	238	3/21/2007	11/12/2008
pH	226	4/2/2007	11/12/2008
Phosphorus as P	237	4/2/2007	11/12/2008

Northeast Iowa RC&D/Upper Iowa River

Site Location Allamakee, Howard, and Winneshiek counites
 # sampling sites 28
Sample Frequency
Data Summary

Parameter	Count	Begin Date	End Date
Nitrogen, ammonia as N	600	4/27/2004	10/3/2006

Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	600	4/27/2004	10/3/2006
Phosphorus as P	594	4/27/2004	10/3/2006

Northeast Iowa RC&D has additional data after 10/3/2006

Sny Magill 319

Site Location Allamakee and Clayton counties
 # sampling sites 10
Sample Frequency weekly
Data Summary

Parameter	Count	Begin Date	End Date
Dissolved oxygen (DO)	3540	10/7/1991	9/25/2001
Nitrogen, ammonia as N	3564	10/7/1991	9/25/2001
Nitrogen, Kjeldahl	6	3/23/1999	9/19/2000
Nitrogen, Nitrate (NO3) as N	730	9/28/1994	9/24/1996
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	3048	10/7/1991	9/25/2001
Nitrogen, Nitrite (NO2) as N	730	9/28/1994	9/24/1996
Nitrogen, organic	1149	10/7/1991	9/25/2001
Phosphorus as P	1139	10/7/1991	9/25/2001
Phosphorus, orthophosphate as P	730	9/28/1994	9/24/1996
Temperature, water	3570	10/7/1991	9/25/2001
Turbidity	3528	10/7/1991	9/25/2001

Yellow River Watershed

Site Location Buchanan and Delaware counties
 # sampling sites 14
Sample Frequency monthly in winter; biweekly/weekly in summer
Data Summary

Parameter	Count	Begin Date	End Date
Dissolved oxygen (DO)	898	5/20/2004	11/16/2006
Nitrogen, ammonia as N	947	5/20/2004	9/4/2008
Nitrogen, Kjeldahl	947	5/20/2004	9/4/2008
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	1100	5/20/2004	9/4/2008
pH	26	4/14/2005	10/27/2005
Phosphorus as P	1100	5/20/2004	9/4/2008
Phosphorus, orthophosphate as P	958	5/20/2004	9/4/2008
Solids, Total Suspended (TSS) - Total	745	5/12/2005	9/4/2008
Temperature, water	904	5/20/2004	11/16/2006
Turbidity	876	5/20/2004	11/16/2006

Allamakee Co. SWCD has additional data that is not available in STORET, but is available electronically

135 sampling sites total

DNR Stream Biological Assessment Program (1994-2008)

		Project					
	no.	Ambient	Reference / Candidate Reference	REMAP	TMDL	Other Targeted	Totals
Benthic macroinvertebrates (BMIBI) & nutrients	samples	67	275	226	87	206	861
	sites	16	127	204	61	120	528
Fish assemblage (FIBI) & nutrients	samples	5	289	249	86	120	749
	sites	5	122	222	71	113	533
Benthic & Fish & Nutrients & Chlorophyll & Diurnal D.O./Temp & Stream	samples	0	0	186	50	3	239
	sites	0	0	186	30	3	219

Bibl.No.	Title	Primary Author	Year	Geographic Region	Ammonia Toxicity	Biological Assemblages - Algae	Biological Assemblages - Benthic Macroinvertebrates	Biological Assemblages - Fish	Biological Assemblages - Macrophytes	Biological Assemblages - Mussels	Chlorophyll - Benthic	Chlorophyll - Seston	Dissolved Oxygen - Stream Metabolism	Literature Review	Nitrate - Nitrite Toxicity	Nutrient - Biological Response Breakpoint / Threshold Analysis	Nutrient Criteria Derivation / Modeling	Nutrient Criteria Guidance	Nutrient Dynamics - Nitrogen	Nutrient Dynamics - Phosphorus	Nutrient Enrichment - Trophic State
1	Linkages between nutrients and assemblages of macroinvertebrates and fish in wadeable streams: implications to nutrient criteria development.	Wang	2007	WI			X	X													
2	Empirical approaches for nutrient criteria development.	USEPA	2009	U.S.												X	X	X			
3	U.S. EPA Science Advisory Board Ecological Processes and Effects Subcommittee (FY2009) Augmented for Review of Nutrient Criteria Guidance.	SAB	2009	U.S.												X		X			
4	A technique for establishing reference nutrient concentrations across watersheds affected by humans.	Dodds	2004	U.S.													X				
5	Sparrow modeling – enhancing understanding of the nation's water quality.	USGS	2009	U.S.													X				
6	Controls on chlorophyll-a in nutrient-rich agricultural streams in Illinois, USA	Figueroa-Nieves	2006	IL		X					X	X									

Bibl.No.	Title	Primary Author	Year	Geographic Region	Ammonia Toxicity	Biological Assemblages - Algae	Biological Assemblages - Benthic Macroinvertebrates	Biological Assemblages - Fish	Biological Assemblages - Macrophytes	Biological Assemblages - Mussels	Chlorophyll - Benthic	Chlorophyll - Seston	Dissolved Oxygen - Stream Metabolism	Literature Review	Nitrate - Nitrite Toxicity	Nutrient - Biological Response Breakpoint / Threshold Analysis	Nutrient Criteria Derivation / Modeling	Nutrient Criteria Guidance	Nutrient Dynamics - Nitrogen	Nutrient Dynamics - Phosphorus	Nutrient Enrichment - Trophic State
7	Relationships between benthic sediments and water column phosphorus in Illinois streams.	McDaniel	2009	IL																X	
8	Trophic state, eutrophication and nutrient criteria in streams.	Dodds	2007	U.S.																	X
9	Assessment of Chlorophyll-a as a criterion for establishing nutrient standards in the streams and rivers of Illinois.	Royer	2008	IL							X	X					X				
10	Ecosystem modeling applied to nutrient criteria development in rivers	Carleton	2009	MN		X					X	X					X				
11	Eutrophication of agricultural streams: defining nutrient concentrations to protect ecological condition	Chambers	2008	Ontario							X	X				X	X				
12	Identifying biotic integrity and water chemistry relations in nonwadeable rivers of Wisconsin: toward the development of nutrient criteria.	Weigel	2007	WI			X	X								X					

Bibl.No.	Title	Primary Author	Year	Geographic Region	Ammonia Toxicity	Biological Assemblages - Algae	Biological Assemblages - Benthic Macroinvertebrates	Biological Assemblages - Fish	Biological Assemblages - Macrophytes	Biological Assemblages - Mussels	Chlorophyll - Benthic	Chlorophyll - Seston	Dissolved Oxygen - Stream Metabolism	Literature Review	Nitrate - Nitrite Toxicity	Nutrient - Biological Response Breakpoint / Threshold Analysis	Nutrient Criteria Derivation / Modeling	Nutrient Criteria Guidance	Nutrient Dynamics - Nitrogen	Nutrient Dynamics - Phosphorus	Nutrient Enrichment - Trophic State
13	Natural background concentrations of nutrients in streams and rivers of the conterminous United States	Smith	2003	U.S.													X				
14	Relation of nutrient concentrations and biological responses in Minnesota streams: Applications for river nutrient criteria development.	Heiskary	2008	MN			X	X				X	X			X					
15	Algae–P relationships, thresholds, and frequency distributions guide nutrient criterion development	Stevenson	2009	MAH		X					X					X	X				
16	Establishing nutrient criteria in streams	Dodds	2000	U.S.													X	X			
17	Eutrophication and trophic state in rivers and streams	Dodds	2006	U.S.									X				X				X
18	How green is too green? Public opinion of what constitutes undesirable algae levels in streams.	Suplee	2009	MT							X						X				

Bibl.No.	Title	Primary Author	Year	Geographic Region	Ammonia Toxicity	Biological Assemblages - Algae	Biological Assemblages - Benthic Macroinvertebrates	Biological Assemblages - Fish	Biological Assemblages - Macrophytes	Biological Assemblages - Mussels	Chlorophyll - Benthic	Chlorophyll - Seston	Dissolved Oxygen - Stream Metabolism	Literature Review	Nitrate - Nitrite Toxicity	Nutrient - Biological Response Breakpoint / Threshold Analysis	Nutrient Criteria Derivation / Modeling	Nutrient Criteria Guidance	Nutrient Dynamics - Nitrogen	Nutrient Dynamics - Phosphorus	Nutrient Enrichment - Trophic State
19	A framework for developing ecosystem-specific nutrient criteria: Integrating biological thresholds with predictive modeling	Soranno	2008	MI												X	X				
20	Nutrient limitation of epilithic and epixylic biofilms in 10 North American streams	Tank	2003	U.S.							X										X
21	A nutrient biotic index (NBI) for use with benthic macroinvertebrate communities	Smith	2007	NY			X									X	X				X
22	Primary nutrients and the biotic integrity of rivers and streams	Miltner	1998	OH			X	X								X					
23	Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrate	Camargo	2005	Global											X						
24	Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment.	Camargo	2006	Global											X						

Bibl.No.	Title	Primary Author	Year	Geographic Region	Ammonia Toxicity	Biological Assemblages - Algae	Biological Assemblages - Benthic Macroinvertebrates	Biological Assemblages - Fish	Biological Assemblages - Macrophytes	Biological Assemblages - Mussels	Chlorophyll - Benthic	Chlorophyll - Seston	Dissolved Oxygen - Stream Metabolism	Literature Review	Nitrate - Nitrite Toxicity	Nutrient - Biological Response Breakpoint / Threshold Analysis	Nutrient Criteria Derivation / Modeling	Nutrient Criteria Guidance	Nutrient Dynamics - Nitrogen	Nutrient Dynamics - Phosphorus	Nutrient Enrichment - Trophic State
25	Nitrogen and phosphorus budgets for Iowa and Iowa watersheds	Libra	2004	IA																	
26	Diatom-based TP and TN inference models and indices for monitoring nutrient enrichment of New Jersey stream.	Ponader	2005	NJ		X										X					
27	A model of algal exports in some Iowa streams	Swanson	1976	IA		X					X	X									
28	Developing nutrient criteria for streams: an evaluation of the frequency distribution method.	Suplee	2007	MT													X				
29	Developing nutrient criteria and classification schemes for wadeable stream in the conterminous US	Herlihy	2008	U.S.													X				
30	Relationships among nutrients, chlorophyll-a, and dissolved oxygen in agricultural streams in Illinois.	Morgan	2006	IL		X					X	X	X								

Bibl.No.	Title	Primary Author	Year	Geographic Region	Ammonia Toxicity	Biological Assemblages - Algae	Biological Assemblages - Benthic Macroinvertebrates	Biological Assemblages - Fish	Biological Assemblages - Macrophytes	Biological Assemblages - Mussels	Chlorophyll - Benthic	Chlorophyll - Seston	Dissolved Oxygen - Stream Metabolism	Literature Review	Nitrate - Nitrite Toxicity	Nutrient - Biological Response Breakpoint / Threshold Analysis	Nutrient Criteria Derivation / Modeling	Nutrient Criteria Guidance	Nutrient Dynamics - Nitrogen	Nutrient Dynamics - Phosphorus	Nutrient Enrichment - Trophic State
31	Assimilatory uptake rather than nitrification and denitrification determines nitrogen removal patterns in streams of varying land use.	Arango	2008	MI									X						X		
32	Suggested classification of stream trophic state: distributions of temperate stream types by chlorophyll, total nitrogen, and phophorus.	Dodds	1998	U.S.																	X
33	Nutrients and algae in some Central Iowa streams.	Kilkus	1975	IA								X									
34	Stream classification system based on susceptibility to algal growth in response to nutrients	Lin	2007	IL								X					X				
35	Does nutrient enrichment decouple algal–bacterial production in periphyton?	Scott	2008	TX							X										X
36	The influence of land use on stream biofilm nutrient limitation across eight North American ecoregions.	Johnson	2009	U.S.							X		X								

Bibl.No.	Title	Primary Author	Year	Geographic Region	Ammonia Toxicity	Biological Assemblages - Algae	Biological Assemblages - Benthic Macroinvertebrates	Biological Assemblages - Fish	Biological Assemblages - Macrophytes	Biological Assemblages - Mussels	Chlorophyll - Benthic	Chlorophyll - Seston	Dissolved Oxygen - Stream Metabolism	Literature Review	Nitrate - Nitrite Toxicity	Nutrient - Biological Response Breakpoint / Threshold Analysis	Nutrient Criteria Derivation / Modeling	Nutrient Criteria Guidance	Nutrient Dynamics - Nitrogen	Nutrient Dynamics - Phosphorus	Nutrient Enrichment - Trophic State
37	Relationships among nutrients, algae, and land use in urbanized southern California streams.	Busse	2006	CA							X	X									X
38	Trends in the nutrient enrichment of U.S. rivers during the late 20th century and their relation to changes in probable stream trophic conditions	Alexander	2006	U.S.																	
39	Thresholds in macroinvertebrate biodiversity and stoichiometry across water-quality gradients in Central Plains (USA) streams	Evans-White	2009	KS,MO, NE			X									X					X
40	Large rivers and eutrophication.	Murdock												X							X
41	Effects of eutrophication on stream ecosystems.	Zheng												X							X

Bibl.No.	Title	Primary Author	Year	Nutrient Limitation	Nutrient Trends	Nutrient Watershed Loading / Budget	pH	Physical Factors - Flow, Light, Substrate, Temp. Turbidity	Reference Condition	Watershed / Landscape Factors
1	Linkages between nutrients and assemblages of macroinvertebrates and fish in wadeable streams: implications to nutrient criteria development.	Wang	2007							
2	Empirical approaches for nutrient criteria development.	USEPA	2009							
3	U.S. EPA Science Advisory Board Ecological Processes and Effects Subcommittee (FY2009) Augmented for Review of Nutrient Criteria Guidance.	SAB	2009							
4	A technique for establishing reference nutrient concentrations across watersheds affected by humans.	Dodds	2004						X	X
5	Sparrow modeling – enhancing understanding of the nation's water quality.	USGS	2009							
6	Controls on chlorophyll-a in nutrient-rich agricultural streams in Illinois, USA	Figueroa-Nieves	2006					X		

Bibl.No.	Title	Primary Author	Year	Nutrient Limitation	Nutrient Trends	Nutrient Watershed Loading / Budget	pH	Physical Factors - Flow, Light, Substrate, Temp. Turbidity	Reference Condition	Watershed / Landscape Factors
7	Relationships between benthic sediments and water column phosphorus in Illinois streams.	McDaniel	2009							
8	Trophic state, eutrophication and nutrient criteria in streams.	Dodds	2007							
9	Assessment of Chlorophyll-a as a criterion for establishing nutrient standards in the streams and rivers of Illinois.	Royer	2008							
10	Ecosystem modeling applied to nutrient criteria development in rivers	Carleton	2009							
11	Eutrophication of agricultural streams: defining nutrient concentrations to protect ecological condition	Chambers	2008							
12	Identifying biotic integrity and water chemistry relations in nonwadeable rivers of Wisconsin: toward the development of nutrient criteria.	Weigel	2007							X

Bibl.No.	Title	Primary Author	Year	Nutrient Limitation	Nutrient Trends	Nutrient Watershed Loading / Budget	pH	Physical Factors - Flow, Light, Substrate, Temp. Turbidity	Reference Condition	Watershed / Landscape Factors
13	Natural background concentrations of nutrients in streams and rivers of the conterminous United States	Smith	2003						X	
14	Relation of nutrient concentrations and biological responses in Minnesota streams: Applications for river nutrient criteria development.	Heiskary	2008							
15	Algae–P relationships, thresholds, and frequency distributions guide nutrient criterion development	Stevenson	2009				X		X	X
16	Establishing nutrient criteria in streams	Dodds	2000							
17	Eutrophication and trophic state in rivers and streams	Dodds	2006							
18	How green is too green? Public opinion of what constitutes undesirable algae levels in streams.	Suplee	2009							

Bibl.No.	Title	Primary Author	Year	Nutrient Limitation	Nutrient Trends	Nutrient Watershed Loading / Budget	pH	Physical Factors - Flow, Light, Substrate, Temp. Turbidity	Reference Condition	Watershed / Landscape Factors
19	A framework for developing ecosystem-specific nutrient criteria: Integrating biological thresholds with predictive modeling	Soranno	2008							X
20	Nutrient limitation of epilithic and epixylic biofilms in 10 North American streams	Tank	2003	X						
21	A nutrient biotic index (NBI) for use with benthic macroinvertebrate communities	Smith	2007							
22	Primary nutrients and the biotic integrity of rivers and streams	Miltner	1998					X		
23	Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrate	Camargo	2005							
24	Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment.	Camargo	2006							

Bibl.No.	Title	Primary Author	Year	Nutrient Limitation	Nutrient Trends	Nutrient Watershed Loading / Budget	pH	Physical Factors - Flow, Light, Substrate, Temp. Turbidity	Reference Condition	Watershed / Landscape Factors
25	Nitrogen and phosphorus budgets for Iowa and Iowa watersheds	Libra	2004			X				
26	Diatom-based TP and TN inference models and indices for monitoring nutrient enrichment of New Jersey stream.	Ponader	2005							X
27	A model of algal exports in some Iowa streams	Swanson	1976					X		
28	Developing nutrient criteria for streams: an evaluation of the frequency distribution method.	Suplee	2007						X	
29	Developing nutrient criteria and classification schemes for wadeable stream in the conterminous US	Herlihy	2008						X	X
30	Relationships among nutrients, chlorophyll-a, and dissolved oxygen in agricultural streams in Illinois.	Morgan	2006							

Bibl.No.	Title	Primary Author	Year	Nutrient Limitation	Nutrient Trends	Nutrient Watershed Loading / Budget	pH	Physical Factors - Flow, Light, Substrate, Temp. Turbidity	Reference Condition	Watershed / Landscape Factors
31	Assimilatory uptake rather than nitrification and denitrification determines nitrogen removal patterns in streams of varying land use.	Arango	2008							X
32	Suggested classification of stream trophic state: distributions of temperate stream types by chlorophyll, total nitrogen, and phophorus.	Dodds	1998							
33	Nutrients and algae in some Central Iowa streams.	Kilkus	1975	X				X		
34	Stream classification system based on susceptibility to algal growth in response to nutrients	Lin	2007					X		
35	Does nutrient enrichment decouple algal–bacterial production in periphyton?	Scott	2008	X						
36	The influence of land use on stream biofilm nutrient limitation across eight North American ecoregions.	Johnson	2009	X						X

Bibl.No.	Title	Primary Author	Year	Nutrient Limitation	Nutrient Trends	Nutrient Watershed Loading / Budget	pH	Physical Factors - Flow, Light, Substrate, Temp. Turbidity	Reference Condition	Watershed / Landscape Factors
37	Relationships among nutrients, algae, and land use in urbanized southern California streams.	Busse	2006	X						X
38	Trends in the nutrient enrichment of U.S. rivers during the late 20th century and their relation to changes in probable stream trophic conditions	Alexander	2006	X	X					X
39	Thresholds in macroinvertebrate biodiversity and stoichiometry across water-quality gradients in Central Plains (USA) streams	Evans-White	2009	X						
40	Large rivers and eutrophication.	Murdock								
41	Effects of eutrophication on stream ecosystems.	Zheng								

Bibl.No.	Title	Primary Author	Year	Full Citation
1	Linkages between nutrients and assemblages of macroinvertebrates and fish in wadeable streams: implications to nutrient criteria development.	Wang	2007	Wang, L., R.M., Robertson, P.J. Garrison. 2007. Linkages between nutrients and assemblages of macroinvertebrates and fish in wadeable streams: implications to nutrient criteria development. Environ Manage. 39:194-212.
2	Empirical approaches for nutrient criteria development.	USEPA	2009	Empirical approaches for nutrient criteria development. U.S. EPA Office of Water. Non-published draft: 8/17/2009
3	U.S. EPA Science Advisory Board Ecological Processes and Effects Subcommittee (FY2009) Augmented for Review of Nutrient Criteria Guidance.	SAB	2009	U.S. EPA Science Advisory Board Ecological Processes and Effects Subcommittee (FY2009) Augmented for Review of Nutrient Criteria Guidance. Non-published draft: 12/3/2009
4	A technique for establishing reference nutrient concentrations across watersheds affected by humans.	Dodds	2004	Dodds, W.K.. and R.M. Oakes. 2004. A technique for establishing reference nutrient concentrations across watersheds affected by humans. Limnol.Oceanogr.: Methods 2:333-341.
5	Sparrow modeling – enhancing understanding of the nation's water quality.	USGS	2009	USGS 2009. Sparrow modeling – enhancing understanding of the nation's water quality. U.S. Dept. of the Interior, U.S. Geological Survey, Fact Sheet 2009-3019. p6.
6	Controls on chlorophyll-a in nutrient-rich agricultural streams in Illinois, USA	Figueroa-Nieves	2006	Figueroa-Nieves, D., T.V. Royer, and M.D. Royer. 2006. Controls on chlorophyll-a in nutrient-rich agricultural streams in Illinois, USA. Hydrobiologia 568:287-298

Bibl.No.	Title	Primary Author	Year	Full Citation
7	Relationships between benthic sediments and water column phosphorus in Illinois streams.	McDaniel	2009	McDaniel, M.D. and M.B. David. 2009. Relationships between benthic sediments and water column phosphorus in Illinois streams. J. Environ. Qual. 38:607-617
8	Trophic state, eutrophication and nutrient criteria in streams.	Dodds	2007	Dodds, W.K. 2007. Trophic state, eutrophication and nutrient criteria in streams. Trends in Ecology and Evolution 22(12):669-676.
9	Assessment of Chlorophyll-a as a criterion for establishing nutrient standards in the streams and rivers of Illinois.	Royer	2008	Royer, T.V., M.B. David, L.E. Gentry, C.A. Mitchell, K.M. Starks, T. Heatherly II, M.R. Whiles. 2008. Assessment of Chlorophyll-a as a criterion for establishing nutrient standards in the streams and rivers of Illinois. J. Environ. Qual. 37:437-447
10	Ecosystem modeling applied to nutrient criteria development in rivers	Carleton	2009	Carleton, J.N., R.A. Park, and J.S. Clough. 2009. Ecosystem modeling applied to nutrient criteria development in rivers. Environmental Management 44:485-492
11	Eutrophication of agricultural streams: defining nutrient concentrations to protect ecological condition	Chambers	2008	Chambers, P.A., C. Vis, R.B. Brua, M. Guy, J.M. Culp, and G.A. Benoy. Eutrophication of agricultural streams: defining nutrient concentrations to protect ecological condition. Water Science & Technology 58(11):2203-2210
12	Identifying biotic integrity and water chemistry relations in nonwadeable rivers of Wisconsin: toward the development of nutrient criteria.	Weigel	2007	Weigel, B.M. and D.M. Robertson. 2007. Identifying biotic integrity and water chemistry relations in nonwadeable rivers of Wisconsin: toward the development of nutrient criteria. Environ. Management. 40:691-708

Bibl.No.	Title	Primary Author	Year	Full Citation
13	Natural background concentrations of nutrients in streams and rivers of the conterminous United States	Smith	2003	Smith, R.A., R.B. Alexander, G.B. Schwarz. 2003. Natural background concentrations of nutrients in streams and rivers of the conterminous United States. Environmental Science & Technology 37(14):3039-3047
14	Relation of nutrient concentrations and biological responses in Minnesota streams: Applications for river nutrient criteria development.	Heiskary	2008	Heiskary, S. 2008. Relation of nutrient concentrations and biological responses in Minnesota streams: Applications for river nutrient criteria development. Minnesota Pollution Control Agency (MPCA), St. Paul, MN. 60p.
15	Algae–P relationships, thresholds, and frequency distributions guide nutrient criterion development	Stevenson	2009	Stevenson, R.J., B.H. Hill, A.T. Herlihy, L.L. Yuan, S.B. Norton. 2008. Algae–P relationships, thresholds, and frequency distributions guide nutrient criterion development. J. N. Am. Benthol
16	Establishing nutrient criteria in streams	Dodds	2000	Dodds, W.K. and E.B. Welch. 2000. Establishing nutrient criteria in streams. J. N. Am. Benthol. Soc., 2000, 19(1):186-196
17	Eutrophication and trophic state in rivers and streams	Dodds	2006	Dodds, W.K. 2006. Eutrophication and trophic state in rivers and streams. Limnol. Oceanogr., 51(1, part 2):671–680
18	How green is too green? Public opinion of what constitutes undesirable algae levels in streams.	Suplee	2009	Suplee, M.W., V. Watson, M. Teply, H. McKee. 2009. How green is too green? Public opinion of what constitutes undesirable algae levels in streams. Journal American Water Resources Association, 45(1):123-140

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19	A framework for developing ecosystem-specific nutrient criteria: Integrating biological thresholds with predictive modeling	Soranno	2008	Soranno, P.A., K.S. Cheruvelil, R.J. Stevenson, S.L. Rollins, S.W. Holden, S. Heaton, E. Torng. 2008. A framework for developing ecosystem-specific nutrient criteria: Integrating biological thresholds with predictive modeling. Limnol. Oceanogr., 53(2):773–787
20	Nutrient limitation of epilithic and epixylic biofilms in 10 North American streams	Tank	2003	Tank, J.L. and W.K. Dodds. 2003. Nutrient limitation of epilithic and epixylic biofilms in 10 North American streams. Freshwater Biology, 48, 1031–1049.
21	A nutrient biotic index (NBI) for use with benthic macroinvertebrate communities	Smith	2007	Smith, A.J., R.W. Bode, J.S. Kleppel. 2007.A nutrient biotic index (NBI) for use with benthic macroinvertebrate communities. Ecological Indicators, 7:371–386
22	Primary nutrients and the biotic integrity of rivers and streams	Miltner	1998	Miltner, R.J. and E.T. Rankin. 1998. Primary nutrients and the biotic integrity of rivers and streams. Freshwater Biology, 40:145-148
23	Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrate	Camargo	2005	Camargo, J.A., A. Alonso, A. Salamanca. 2005. Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrate. Chemosphere 58:1255–1267.
24	Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment.	Camargo	2006	Camargo, J.A. and A. Alonso. 2006. Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. Environment International 32:831–849

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25	Nitrogen and phosphorus budgets for Iowa and Iowa watersheds	Libra	2004	Libra, R.D., C.F. Wolter, and R.J. Langel. 2004. Nitrogen and phosphorus budgets for Iowa and Iowa watersheds. Iowa Geological Survey Technical Information Series 47. Iowa Department of Natural Resources-Geological Survey. 43p.
26	Diatom-based TP and TN inference models and indices for monitoring nutrient enrichment of New Jersey stream.	Ponader	2005	Ponader, K.C., D.F. Charles, and T.J. Belton. 2005. Diatom-based TP and TN inference models and indices for monitoring nutrient enrichment of New Jersey stream Ecological Indicators 7(1):71-93.
27	A model of algal exports in some Iowa streams	Swanson	1976	Swanson, C.D. and R.W. Bachman. 1976. A model of algal exports in some Iowa streams. Ecology 57:1076-1080
28	Developing nutrient criteria for streams: an evaluation of the frequency distribution method.	Suplee	2007	Suplee, M.W., A.Varghese, and J. Cleland. 2007. Developing nutrient criteria for streams: an evaluation of the frequency distribution method. Journal of the American Water Resources Association, 43(2):453-472.
29	Developing nutrient criteria and classification schemes for wadeable stream in the conterminous US	Herlihy	2008	Herlihy, A.T. and J.T. Sifneos. 2008. Developing nutrient criteria and classification schemes for wadeable stream in the conterminous U.S. J. N. Am. Benthol. Soc., 2008, 27(4):932–948.
30	Relationships among nutrients, chlorophyll-a, and dissolved oxygen in agricultural streams in Illinois.	Morgan	2006	Morgan, A.M., T.V. Royer, M.B. David, and L.E. Gentry. 2006. Relationships among nutrients, chlorophyll-a, and dissolved oxygen in agricultural streams in Illinois. J. Environ. Qual. 35:1110– 1117.

Bibl.No.	Title	Primary Author	Year	Full Citation
31	Assimilatory uptake rather than nitrification and denitrification determines nitrogen removal patterns in streams of varying land use.	Arango	2008	Arango, C.P., J. L. Tank, L. T. Johnson, and S. K. Hamilton. 2008. Assimilatory uptake rather than nitrification and denitrification determines nitrogen removal patterns in streams of varying land use. Limnol. Oceanogr., 53(6):2558–2572.
32	Suggested classification of stream trophic state: distributions of temperate stream types by chlorophyll, total nitrogen, and phophorus.	Dodds	1998	Dodds, W.K., J.R. Jones, E.B. Welch. 1998. Suggested classification of stream trophic state: distributions of temperate stream types by chlorophyll, total nitrogen, and phophorus. Wat. Res. 32(5):1455-1462.
33	Nutrients and algae in some Central Iowa streams.	Kilkus	1975	Kilkus, S.P., J.D. LaPerriere, and R.W. Bachmann. 1975. Nutrients and algae in some Central Iowa streams. Journal of the Water Pollution Control Federation, 47(7):1870-1879.
34	Stream classification system based on susceptibility to algal growth in response to nutrients	Lin	2007	Lin, L.S., M. Markus, and A. Russell. 2007. Stream classification system based on susceptibility to algal growth in response to nutrients. Journal of Environmental Engineering, 7:692-697.
35	Does nutrient enrichment decouple algal–bacterial production in periphyton?	Scott	2008	Scott, J.T., J.A. Back, J.M. Taylor, and R.S. King. 2008. Does nutrient enrichment decouple algal–bacterial production in periphyton? J. N. Am. Benthol. Soc., 27(2):332–344.
36	The influence of land use on stream biofilm nutrient limitation across eight North American ecoregions.	Johnson	2009	Johnson, L.T., J.L. Tank, and W.K. Dodds. 2009. The influence of land use on stream biofilm nutrient limitation across eight North American ecoregions. Can. J. Fish. Aquat. Sci. *66*(7):1081–1094.

Bibl.No.	Title	Primary Author	Year	Full Citation
37	Relationships among nutrients, algae, and land use in urbanized southern California streams.	Busse	2006	Busse, L.B., J.C. Simpson, and S.D. Cooper. 2006. Relationships among nutrients, algae, and land use in urbanized southern California streams. Can. J. Fish. Aquat. Sci. 63: 621–2638.
38	Trends in the nutrient enrichment of U.S. rivers during the late 20th century and their relation to changes in probable stream trophic conditions	Alexander	2006	Alexander R.B., and R.A.. Smith. 2006. Trends in the nutrient enrichment of U.S. rivers during the late 20th century and their relation to changes in probable stream trophic conditions Limnol. Oceanogr., 51(1, part 2):639–654.
39	Thresholds in macroinvertebrate biodiversity and stoichiometry across water-quality gradients in Central Plains (USA) streams	Evans-White	2009	Evans-White, M.A., W.K. Dodds, D.H., Huggins, and D.S. Baker. 2009. Thresholds in macroinvertebrate biodiversity and stoichiometry across water-quality gradients in Central Plains (USA) streams J. N. Am. Benthol. Soc., 2009, 28(4):855–868.
40	Large rivers and eutrophication.	Murdock		Murdock, J.M., and W.K. Dodds. Large rivers and eutrophication. Kansas State University, Division of Biology. 12p.
41	Effects of eutrophication on stream ecosystems.	Zheng		Zheng, L. and M.J. Paul. Effects of eutrophication on stream ecosystems. Tetra Tech Inc.

Nutrient Benchmarks

Source	Geographic Applicability	Derivation Method / Response Variable	TN (mg/L calculated)	TN (mg/L reported)	NO3+NO2 (mg/L)	TKN (mg/L)	NH4 (mg/L)	TP (ug/L)	DP (ug/L)	Seston Chla (ug/L fluorometric)	Seston Chla (ug/L spectrophotometric)
U.S. EPA Ambient WQ Criteria Recommendations	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	25th percentile (P25) for all seasons, all data for decade	0.54	0.54				33		1.54	3.5
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 52 - Driftless Region)	25th percentile (P25) for all seasons, all data for decade	1.88	1.51	1.73	0.15		70		1	2.32
U.S. EPA Ambient WQ Criteria Recommendations	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	25th percentile (P25) for all seasons, all data for decade	1.22	2.18	0.633	0.591		76.25		2.7	7.33
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 47 - WCBP)	25th percentile (P25) for all seasons, all data for decade	2.615	3.26	1.965	0.65		118.13		4.4	7.85
U.S. EPA Ambient WQ Criteria Recommendations	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	25th percentile (P25) for all seasons, all data for decade	0.425	0.69	0.125	0.3		36.56		2.25	0.93
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 40 - CIP)	25th percentile (P25) for all seasons, all data for decade	0.855	0.712	0.23	0.625		92.5		2.75	5.488
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 72 - MRL)	25th percentile (P25) for all seasons, all data for decade	0.754	1.669	0.215	0.539		83.125		1.5	5.74

Source	Geographic Applicability	Derivation Method / Response Variable	TN (mg/L calculated)	TN (mg/L reported)	NO3+NO2 (mg/L)	TKN (mg/L)	NH4 (mg/L)	TP (ug/L)	DP (ug/L)	Seston Chla (ug/L fluorometric)	Seston Chla (ug/L spectrophotometric)
EPA R7 RTAG	EPA Region 7: IA, KS, MO, NE	draft benchmarks based on consensus, weight of evidence, multiple evidence lines? Methods considered included literature vals, EPA nutrient regions, reference stream median, bmv tri-section upper third, 25th percentile.		0.9				75		8	
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	WSA 25% random	-	0.581				17			
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	WSA 25% random	-	1.86				65.8			
Herlihy & Sifneous, 2008	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	WSA 25% random	-	0.331				20.4			
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	WSA 75% reference	-	-				-			
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	WSA 75% reference	-	2.5				181			
Herlihy & Sifneous, 2008	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	WSA 75% reference	-	0.681				60.2			
Dodds et al. 1998	Temperate Streams Oligotrophic-Mesotrophic boundary	33% of data distribution	-	0.7				25			10*

Source	Geographic Applicability	Derivation Method / Response Variable	TN (mg/L calculated)	TN (mg/L reported)	NO3+NO2 (mg/L)	TKN (mg/L)	NH4 (mg/L)	TP (ug/L)	DP (ug/L)	Seston Chla (ug/L fluorometric)	Seston Chla (ug/L spectrophotometric)
Dodds et al. 1998	Temperate Streams Mesotrophic-Eutrophic boundary	67% of data distribution	-	1.5				75			30*
Dodds et al. 1998	Streams nuissance threshold	various studies ciited	-								
Dodds and Oakes, 2004	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	Regression Intercept	-	0.565				23			
Dodds and Oakes, 2004	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	Regression Intercept	-	0.215				23			
Dodds and Oakes, 2005	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	Regression Intercept	-	0.37				31			
Wang et al. 2007	Driftless Area of Wisconsin	Avg. of Regression & 25th Percentile	-	1.065		0.23	0.025	45	25		
Wang et al. 2007	Wisconsin (statewide - wadeable)	Avg. of Regression Tree & Kolmogorov-Smirnoff thresholds/breakpoints based on benthic macroinvertebreate & fish metrics	-	0.988		0.644	0.03	73	55		
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis Avg. of Benthic Macroinvert metric breakpoints	-	0.895	2.732	0.985	0.03	89	72		
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis Avg. of Fish indicator breakpoints	-	0.539	2.747	0.411	0.026	59	49		
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis of Benthic Chlorophyll response	-	0.918	0.187	0.31	0.04	39	20		

Source	Geographic Applicability	Derivation Method / Response Variable	TN (mg/L calculated)	TN (mg/L reported)	NO3+NO2 (mg/L)	TKN (mg/L)	NH4 (mg/L)	TP (ug/L)	DP (ug/L)	Seston Chla (ug/L fluorometric)	Seston Chla (ug/L spectrophotometric)
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis of Diatom Nutrient Index	-	1.216	0.381	0.745	0.21	57	26		
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis of Seston Chlorophyll	-	1.679				70			
Weigal & Robertson 2007	Wisconsin (statewide - nonwadeable)	Regression Tree breakpoints indicating benthic macroinvertebrate or fish impairment	-	0.64				60			
Carleton et al. 2009	Minnesota River Basin - Blue Earth River	AQUATOX model threshold to prevent nuissance seston chlorophyll & Bluegreen dominance	-	2.7				100			
Smith et al. 2003	U.S.	Regression model w/ instream loss rates, background nutrient yield & concentrations	-	0.02-0.5				6-80			
Heiskary 2008	Minnesota	Bivariate relationships nutrients or DO flux vs. invertebrate & fish metrics	-	<1.5-2; 3-4; >6				~125-150			
Stevenson et al. 2009	Mid-Atlantic Highlands	75% reference; lowess regression; regression tree	-					10-20			
Suplee et al. 2009	Montana	Public survey; benthic algae chlorophyll	-								

Source	Geographic Applicability	Derivation Method / Response Variable	TN (mg/L calculated)	TN (mg/L reported)	NO3+NO2 (mg/L)	TKN (mg/L)	NH4 (mg/L)	TP (ug/L)	DP (ug/L)	Seston Chla (ug/L fluorometric)	Seston Chla (ug/L spectrophotometric)
Smith et al. 2007	New York	bray-curtiss, weighted average benthic macroinvertebrate tolerance value	-	0.98				65			
Miltner & Rankin 1998	Ohio	multiple regression; benthic macroinvertebrate & fish IBI	-	0.61				60			
Camargo et al. 2005	Global	toxicology studies review; sensitive freshwater species	-		2						
Camargo & Alonso 2006	Global	ecological & toxicology studies review; to prevent toxicity & eutrophication in sensitive waters	-		0.5-1						
Evans-Smith et al. 2009	KS, MO, NE	spearman correlation & nonparametric changepoint; primary consumers	-	1				60			
Evans-Smith et al. 2009	KS, MO, NE	spearman correlation & nonparametric changepoint; secondary consumers	-					90			
			-								
			-								

* analytical method not specified; spectrophometric is default assumption

Nutrient Benchmarks

Source	Geographic Applicability	Derivation Method / Response Variable	Seston Chla (ug/L trichromatic)	Benthic Chla (mg/m2)	Turbidity (NTU)	Turbidity (FTU)	Turbidity (JCU)	DO Flux (mg?L
U.S. EPA Ambient WQ Criteria Recommendations	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	25th percentile (P25) for all seasons, all data for decade			1.7	2.32		
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 52 - Driftless Region)	25th percentile (P25) for all seasons, all data for decade			3.38	2.4	4.25	
U.S. EPA Ambient WQ Criteria Recommendations	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	25th percentile (P25) for all seasons, all data for decade	6.83		9.89	6.36	10.4	
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 47 - WCBP)	25th percentile (P25) for all seasons, all data for decade	9.38		15	7.69	10.15	
U.S. EPA Ambient WQ Criteria Recommendations	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	25th percentile (P25) for all seasons, all data for decade	0.53	20.35	7.02	5.7	3.53	
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 40 - CIP)	25th percentile (P25) for all seasons, all data for decade						
U.S. EPA Ambient WQ Criteria Recommendations	Level III ecoregion # 72 - MRL)	25th percentile (P25) for all seasons, all data for decade			15	6.263	29.75	

Source	Geographic Applicability	Derivation Method / Response Variable	Seston Chla (ug/L trichromatic)	Benthic Chla (mg/m2)	Turbidity (NTU)	Turbidity (FTU)	Turbidity (JCU)	DO Flux (mg?L
EPA R7 RTAG	EPA Region 7: IA, KS, MO, NE	draft benchmarks based on consensus, weight of evidence, multiple evidence lines? Methods considered included literature vals, EPA nutrient regions, reference stream median, bmv tri-section upper third, 25th percentile.		40				
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	WSA 25% random						
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	WSA 25% random						
Herlihy & Sifneous, 2008	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	WSA 25% random						
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	WSA 75% reference						
Herlihy & Sifneous, 2008	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	WSA 75% reference						
Herlihy & Sifneous, 2008	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	WSA 75% reference						
Dodds et al. 1998	Temperate Streams Oligotrophic-Mesotrophic boundary	33% of data distribution		20				

Source	Geographic Applicability	Derivation Method / Response Variable	Seston Chla (ug/L trichromatic)	Benthic Chla (mg/m2)	Turbidity (NTU)	Turbidity (FTU)	Turbidity (JCU)	DO Flux (mg?L
Dodds et al. 1998	Temperate Streams Mesotrophic-Eutrophic boundary	67% of data distribution		70				
Dodds et al. 1998	Streams nuissance threshold	various studies ciited		150				
Dodds and Oakes, 2004	Aggregate Nutrient Region VII (including Iowa's Driftless region #52)	Regression Intercept						
Dodds and Oakes, 2004	Aggregate Nutrient Region VI (including Iowa's WCBP #47)	Regression Intercept						
Dodds and Oakes, 2005	Aggregate Nutrient Region IX (including Iowa's CIP#40 & MRL#72)	Regression Intercept						
Wang et al. 2007	Driftless Area of Wisconsin	Avg. of Regression & 25th Percentile						
Wang et al. 2007	Wisconsin (statewide - wadeable)	Avg. of Regression Tree & Kolmogorov-Smirnoff thresholds/breakpoints based on benthic macroinvertebreate & fish metrics						
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis Avg. of Benthic Macroinvert metric breakpoints						
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis Avg. of Fish indicator breakpoints						
Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis of Benthic Chlorophyll response						

Source	Geographic Applicability	Derivation Method / Response Variable	Seston Chla (ug/L trichromatic)	Benthic Chla (mg/m2)	Turbidity (NTU)	Turbidity (FTU)	Turbidity (JCU)	DO Flux (mg?L
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Robertson et al. 2006	Wisconsin (statewide - wadeable)	Regression Tree Analysis of Seston Chlorophyll						
Weigal & Robertson 2007	Wisconsin (statewide - nonwadeable)	Regression Tree breakpoints indicating benthic macroinvertebrate or fish impairment						
Carleton et al. 2009	Minnesota River Basin - Blue Earth River	AQUATOX model threshold to prevent nuissance seston chlorophyll & Bluegreen dominance						
Smith et al. 2003	U.S.	Regression model w/ instream loss rates, background nutrient yield & concentrations						
Heiskary 2008	Minnesota	Bivariate relationships nutrients or DO flux vs. invertebrate & fish metrics						4
Stevenson et al. 2009	Mid-Atlantic Highlands	75% reference; lowess regression; regression tree						
Suplee et al. 2009	Montana	Public survey; benthic algae chlorophyll		150				

Source	Geographic Applicability	Derivation Method / Response Variable	Seston Chla (ug/L trichromatic)	Benthic Chla (mg/m2)	Turbidity (NTU)	Turbidity (FTU)	Turbidity (JCU)	DO Flux (mg?L
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Evans-Smith et al. 2009	KS, MO, NE	spearman correlation & nonparametric changepoint; primary consumers						
Evans-Smith et al. 2009	KS, MO, NE	spearman correlation & nonparametric changepoint; secondary consumers						

* analytical method not specified; spectrophometric is default assumption