Story County Water Monitoring & Interpretation Plan, 2021-2030

Squaw Creek Watershed Coalition conducts invertebrate sampling

Purpose of the Plan

To collect and analyze water sampling data, to increase *residents'* knowledge and *understandings* and identify problems in our watersheds, to *support and improve* water quality.

Acknowledgements

This final report was achieved through the commitment of the Story County Water Monitoring Planning Team assembled during 2020. Despite the disruption of a global pandemic, the planning team met monthly between April and December by utilizing ZOOM conferencing. In addition, the planning team broke into small topical areas to complete work necessary for the plan. It was an effort of discussions and identifying solutions; and it was an effort of good will and future thinking.

We wish to recognize those who served on the Planning Team from:
Story County (Mike Cox, Jerry Keys and Margaret Jaynes),
the City of Ames (Tracy Peterson, Liz Calhoun, Neil Weiss, Dustin Albrecht, Maryann Ryan and Ashley Geesman), the City of Nevada (Jordan Cook and Jeremy Rydl), the City of Gilbert (Sonia Arellano Sundberg, the City of Huxley (Rita Connor and Mark Kahler), Iowa State University Leopold Center for Sustainable Agriculture (Mark Rasmussen), Izaak Walton League (Zack Moss and Paul Readhead), Story County Soil and Water Conservation District (Kayla Bergman), and the Story County Community Foundation (Jennifer Dieter).

The Board and staff of Prairie Rivers of Iowa are grateful for
the commitment of time and support each organization and its representatives provided to this planning.

Authors

Prairie Rivers of Iowa is 501(c)(3) non-profit based in Ames, Iowa.
Penny Brown Huber, Executive Director, facilitated meetings and the development of the Goals and Strategies by the Planning Team. The supporting chapters of the report were prepared by Daniel Haug, Watershed Educator, including maps and data analysis. Unless otherwise acknowledged, photos were provided by Prairie Rivers of Iowa staff including Mike Kellner and Daniel Haug. Graphic design by Katie Sailer.

January, 2021

Foreward

Planning for a locally-led water monitoring program in Story County was a process of discovery that began before 2020 (see Chapter 1) and will continue to unfold over the next 10 years (see Chapter 6). We discovered:

• There are many stakeholders with an interest in improving water quality in lakes and rivers and managing water to make our communities more resilient to extremes of weather. By getting to know one another, we have opened up exciting new possibilities for collaborating on projects and sharing knowledge and resources—both for understanding water quality and improving it.

• More data was available than anyone had realized (Chapter 3). The City of Ames has been monitoring the South Skunk River on a weekly basis for 18 years, a rich dataset that we are already using to understand long-term and seasonal trends. The US Geological Survey took over 3,700 measurements at a tributary of East Indian Creek near Zearing, giving us a complete scorecard of the pressures on fish and other aquatic life. Over 61,000 measurements were collected from Walnut Creek near Kelley by the USDA Agricultural Research Service as part of a study that can help us isolate and understand the influence of specific land management practices in our part of Iowa.

• Guidelines for interpreting and using water quality data are sorely lacking (Chapters 2 and 4). State standards and criteria have not been developed for many of the pollutants we monitor and issues we are concerned with. Where criteria exist, there are inconsistencies in the databases and exceptions in the law that make it difficult to understand what designated uses apply to a given water body, which criteria to refer to when evaluating the data, and what can be done if water quality is impaired.

• Most rivers and streams in Story County either do not meet the recreation standard or have not been officially assessed (Chapter 2). Based on the data collected by local partners, there is widespread fecal bacteria contamination of our rivers.

• Using water quality monitoring to track short-term progress toward the Iowa Nutrient Reduction Strategy goals is virtually impossible (Chapter 4). While all of us had heard the term “statistical significance” it was easy to dismiss it as an academic concern until we saw a practical demonstration—sampling on a different day of the week or week of the month can lead to different conclusions unless the trends are very large or we are diligent in quantifying the uncertainty associated with water quality averages. This finding also underscores the importance of sustaining water monitoring for the long-term.

Testing water quality is the easy part. Story County has a proud history of stream monitoring by both volunteers and certified labs, and many people stepped up in 2020 to ensure that it continued (Chapter 5).

Correctly interpreting the data is a challenge, as is using the data to guide conservation efforts and evaluate their effectiveness. However the information and relationships we have assembled through this effort put the government of Story County and its many partners in as a good a position to tackle this challenge as anyone in Iowa.

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Why do we want data?

In December 2019, a cooperative agreement between Story County Conservation, the City of Ames, and Prairie Rivers of Iowa (PRI) secured PRI's services for conducting water quality monitoring and outreach throughout the county. Additional funding for the project was provided by Story County Community Foundation, the Iowa State University Leopold Center for Sustainable Agriculture, Outdoor Alliance of Story County, and the Renewable Energy Group. Additional partners—the Izaak Walton League, City of Gilbert, City of Nevada, City of Huxley, and Story County Soil & Water Conservation District—joined the planning team by spring of 2020.

The results of that work are described in the report that follows: both the collaborative work of building partnerships and setting goals, and the technical work necessary to understand existing data and collect additional samples.

However, 2020 was by no means the first year that local partners had worked together on water monitoring. The history and needs that motivated the development of this plan are described next.

Need for Local Leadership for Volunteer Water Monitoring

The need for local leadership in water monitoring became apparent with the ending of the IOWATER program. The IOWATER program, created by the Iowa Department of Natural Resources in 1998, had provided volunteers with training and supplies to test water chemistry and survey invertebrates, as well as managing an online database. The program was formally discontinued in January 2016, the database was shut down in 2017, and departmental support for supplies were gradually scaled back over the next few years. Reasons cited for the decision include budget cuts and a hiring freeze, declining participation, and security concerns with the database—the site had been hacked in 2012 and was not compatible with new IT projects in the Department.

While the loss of state support presented a serious challenge to continued volunteer monitoring, it also presented an opportunity for tighter feedback between water quality data and conservation efforts. As the DNR put it:

> ***Volunteer water monitoring is best able to inform local water quality goals if the decision-making and coordination is locally-led****. With the help of the DNR to get started, interested communities, watersheds, counties, and regions have an opportunity to take ownership and derive more value from their locally-led volunteer water monitoring programs.*[1]

Who would provide local leadership for volunteer monitoring in Story County?

Prairie Rivers of Iowa was approached in 2018 by the Ioway (Squaw) Creek Watershed Coalition (SCWC), an experienced and active group of IOWATER volunteers, for help in ordering supplies and recruiting volunteers to support annual snapshot events in May and October, a tradition since 2006. The Outdoor Alliance of Story County provided short-term funding to also support this. A formal M.O.U. between SCWC and PRI was proposed but never completed.

Other than Ioway (Squaw) Creek watershed, volunteer monitoring across the county has fallen off in the last decade. Story County Conservation (SCC) expressed interest in taking on a leadership role in order to support assessments and new projects in other watersheds, beginning with mapping and scouting of potential volunteer sites in 2017 by Environmental Education Coordinator Jerry Keys and volunteers John and Gregg Hadish as part of the Master River Stewards Program. Story County Conservation staff have experience managing volunteers and planning environmental education programming. SCC also considered training and supplying staff to adopt a site for monthly or twice monthly monitoring, following the approach taken by Polk County Conservation[2].

At the state level, the Izaak Walton League organized an Iowa Water Quality Summit on July 20, 2019 to bring together various groups interested in water monitoring and discuss the role that both local chapters and the national organization could play.

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[1] https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Volunteer-Water-Monitoring

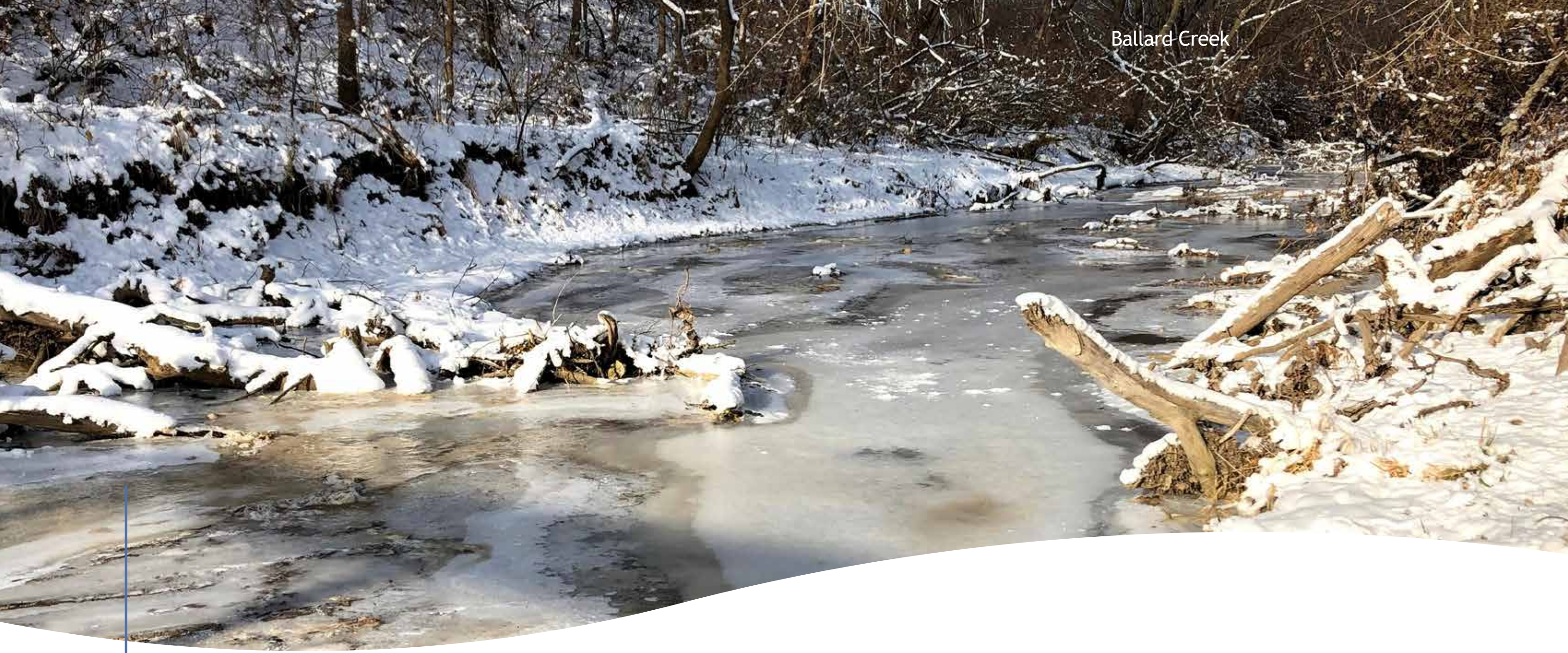
[2] https://www.polkcountyiowa.gov/conservation/water-quality/

Laura Merrick (Iowa State University) monitoring at S. Branch Worrell Creek

The Izaak Walton League's Save Our Streams program for volunteer stream monitoring was a major influence on the IOWATER program and uses almost identical protocols. The Izaak Walton League of America hired an Iowa coordinator, Zach Moss, to train and support volunteers. It also developed a web portal (The Clean Water Hub) that volunteers can use for data entry. Story County and Prairie Rivers of Iowa also approached the Ames Chapter of the Izaak Walton League in 2019 to organize local training events.

Iowa State University (ISU) also has supported volunteer monitoring. The University Translational Research Network (U-TuRN) funded two mini-grants for an interdisciplinary research project that included regular monitoring of the south branch of Worrell Creek by Laura Merrick, a faculty member in the agronomy department and long-term volunteer with the Ioway (Squaw) Creek Watershed Coalition. Story County Conservation restored this stream as part of a new county park within the City of Ames and ISU Research Park, the Tedesco Environmental Learning Corridor. County-University partnerships continued with water monitoring, with Story County Conservation and Iowa DNR providing supplies and reimbursing the University for laboratory services, and the University covering staff time. Merrick often recruited neighbors, high school students, and college students to become involved with the project. The project is a good model for how lab testing, volunteer monitoring, research, education, and outreach can be combined. While some of the monitoring was conducted using field kits, samples collected by volunteers and processed by a certified lab narrowed down sources of *E. coli* bacteria in the watershed and revealed phosphorus releases by an aging stormwater pond.

As these discussions evolved, we saw a need to bring in additional partners and discuss how volunteer monitoring could be paired with lab testing and sensor technology.



Ballard Creek

Need for Data to Support New Watershed Projects

This Plan has a countywide scope because Story County is pursuing multiple watershed projects.

The Story County Board of Supervisors is an active participant in two watershed management authorities, Ioway (formerly Squaw) Creek WMA and Fourmile Creek WMA, and took the lead in submitting a 28E agreement to form the Headwaters of the South Skunk River WMA, approved in October of 2018.

In order to take a more comprehensive approach to water resources and lay the groundwork for future watershed projects, the County commissioned an assessment of all its 12-digit hydrologic units. (Abbreviated as HUC12s, these are small watersheds or parts of watersheds, on the order of 10,000-40,000 acres in size). Completed by Emmons & Olivier Resources in June 2018, the assessment included GIS mapping, identification of suitable sites for best management practices using the Agricultural Conservation Planning Framework and analysis of how these could be combined to meet nutrient reduction goals, a watershed prioritization framework, and recommendations for changes to county ordinances and operations to better protect water quality. The assessment did not include any collection or analysis of water quality data, but did make recommendations for future monitoring.

Following this assessment, county staff from multiple departments (Board of Supervisors, Conservation, Planning and Development, Secondary Roads, Environmental Health, etc.) began meeting to discuss how to implement the recommendations in the report, including water quality monitoring. The assessment was intended to be a living document and reviewed periodically to reassess its priorities and findings. Story County developed an implementation plan to accompany the assessment. The implementation plan calls for development of a water quality monitoring program.

Four participants in the Planning Team are active members of the Ioway (Squaw) Creek Watershed Management Authority: the Story County Supervisors, the City of Ames, the City of Gilbert, and the Story County Soil and Water Conservation District. Those who participated in either the development or implementation of that watershed plan see the experience as a model for how water quality can be improved in other rivers and lakes. Water quality monitoring plays an essential role in this conceptual model, which looks something like this:

1. Water monitoring by volunteers raises awareness and public support to address water quality issues in a local stream or lake, and strengthens grant applications for watershed planning.

2. The watershed plan identifies the best opportunities for conservation in the watershed that can lead to water quality improvement, brings together the stakeholders needed to address the problem (formalized through a WMA), and supports grant applications for funding to hire a watershed coordinator and make additional cost share available to farmers and landowners in the watershed.

3. A watershed coordinator provides outreach and technical support to encourage adoption of conservation practices by farmers and landowners in the watershed.

4. Water monitoring is used to track progress, as conservation practices in the watershed gradually lead to water quality improvements.

Need for Better Planning and Coordination of Monitoring to Support Existing Watershed Projects

In reality, the pathway for water quality improvement is not as straightforward as we imagined it to be.

> *"An intense monitoring effort over several years is recommended to adequately assess pollutant loading and to detect trends."*
> - Squaw Creek Watershed Management Plan, 2014
>
> *"It is very unlikely that nutrient reduction in a watershed of this size will be detected within a few year period, especially when BMPs implementation is limited and gradual."*
> - Law and Soupir, 2019

In the Ioway Creek Watershed (formerly Squaw Creek) volunteer monitoring did lead to successful grant applications, and the data was included in the Watershed Management Plan. However, the data to date has not influenced goal-setting or prioritization of conservation practices, and were not considered to be of sufficiently high quality to characterize baseline nutrient loads. Ultimately, the nutrient reduction goals in the watershed plan were taken directly from the Iowa Nutrient Reduction Strategy (41% nitrogen reduction, 29% phosphorus reduction) per guidance from the Iowa Department of Agriculture at that time. In order to determine when those goals have been met, Chapter 7 of the plan recommended we start monitoring from scratch: at least 25 samples a year at a gaged site, including flow-paced samples during storm events using an automated sampler, to be tested by a certified lab for total phosphorus soluble reactive phosphorus, total suspended solids, and nitrate-nitrogen.

This monitoring plan was put into effect once conservation efforts were underway. A Water Quality Initiative (WQI) grant from the Iowa Department of Agriculture and Land Stewardship (IDALS) made available additional cost share and funded a watershed coordinator, watershed educator, and outreach efforts by Prairie Rivers of Iowa and partners in the Ioway (Squaw) Creek Watershed from April of 2015 to March of 2019. A second watershed, East Indian Creek, was included in the original grant application but was not funded. Ioway Creek and East Indian Creek were monitored 2016, 2017, and 2018. The City of Ames and Story County each purchased a Teledyne ISCO automated sampler for the project, which was programmed to collect time-paced composite samples during storm events. The samplers were usually deployed in the stream from April or May thru November. City and county staff retrieve the storm samples and collected biweekly grab samples during that period, which were then processed by the City of Ames Water and Pollution Control Laboratory.

However, even this level of effort proved to be insufficient to accurately estimate baseline phosphorus loads. This was one conclusion of a March 2019 report[3] by Michelle Soupir (ISU Professor of Ag and Biosystems Engineering) and Ji Yeow Law. The report was commissioned by Prairie Rivers of Iowa at the end of the grant period to provide an independent review of the data collected and the monitoring design. For detecting changes over a shorter time-frame, the report recommended monitoring at the catchment (small watershed) scale, using a paired watershed design. For detection of nitrogen trends in Ioway Creek over the long-term, it recommended instead using the data from the nitrate sensor installed by IIHR Hydroscience and Engineering in 2016. Short of an entirely different monitoring program, it recommended collecting flow-weighted (rather than time-paced) composite samples during and extending the monitoring season from March to November, but characterized the benefit of this as more accurate loading estimate rather than detection of trends. A parallel analysis by PRI's Dan Haug found that continued monitoring at these sites may not be able to detect statistically significant trends until goals are close to being met (see Chapter 4).

The monitoring from 2016-2018 did provide valuable information, revealing that *E. coli* levels are consistently high. Based on our data, in the 2018 assessment cycle, Iowa DNR reclassified both streams as "potentially impaired" waters "in need of further investigation." The report does include a calculation of nitrate load in Ioway Creek and discussion of seasonal and flow patterns in both creeks. However water quality monitoring was not effective in achieving its stated goal of assessing pollutant load during the grant period, and may not be effective for interim progress tracking or demonstration purposes.

Learning from this experience, local partners saw the need to clarify goals, set realistic expectations and timelines, and coordinate with other groups doing water monitoring prior to launching new monitoring activities.

[3] https://www.prrcd.org/wp-content/uploads/2020/07/Monitoring-Report-March-2019.pdf

Need for Reuse of Existing Data

> *"Data should not be in search of a problem, but a problem should be in search of data."*
> – from Building an Internet of Water[4]

In 2016, IIHR Hydroscience and Engineering (a research institute at the University of Iowa) installed a nitrate sensor in Ioway (Squaw) Creek at Moore Park in Ames, capable of testing nitrate every 15 minutes. It tested nitrate from April or May through November during the same field seasons that our local partnership was conducting biweekly grab samples at a nearby location. Had we been aware of this earlier, we might have opted not to test for nitrate as part of our biweekly sampling. At the very least, we could have coordinated our efforts, perhaps allowing IIHR to use our data for calibration and making better use of IIHR's data for education and outreach.

Water quality data is often collected for a specific purpose. The Iowa DNR monitors 51 streams across the state, including the South Skunk River, as part of a statewide ambient stream network. The City of Ames monitors above and below its wastewater treatment plant in order to meet its permit conditions and ensure that treated wastewater is not causing problems in the stream. This can lead to duplication—both agencies are monitoring the South Skunk River at the same location, just below the wastewater treatment plant on 280th Street. It's unclear whether this duplication is avoidable. The City of Ames monitors weekly for fewer parameters, while the DNR monitors monthly for more parameters.

> *"Wow this is such a treasure trove! Somehow I did not comprehend that you have 20 years of almost weekly nitrate data!"*
>
> *"Tell me about it. I've always thought it was a shame more use wasn't made of all this data."*
>
> - email exchange between Dan Haug, Prairie Rivers of Iowa, and Maryann Ryan, City of Ames Water and Pollution Control

However, we can certainly make sure to find out what data is available and reuse it for other purposes. As part of this project, Prairie Rivers of Iowa has been analyzing the nitrate and phosphorus data collected in the South Skunk River by the City of Ames, and finding it extremely useful for understanding seasonal patterns and long-term trends.

[4] Patterson, Lauren, Martin Doyle, and Greg Gerhuny. 2019. Building an Internet of Water – A Report from the 2017 to 2019 Internet of Water Roundtables. https://www.aspeninstitute.org/publications/internet-of-water-revisited

West Indian Creek in Nevada

Where do we want data?

West Indian Creek at Carroll Prairie

> *"The map is not the territory." - Alfred Korzybski*

How many lakes and streams are there in Story County? Which streams usually flow year-round (perennial) and which are dry for part of the year (intermittent)? Which streams have enough water to float a kayak or host some good-sized fish? These are the types of questions we'd like to answer in order to review and prioritize monitoring sites.

These types of questions should be answerable by looking at the Designated Uses for each water body in DNR or EPA databases. Under the Clean Water Act, state agencies determine what activities should be possible in a lake or stream, if water quality were protected. Criteria for interpreting water quality data are also linked to Designated Uses. Unfortunately, there are enough special rules and missing data to prevent straightforward interpretation of these categories.

Looking to GIS maps is equally complicated, because Iowa is still in the process of updating and reconciling various maps of hydrography (water features). At present, our maps do not reliably show where streams begin or which streams flow year round.

Local Importance of Water Bodies

Fortunately, our local stakeholders have an abundance of experience and good sense that can help us to understand and prioritize local lakes and streams for monitoring. The preliminary site selections in Chapter 5 are based on discussions from the meetings as summarized below.

- Hickory Grove Lake is a "Significant Publicly Owned Lake" that is monitored by DNR and is currently being improved under a cleanup plan, or Total Maximum Daily Load (TMDL). However, Peterson Park Lake, Dakins Lake, Ada Hayden Lake, and McFarland Lake are also valued for fishing, swimming, or boating and will need local leadership to ensure continued monitoring.

- The distinction between perennial and intermittent streams is not clear-cut. Even our largest rivers in Story County often go dry. However, it is clear that as watershed size and streamflow increases, streams can support more kinds of recreation and a greater variety of aquatic life.

- To protect recreation and fisheries in rivers, the focus should be on the South Skunk River, which is a state water trail and supports a smallmouth bass fishery. Paddling and fishing are common and encouraged. Swimming is also commonplace.

- Ioway (Squaw) Creek in Ames and lower Indian Creek near Maxwell have less flow and more limited public access than the South Skunk River, but are used for paddling, tubing, fishing, and children's play.

- Tributary streams in Story County that can influence water quality and flows on the water trail portion of the South Skunk River include Ballard Creek, Walnut Creek, Ioway Creek, Keigley Branch, Bear Creek, and Long Dick Creek.

- Smaller streams might not have much potential for fishing or recreation, but monitoring or learning about a backyard stream is a great way to educate and engage local stakeholders in our larger water quality and conservation challenges, especially when streams have public access and interpretive features, such as the South Branch of Worrell Creek. Story County Conservation is guiding volunteers and staff to monitor streams in almost every HUC12 watershed (see Chapter 5). This will ensure good coverage of the county and tie into the county watershed assessment.

- Monitoring nitrogen and phosphorus at any scale—from tile outlets, to ditches, to large rivers—can inform and support local implementation of Iowa's Nutrient Reduction Strategy.

- Water quality in Story County lakes and rivers is only tangentially connected to drinking water. However, sourcewater protection around wells can tie into a watershed-scale conservation effort.

Maps of Lakes

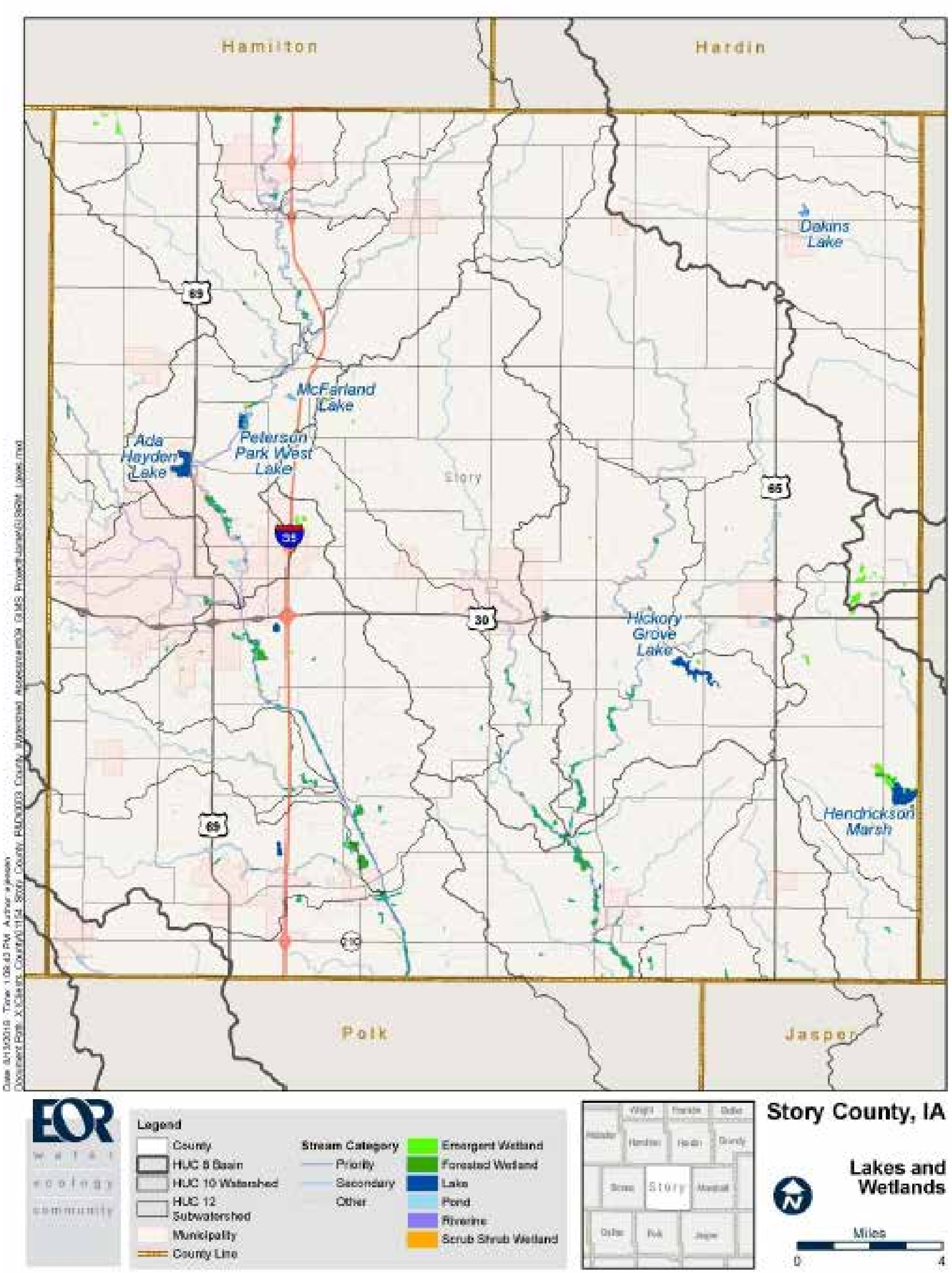


Figure 1: Priority lakes, reproduced from Story Countywide Watershed Assessment (2018)

Five high-priority lakes were discussed in the Countywide Watershed Assessment and will be the focus of future monitoring. The map used in the assessment (Figure 1) was based on the National Wetland Inventory, because Iowa does not have a current and complete GIS coverage showing lake shores.

- Ada Hayden Lake
- Dakins Lake
- Hickory Grove Lake
- McFarland Lake
- Peterson Park West Lake

The Iowa portion of the National Hydrographic Dataset in Iowa (Figure 2) is based on topographic maps from the 1990s and early 2000s, so this map does not show the current shoreline or correct names for Ada Hayden Lake or Peterson Park Lake, former gravel pits that are now valued for recreation. Ada Hayden, Dakins, and Hickory Grove lakes are represented as points of interest in Iowa DNR's fishing atlas. McFarland, Dakins, and Hickory Grove lakes are represented as points of interest in DNR's Assessment Database, ADBNet, along with five Story County wetlands.

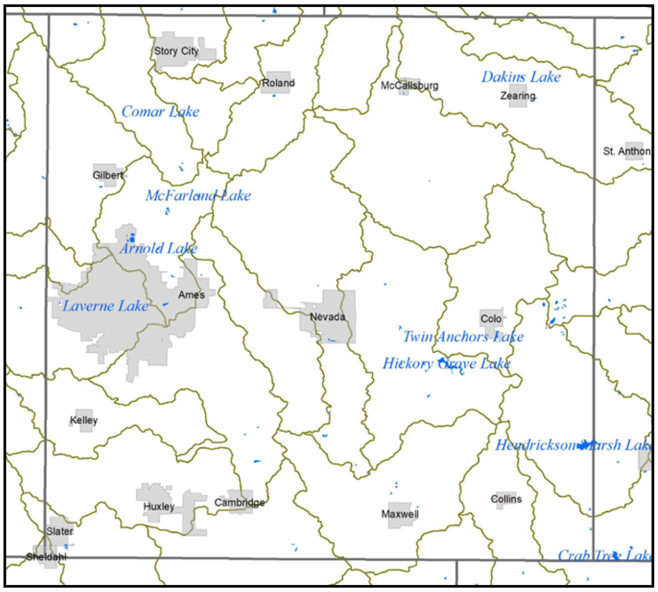


Figure 2: National Hydrographic Dataset lakes map

Hickory Grove Lake, during renovation in 2020.
Photo courtesy of Story County Conservation

Maps of Streams

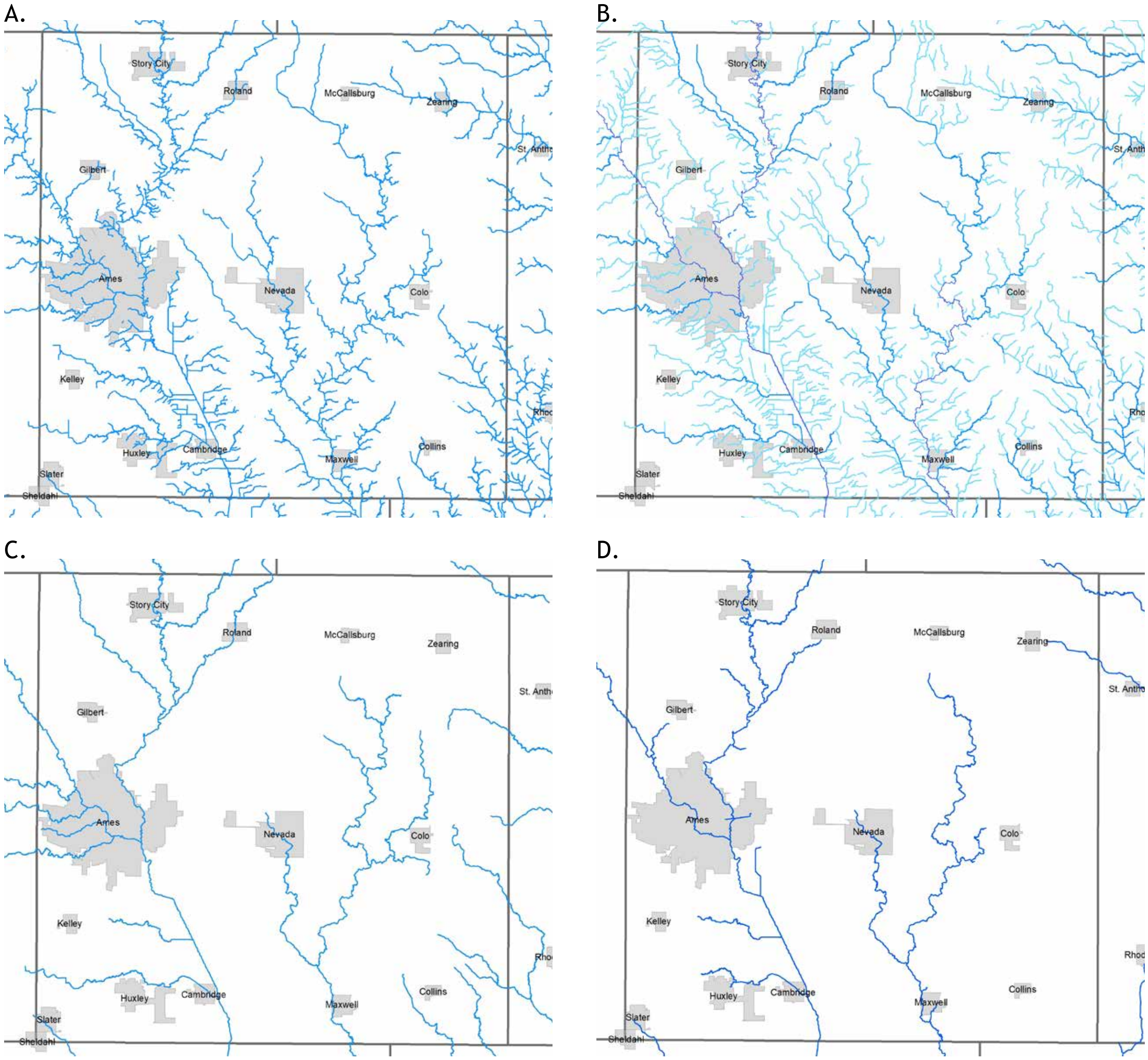


Figure 3: Iowa has multiple stream maps with major differences. A) LiDAR based stream centerlines, B) National Hydrographic Dataset streams, perennial and intermittent, C) subset of NHD flowlines included in Iowa DNR's assessment database, D) subset of NHD flowlines for which a Use Attainability Analysis has been completed

(Figure 3A) The most accurate stream maps are based on LiDAR, flown across Iowa between 2006 and 2010. As part of Iowa's Statewide Flood Plain Mapping Project, Iowa DNR used high resolution digital elevation models to map stream centerlines[5], or both banks of stream channels wider than 7 meters[6]. While the shapes on the map are complete, DNR is still in the process of adding the codes and other attributes that allow various kinds of water data—designated uses, reports of spills, monitoring

[5] Search for "Stream Centerlines" on geodata.iowa.gov

[6] Search for "Stream Channels" on geodata.iowa.gov

stations, permitted facilities, watersheds, etc.—to be matched to the appropriate section of stream. These attributes will come from the National Hydrographic Dataset.

Together with the Watershed Boundary Dataset, the National Hydrographic Dataset (NHD) provides a consistent framework for relating environmental data to the stream network. NHD started out as a digital representation of the blue lines on a USGS topo map but has evolved into something more. Applications built around the NHD have been used to identify water monitoring stations downstream from spills, estimate streamflow at ungaged sites, and estimate nutrient loads[7].

(Figure 3B) In Iowa, the NHD flowlines are currently based on 1:100,000 scale maps from the late 1990s and early 2000s. At this mapping scale, 90% of well-defined features are within 167 feet of their true geographic position[8]. This is good enough for many purposes but there are large enough discrepancies between the NHD and higher resolution aerial photos and LiDAR to cause problems for some kinds of analysis—like the identification of riparian buffer opportunities using the Agricultural Conservation Planning Framework (ACPF).

> *DO NOT use National Hydrography Datasets (e.g., NHD+) to forcibly assign stream locations. This is strongly discouraged for several reasons; the age (circa 1950s) and coarser scales from which those datasets originate will negatively impact the accuracy of flow routing, which will consequently impact results of the ACPF, particularly the riparian assessment.*
>
> *-ACPF User Manual, version 3.0*

There is also a lot of inconsistency between GIS coverages as to where streams start and which streams are treated as perennial or intermittent[9]. This poses a challenge for selecting monitoring sites and interpreting the data, but also for any project where GIS is used to inventory or analyze streams. For example, as part of Story County's ambitious watershed and creek sign project[10], Prairie Rivers of Iowa used the NHD to identify locations where named creeks crossed a paved county road. One pair of road signs that were ordered went unused when it became apparent that Mud Creek is not a perennial stream where it crosses County Road E63, but rather a grassed waterway that is usually dry and has no defined bed and banks (See Figure 4). The mapping error has been corrected in the most recent version of the NHD but also appears in DNR's assessment database and led to two conflicting sets of recommendations for stream buffers in the Story County Watershed Assessment. Now that we are aware of the issue, we can be sure to verify stream locations using aerial photos or field visits at an early stage of future projects.

[7] Moore, Richard B., and Thomas G. Dewald. 2016. "The Road to NHDPlus — Advancements in Digital Stream Networks and Associated Catchments." JAWRA Journal of the American Water Resources Association 52 (4): 890–900. https://doi.org/10.1111/1752-1688.12389.

[8] https://www.usgs.gov/faqs/what-positional-accuracy-national-hydrography-dataset-nhd?qt-news_science_products=0#qt-news_science_products

[9] Note that topographic maps in Iowa do not include a category for ephemeral streams, which flow only after rain and are no longer considered jurisdiction Waters of the United States. It is unclear whether the concept is limited to arid regions.

[10] https://www.prrcd.org/signage/ for more details on the project

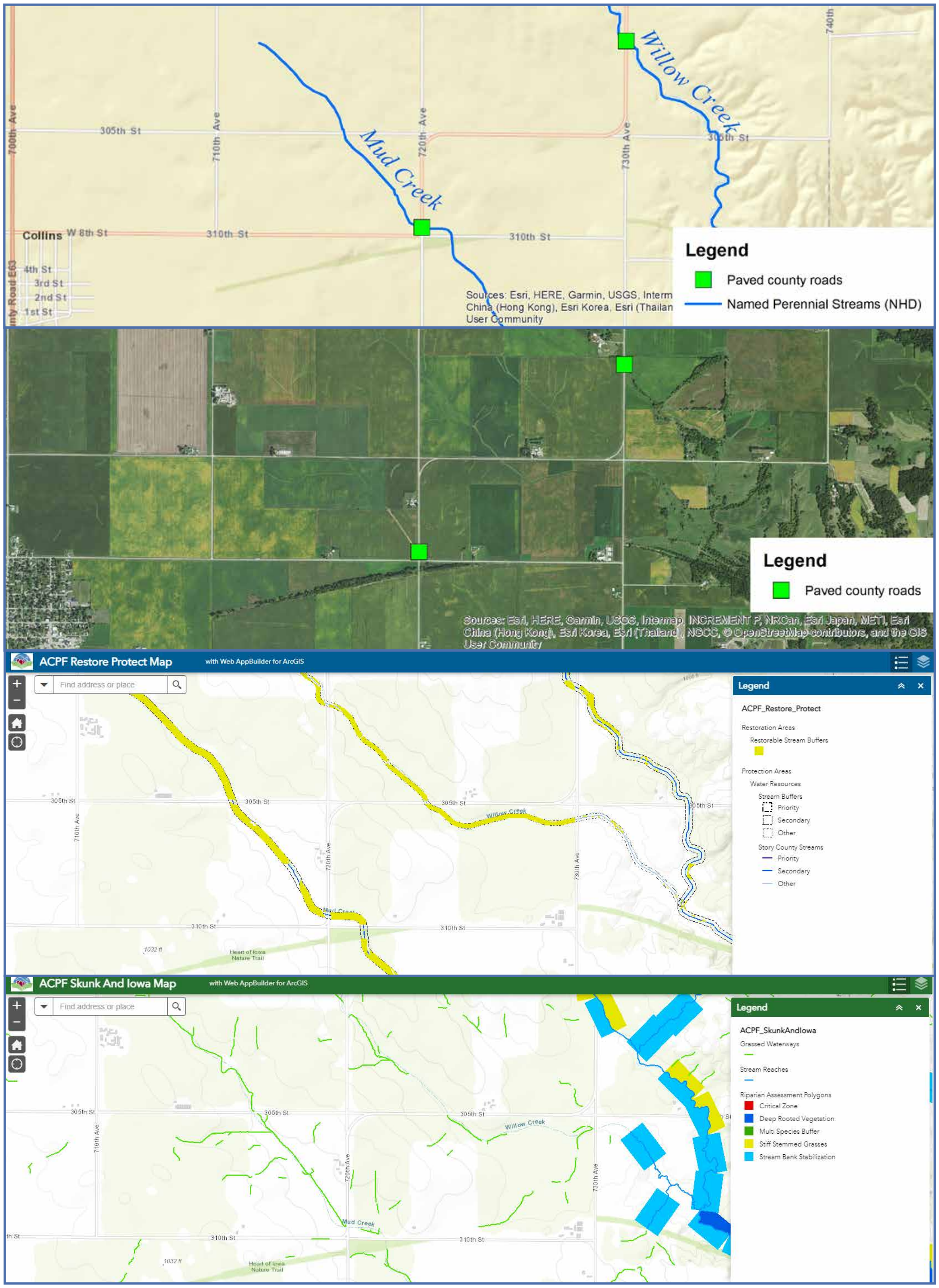


Figure 4: Inconsistency in stream mapping can affect road signs and stream buffer recommendations. A) Mud Creek was mapped as a perennial stream in some versions of NHD, B) but there is no channel visible on the ground or aerial photos, C) buffers were recommended for this section of Mud Creek based on GIS analysis of NHD lines and interpretation of DNR databases, D) but buffers were not recommended for Mud Creek based on the Agricultural Conservation Planning Framework, which used LiDAR and aerial photos.

Iowa DNR plans to use the drainage area of each stream segment to classify new LiDAR based stream centerlines in a consistent way[11]. Until this dataset is released, we can use a similar map prepared by Prairie Rivers of Iowa using NHDPlus[12] version 2.0, which combines NHD stream lines with watershed information derived from medium-resolution elevation and landcover data from 2011. Prairie Rivers of Iowa proposed adapting the categories and thresholds used by the Iowa DNR biological monitoring program[13] to help select monitoring sites and interpret data. The only streams for which benchmarks have been developed for assessing fish and invertebrate surveys are "wadeable" streams draining a watershed of between 10 and 700 square miles, as distinct from "headwater" streams sampled with a slightly different protocol, or "non-wadeable" streams sampled with a boat. When Iowa DNR proposed draft nutrient criteria in 2013, they were limited to "wadeable" streams which had clear biological monitoring data for comparison.

Figure 5 and Table 1 show this classification. Headwater streams are less likely to sustain flow year round and have sufficient water and habitat to sustain a large variety of aquatic life. A distinction is not made between natural streams and drainage ditches. Place names aside, the distinction is not always clear. For example, the lower part of Grant Ditch 5 is mapped as a creek on General Land Office surveys from the nineteenth century, and the lower section still retains its natural meanders. The headwater reaches of many named streams have been channelized. The legal distinction between ditches and streams is also unclear. Numbered ditches have appeared in 305(b) assessments and on the 303(d) Impaired Waters List. Even after changes by the Trump administration, many ditches are still considered jurisdictional Waters of the United States.

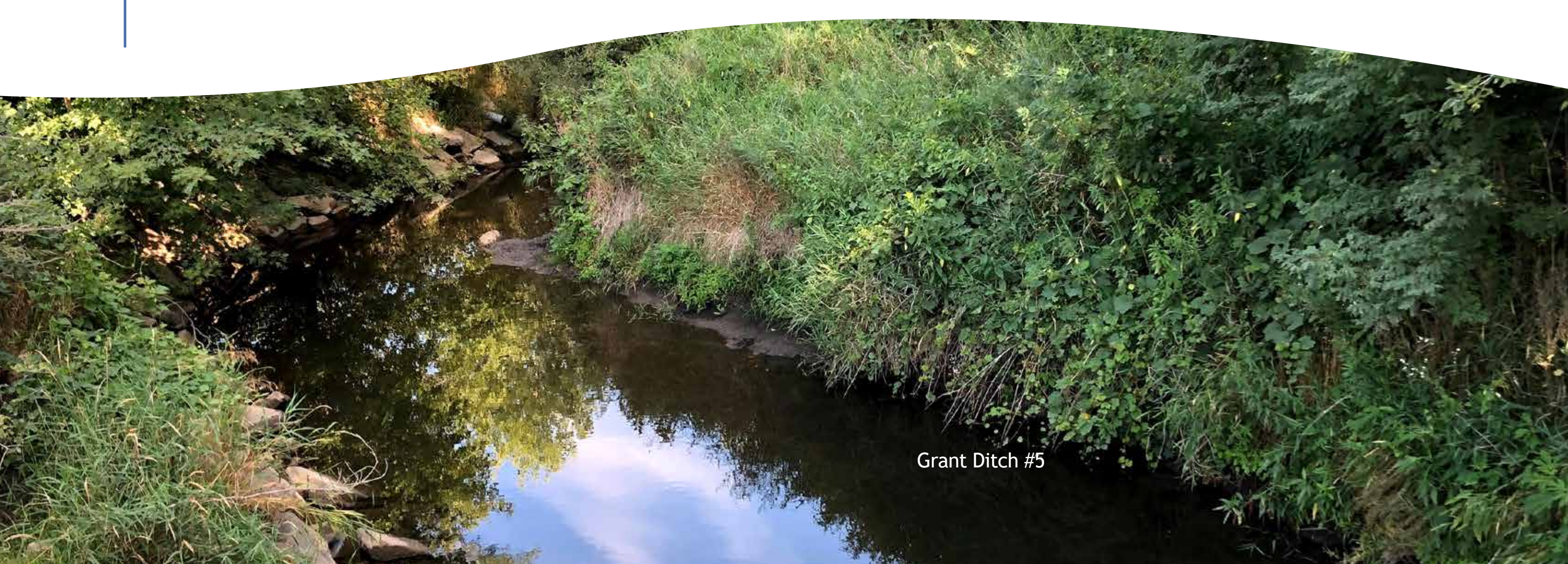
> *"The term 'tributary' includes a ditch that either relocates a tributary, is constructed in a tributary, or is constructed in an adjacent wetland as long as the ditch is perennial or intermittent and contributes surface water flow to a traditional navigable water or territorial sea in a typical year."*
>
> *-Federal Register[14], vol. 85, April 2020*

[11] Personal communication from Samuel McDeid, IDNR. Nov 21, 2019

[12] https://www.epa.gov/waterdata/nhdplus-national-hydrography-dataset-plus

[13] https://programs.iowadnr.gov/bionet/docs/about

[14] https://www.epa.gov/sites/production/files/2020-01/documents/navigable_waters_protection_rule_prepbulication.pdf



Grant Ditch #5

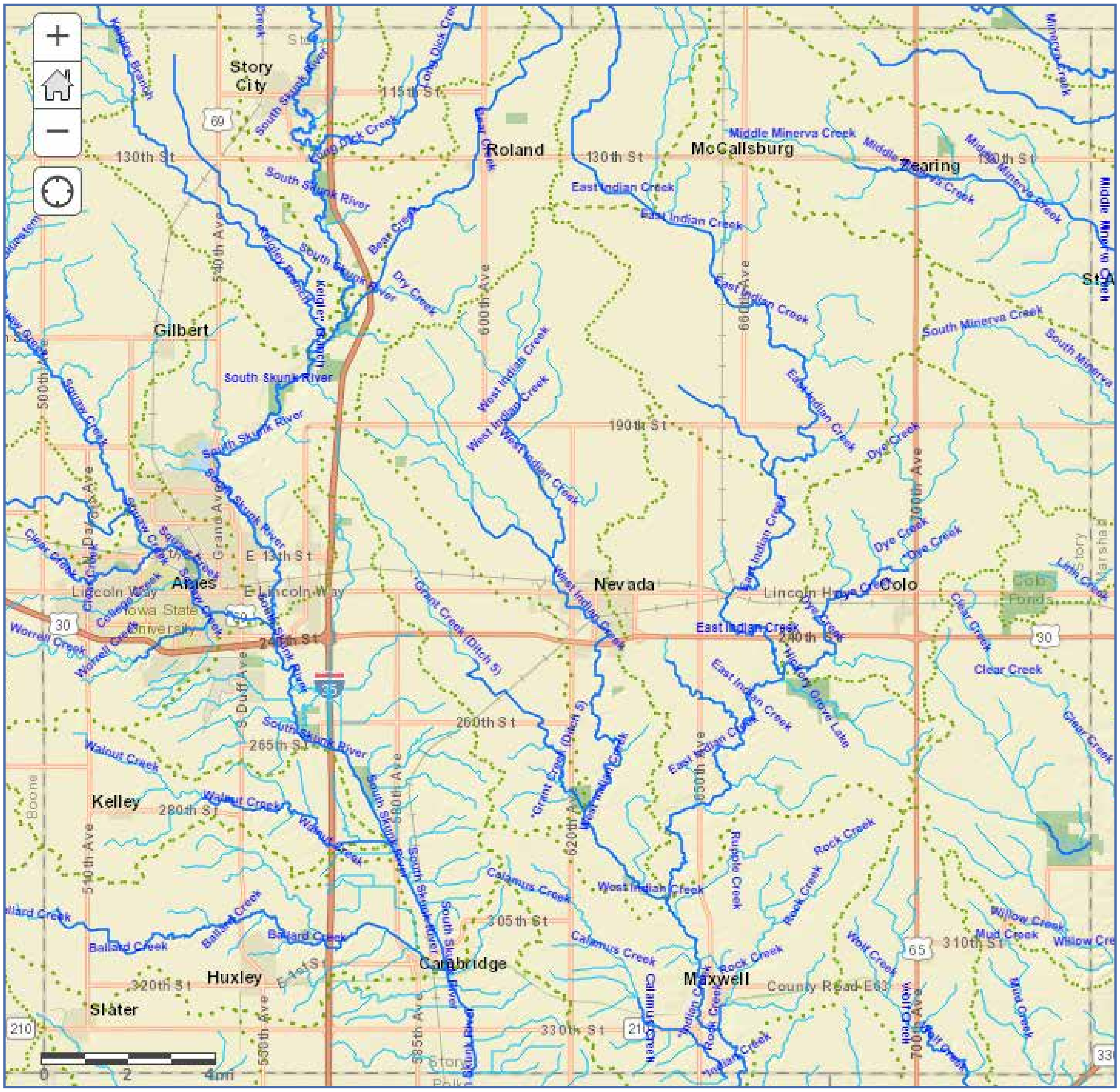


Figure 5: Prairie Rivers of Iowa proposed stream classification, based on NHDPlus and watershed area. "Headwater streams" (light blue) drain less than 10 square miles of land, and are less likely to flow year-round.

Table 1: Prairie Rivers of Iowa proposed stream classification based on watershed area

Large Wadeable Streams (part of creek has a watershed area between 10 and 700 square miles)	**Headwater Streams (watershed area less than 10 square miles)**
South Skunk River Walnut Creek Ioway (Squaw) Creek Worrell Creek Clear Creek (near Ames) Onion Creek Keigley Branch and an unnamed tributary Bear Creek Long Dick Creek Indian Creek Calamus Creek Rock Creek West Indian Creek Grant Creek (Drainage Ditch 5) Drainage Ditch 32 East Indian Creek Drainage Ditch 81 Drainage Ditch 91 Dye Creek Wolf Creek Middle Minerva Creek Minerva Creek Ditch 1	College Creek "South Branch of Worrell Creek" "Komar Creek" "Gilbert Creek" Dry Creek Rupple Creek *Story County portions of:* Linn Creek Fourmile Creek South Minerva Creek Clear Creek (near Colo) Willow Creek Mud Creek

The Iowa DNR uses subsets of the NHD to organize assessments and map impaired waters (Figure 3C) and to keep track of waters for which a Use Attainability Assessment have been completed (Figure 3D). These are described in the following section.

DNR Assessments and Impaired Waters List

Every two years, as required by Section 305(b) of the Clean Water Act, the Iowa DNR reviews available data to assess whether Iowa waters are supporting their designated uses and report its findings to the EPA. The data used is 2-4 years old for rivers, and 2-5 years old for lakes. Under Section 303d of the Clean Water Act, waters that do not support their designated uses are added to the Impaired Waters List. As time and resources allow, the DNR works through this list to prepare cleanup plans.

(Figure 3C) Iowa DNR's Assessment Database[15] includes all streams that were mapped as perennial in a 1993 version of the NHD. As described above, these categories are not always reliable. Linn Creek is

[15] ADBNet is DNR's Assessment database. https://programs.iowadnr.gov/adbnet/

Keigley Branch

mapped as extending into Story County even though closer inspection of aerial photos shows that the stream channel begins in Marshall County. The database does not include several streams that have since been reclassified as perennial, either through corrections in subsequent editions of the NHD (i.e. Middle Minerva Creek near Zearing, Grant Ditch near Nevada) or by completion of a Use Attainability Analysis (i.e. Gilbert Creek). It also excludes former gravel pits like Peterson Park Lake and Ada Hayden Lake that are valued for recreation.

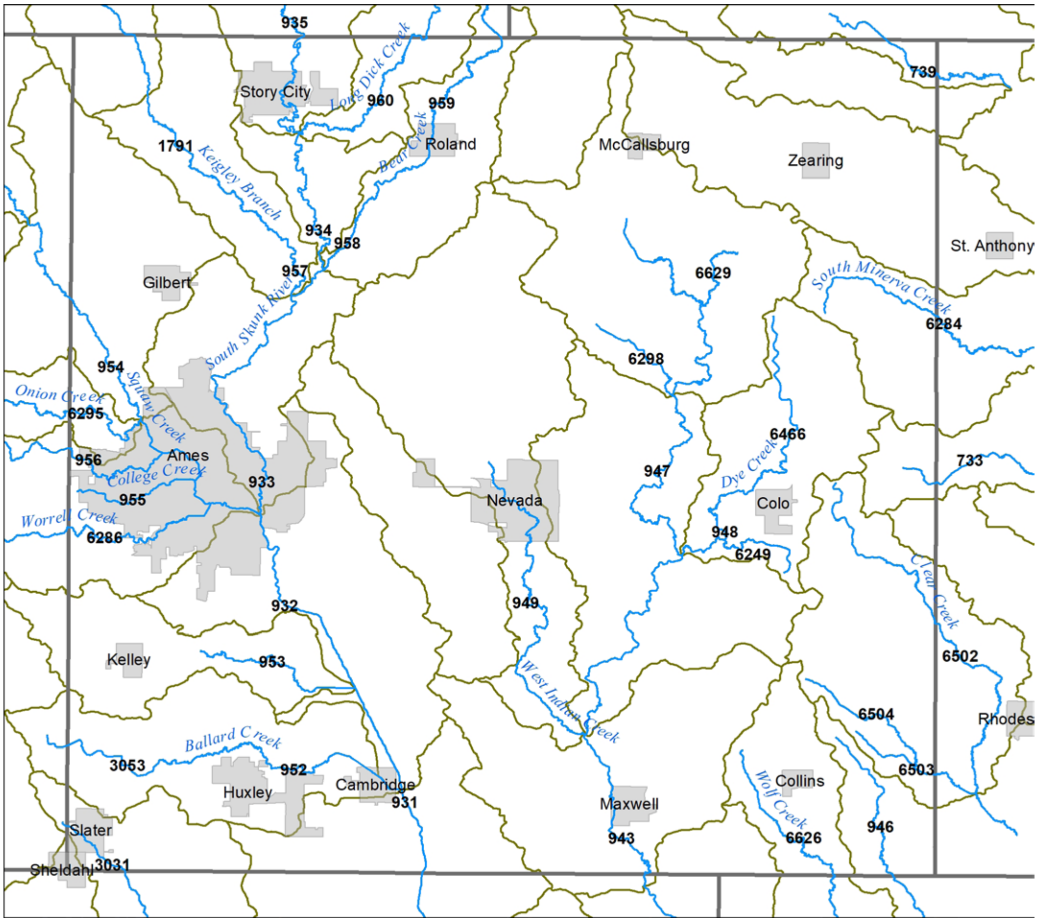


Figure 6: Stream segments in ADBNet

The stream segments and designated uses in ABDNet are generally not split apart and updated to match Iowa's official Surface Water Classification document, described in the next section. For example, West Indian Creek is designated A2 (Secondary contact recreation) downstream Nevada Wastewater Treatment Plant, but in ABDNet, the entire stream is treated as presumed A1 (primary contact recreation).

However DNR's Assessment Database is still an essential starting point for understanding water quality in Story County, and finding information about fish kills, water quality monitoring, and biological monitoring for that water body. Table 2 summarizes the designated uses and 2020 assessment results. Segment numbers can be referenced to the map (Figure 6).

- 3 lakes and 34 streams segments in Story County are included in ADBNet. Most have never been monitored or assessed.
- Only 5 streams and 1 lake were assessed for recreational uses in 2020. None were fully supporting.
- 18 streams and 2 lakes were assessed for aquatic life uses in 2020. Only 4 were fully supporting.
- 6 stream segments were placed on Impaired Waters List in 2018 or previous cycles. The 2020 draft Impaired Waters List did not include any additions or removals.
- 1 lake (Hickory Grove Lake) is impaired but a Total Maximum Daily Load (TMDL) was completed to address algae and bacteria.
- 21 streams segments are only presumed to be capable of supporting gamefish and primary contact recreation[16]. Since these are small streams, it is likely that the designated use would be changed to A2 and B-WW2 when and if a Use Attainability Analysis is completed.
- 8 headwater stream segments were placed on the Waters In Need of Further Investigation list because of low invertebrate or fish scores. DNR has not calibrated metrics for headwater streams with less than 10 square miles of drainage area, so is not able to evaluate if these streams are supporting aquatic life to their full potential.
- As described in Chapter 4 and Chapter 5, local partners tested E. coli in two streams between 2016 and 2018. After public comment by Prairie Rivers of Iowa, these were placed on the Waters In Need of Further Investigation list.
- Hickory Grove Lake fully supports fish consumption (HH) use based on testing of fish tissue for mercury, PCBs, and other chemicals. In previous cycles, the South Skunk River supported fish consumption use, but the data is now over 10 years old. Other priority lakes have not been tested.

[16] See IDNR publication Assessing Iowa Stream Uses for an explanation of the "rebuttable presumption": http://www.iowadnr.gov/Portals/idnr/uploads/water/standards/files/UAA_factsheet_20132014_FINAL_ContactUDate.pdf

Table 2: Story County lakes and streams in ADBNet, designated use and 2020 assessment results

Fully Supporting (◊), Partially Supporting (!), Not Supporting (!!)

HUC12	ABDNet Segment	Geographic Name	Recreation[17]		Aquatic Life[18]		Fish Consumption		303d List
070801050305	6295	Onion Creek	*		*	!			
070801050307	6286	Worrell Creek	*		*	!			
	954	Squaw Creek	A1	!!	BWW2	!			
	955	College Creek	*		*	!!			
	956	Clear Creek	*		*				
070801050401	960	Long Dick Creek	*		BWW2	!			!
070801050403	958	Bear Creek (lower)	A2		BWW2	◊			
	959	Bear Creek	*		*	!			
070801050405	957	Keigley Branch (lower)	*		BWW2				
	1791	Keigley Branch	*		BWW2				
070801050406	933	South Skunk River	*		BWW2				
	934	South Skunk River	A1	!	**BWW1**	!	HH		!
	939	McFarland's Pond	-		BLW		HH		
070801050502	949	West Indian Creek	A2		BWW2				
070801050602	6298	Drainage Ditch #81	*		*	!			
	6629	Unnamed Tributary to East Branch Indian Creek	*		*	◊			
070801050603	6249	Unnamed Tributary to Dye Creek	*		*				
	6466	Dye Creek	*		*				
	948	Dye Creek (lower)	A1		BWW2				
070801050604	947	East Indian Creek	A1	!	BWW2				
	950	Hickory Grove Lake	A1	!	BLW	◊	HH	◊	!
070801050701	6502	Clear Creek	*		*				
	6503	Willow Creek	*		*				
	6504	Unnamed Tributary to Willow Creek	*		*	!			
070801050702	946	Mud Creek	*		*	◊			
070801050801	943	Indian Creek	A1	!	BWW2	!			!
070801050802	6626	Wolf Creek	*		*	!			!
070801050901	953	Walnut Creek	*		BWW2	!			!
070801050902	952	Ballard Creek (lower)	A3		BWW2	!			
	3053	Ballard Creek	A2		BWW2	!			!
070801050903	932	South Skunk River	A1		BWW2				
	931	South Skunk River	A1	!	BWW2	!			!
070802070802	6284	South Minerva Creek	*		*	!			
070802070803	740	Dakin Lake	-		BLW		HH		
070802070804	739	Minerva Creek	A2		BWW2				
070802080101	733	Linn Creek	*		*				
071000080101	3031	Fourmile Creek	A2		BWW2	!			

[17] A1 – Primary contact recreation, A2-Secondary contact recreation, A3- Children's recreation, * Presumed A1

[18] BWW1 – Warmwater streams supporting gamefish, BWW2 Warmwater streams lacking flow and habitat for gamefish, BLW – Lakes and wetlands, HH - Human Health / Fish Consumpion, * Presumed BWW1

Designated Uses

(Figure 3D) Another subset of NHD flowlines was used to prioritize streams for the Story Countywide Watershed Assessment. The source for this map was DNR's Stream Use Assessment and Attainability GIS coverage, sometimes called "Designated Streams." This GIS coverage is used to keep track of streams for which a Use Attainability Analysis (UAA) has been completed[19]. However, it is important to understand that many other waters in Story County also have a presumed Designated Use and would be subject to water quality standards that are the same, or stronger. Not all of them are mapped.

> *"All perennial rivers and streams as identified by the U.S. Geological Survey 1:100,000 DLG Hydrography Data Map (published July 1993) or intermittent streams with perennial pools in Iowa not specifically listed in the surface water classification of 61.3(5) are designated as Class B(WW-1) […and] Class A1 waters."*
>
> *Iowa Administrative Code 567—61.3 (455B) Surface water quality criteria.*

A Use Attainability Analysis is necessary to reclassify designated uses. This often occurs as part of the permitting process for sewage treatment plants and industry that discharge wastewater. DNR staff evaluates the waters receiving the effluent, conducts fish surveys, and solicits public comment to determine how the stream is being used and what uses it could potentially support, which then affects water quality criteria are referred to in preparing the National Pollution Discharge Elimination System (NPDES) permit. These determinations are subject to public comment and approval by the EPA.[20]

Figure 7: Electroshocking at "Gilbert Creek" for a Use Attainability Analysis, source: Iowa DNR

[19] Search for "Stream Use Assessment and Attainability" on geodata.iowa.gov

[20] For a complete explanation of the process, see "Assessing Iowa Stream Uses", a DNR factsheet. http://www.iowadnr.gov/Portals/idnr/uploads/water/standards/files/UAA_factsheet_20132014_FINAL_ContactUDate.pdf

The following examples serve to illustrate the difficulty in interpreting UAAs and designated uses outside of the context of permit applications for wastewater treatment plants (WWTPs) and industry.

- Sometimes called Gilbert Creek, an officially unnamed tributary of Ioway Creek was surveyed below the Gilbert WWTP in 2016. While it is mapped as intermittent in the NHD, DNR determined through field investigations that it was actually perennial. Because water was shallow, access was limited and only non-game fish were captured, DNR assigned it the lowest possible designated use: A2 (secondary contact recreation) and B-WW2 (non-game fish and aquatic life).

- Middle Minerva Creek was surveyed at three locations below the Zearing WWTP in 2016. DNR staff found a variety of non-game fish and water deep enough to support full contact recreation at the lower two locations, and designated part of the stream as A1 and part as A2. The portion of Middle Minerva Creek that flows through Zearing is undoubtedly perennial and shallow, but does not appear on the Designated Waters Map or ADBNet, as it was mistakenly miscoded as intermittent in the 1993 NHD.

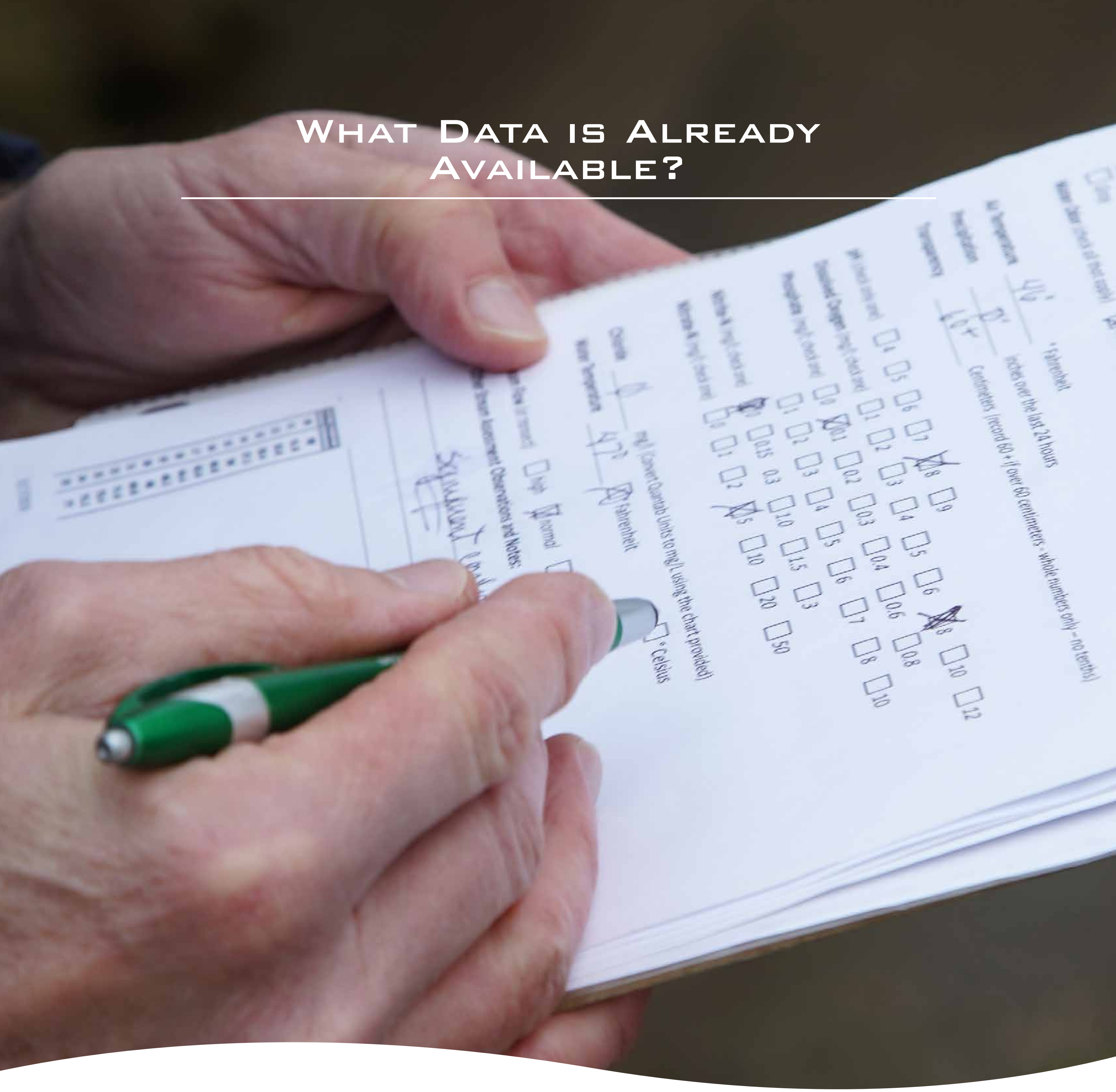
- College Creek is a tributary of Ioway Creek. Only a 46-foot length of the creek downstream of the ISU Heating Plant and the unnamed tributary[21] that connects it were analyzed. DNR assigned this small segment a designated use of A3 (Children's Recreation), based on the possibility that children could wade in from Squaw Creek. The remainder of the creek, which flows through the ISU campus and several city parks, remains unassessed with a presumptive A1 (primary contact recreation) and B-WW1 (gamefish) uses.

- West Indian Creek was surveyed below the Nevada WWTP in 2006. DNR concluded that although *"West Indian Creek is too shallow to support primary contact recreational uses, it does possess the potential of attracting Class A2 Secondary Contact recreational uses particularly associated with recreational canoeing and kayaking, fishing, trapping or hunting."* The portion of West Indian Creek upstream of the WWTP that flows through the City of Nevada was not assessed, and remains presumptively designated Class A1 for "full body immersion with prolonged and direct contact with the water, such as swimming and water skiing." The 160-foot long "effluent dominated ditch" leading from the WWTP to the creek was designated A3—Children's Recreational Use based on the fact that it was in town and within walking distance of schools and playing fields. Of the three designated recreational uses, Class A2 has the most permissive *E. coli* criteria. The public may have difficulty understanding the difference between these categories or why they were assigned.

Ultimately, Designated Uses may be an unnecessary complication for local partners when selecting sites or interpreting data for non-regulatory purposes. When presenting *E. coli* data, it may be simplest to reference both primary and secondary contact recreation criteria (See Chapter 4). The South Skunk River is the only stream in Story County designated B-WW1 for warmwater game fish, but DNR Fisheries Management Biologist Ben Dodd pointed out that Ioway Creek, Indian Creek, East Indian Creek, and West Indian Creek have some limited potential to sustain a fishery and could be included in monitoring focused on aquatic life.

[21] This tributary of College Creek was monitored as part of Squaw Creek Watershed Coalition snapshots, where it as referred to as Cyride Creek.

What Data is Already Available?



> *"Your query [Story County, Iowa] returns 244,787 records from 428 stations."*
>
> -Query results from the Water Quality Portal

Types of Data

Tens of thousands of water quality measurements have been collected in Story County. Making use of this data can improve our understanding of Story County lakes and rivers while saving us time and money. However, the data is scattered across at least six different databases. Categorizing water data by method of collection helps for understanding the types of data availailable and how it is structured.

- Water quality, tested in the field
- Water quality, tested in the laboratory
- Water quality, measured continuously in the field
- Biological monitoring
- Water quantity (flow) measured continuously at a gage

We will use nitrate as an example. Nitrate can be measured in the field with a test strip, recorded on a clipboard, and entered in a database designed specifically for the volunteer program. Since there's a set protocol with a limited number of characteristics being measured, it's easy enough to fit all the results for one date on a single row.

Table 3: Example volunteer data in "wide" format, from the former IOWATER database

Date	Nitrate-N (mg/L)	Orthophosphate (mg/L)	Transparency (cm)	Chloride (mg/L)
2010-06-11	10	0.2	50	<30

A volunteer could also deliver a water sample to a certified laboratory, which will test for nitrate at a higher level of precision using different equipment. The lab may test for hundreds of different chemicals[22] and will use a database built to accommodate that, with each measurement on a separate row. This format has additional columns to accommodate details about detection limits, laboratory methods, and quality control.

Table 4: Same data in "long" format, it would appear in the EPA Water Quality Exchange

Date	Analyte	Result	Units	Detection Limit
2010-06-11	Nitrate + Nitrite as N	10	mg/L	0.1
2010-06-11	Orthophosphate	0.2	mg/L	0.1
2010-06-11	Transparency measured in field with secchi tube	50	cm	
2010-06-11	2010-6-11	30	mg/L	30

Nitrate (and a handful of other parameters) can also be measured continuously with a probe, and recorded with a data logger every hour or 15 minutes. This can generate large amounts of data, which generally can't be accommodated in databases designed for lab samples, but are being hosted in custom built applications like the Iowa Water Quality Information System[23].

[22] In the South Skunk River alone, the Iowa DNR has tested for 265 different chemical or physical characteristics.

[23] https://iwqis.iowawis.org/

Table 5: Example of continuous data from a probe, on the Iowa Water Quality Information System

Date	Time	Nitrate-N (mg/L)
2010-06-11	08:00	10
2010-06-11	09:00	9.9
2010-06-11	10:00	9.8

In order to calculate how many pounds or tons of nitrogen is making its way to downstream waters, we would need to combine water quality data with water *quantity* data. Streamflow data is readily available from the US Geological Survey for gages they monitor.

Table 6: Example of combining water quality data with water quantity (flow) data from the USGS

Date	Nitrate as Nitrogen (mg/L)	Discharge (cfs)	Nitrogen Load (pounds/day)
2018-06-14	3.0	3,330	53,893
2017-05-24	17	509	46,680
2018-09-28	8	476	22,597

In order to determine how nutrients are affecting aquatic life in the stream, we might do a biological survey, with counts of different groups of organisms.

Table 7: Example of biological monitoring data

Date	Mayflies	Stoneflies	Caddisflies
2010-06-11	12	3	56

Software for Data Analysis

In order to make better use of the data we have and handle new data coming in, Prairie Rivers of Iowa has been using the computer programming language R[24] and the integrated development environment R Studio[25].

R is a programming language and software environment for statistical computing and graphics. Unlike point and click spreadsheet and database applications, it involves typing up a series of commands—a script. Scripts can be embedded in a text document using a lightweight markup language (R Markdown) and exported as a print (PDF) or web (HTML) document, so that a graph or table can be presented alongside a discussion of the findings and the code used to produce it.

[24] https://www.r-project.org/

[25] https://rstudio.com/

This approach has a steep learning curve when doing an analysis for the first time, but offers a number of benefits moving forward.

- When new data becomes available or a mistake needs to be corrected, a report containing multiple graphs or tables can be updated in minutes just by running the script.
- There is potential to quickly produce multiple reports customized for a monitoring station or date range.
- If there are questions about how the analysis was done, all the steps used in the analysis are documented in the code.
- Since the software is free, anyone can reproduce and build on the results given the source data and the script, a concept called reproducible research.
- Since R is used by scientists at the US Geological Survey, there are scripts and packages available for retrieving flow data from USGS gages, and water quality data from EPA databases.
- It can replace some of the functions of database software, manipulating and combining large data tables.
- Since R is widely used for data science and statistics, there are scripts and packages available for a number of advanced methods that are helpful for interpreting water quality data, such as boxplots, trend analysis, power analysis, and tests for statistical significance.
- It opens up the possibility of creating interactive web applications using R Shiny platform (free for limited usage, with paid plans for higher traffic).

Sources of Data

AQuIA

The Iowa DNR maintains a public information portal[26], AQuIA, for retrieving the results of water monitoring conducted by the Water Quality Monitoring and Assessment section of Iowa DNR[27] or one of its designees. The website includes tools for searching and downloading data by county, watershed, program, and characteristics measured. Each monitoring station has a summary page with location details and widgets for generating graphs. Data is typically uploaded within a month of collection.

[26] https://programs.iowadnr.gov/aquia/

[27] https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring

Table 8: Story County data available on Iowa DNR AQuiA database, as of Dec 6, 2020

Facility (Program)	Records	Sites	Analytes	Date Range
Iowa DNR surface water monitoring data	23,0539	33	257	10/1998 - 10/2020
Iowa DNR groundwater monitoring data	998	8	173	08/2002 - 11/2019
Iowa snapshots	538	33	4	10/2006 - 05/2013
Fish tissue monitoring	983	5	165	08/1983 - 9/2013

(9376 records) Many of the records for Story County come from a single site, the South Skunk River near Cambridge[28]. It is one of 60 sites in the Iowa DNR's ambient stream monitoring network[29] that help to evaluate water quality status and trends statewide. This stream has been monitored monthly since October 1998 for a wide variety of parameters, including:

- Field measurements, such as dissolved oxygen and flow
- Fecal indicator bacteria, such as *E. coli*
- Inorganic chemicals (naturally occurring but influenced by humans) such as chloride
- Nutrients, such as nitrogen
- Pesticides, such as carbonyl
- Volatile organic compounds such as trihalomethanes
- Metals, such as lead

Some additional sites in the ambient stream monitoring network are located outside the county, but may be helpful for interpreting data from their tributaries in Story County (Figure 7). The nearest downstream station from Indian Creek, Wolf Creek, and Clear Creek (draining the central and southeast part of the county) is on Indian Creek near Colfax[30]. The nearest downstream station from Ballard Creek (in the southwest) is the South Skunk River near Oskaloosa[31]. The nearest downstream station from Minerva Creek (in northeast part of the county) is the Iowa River downstream of Marshalltown[32].

[28] https://programs.iowadnr.gov/aquia/Sites/10850002

[29] https://www.iowadnr.gov/environmental-protection/water-quality/water-monitoring/streams The 2016-2021 ambient water monitoring strategy is described here. http://publications.iowa.gov/23682/

[30] https://programs.iowadnr.gov/aquia/sites/10500001

[31] https://programs.iowadnr.gov/aquia/sites/10620001

[32] https://programs.iowadnr.gov/aquia/sites/10640002

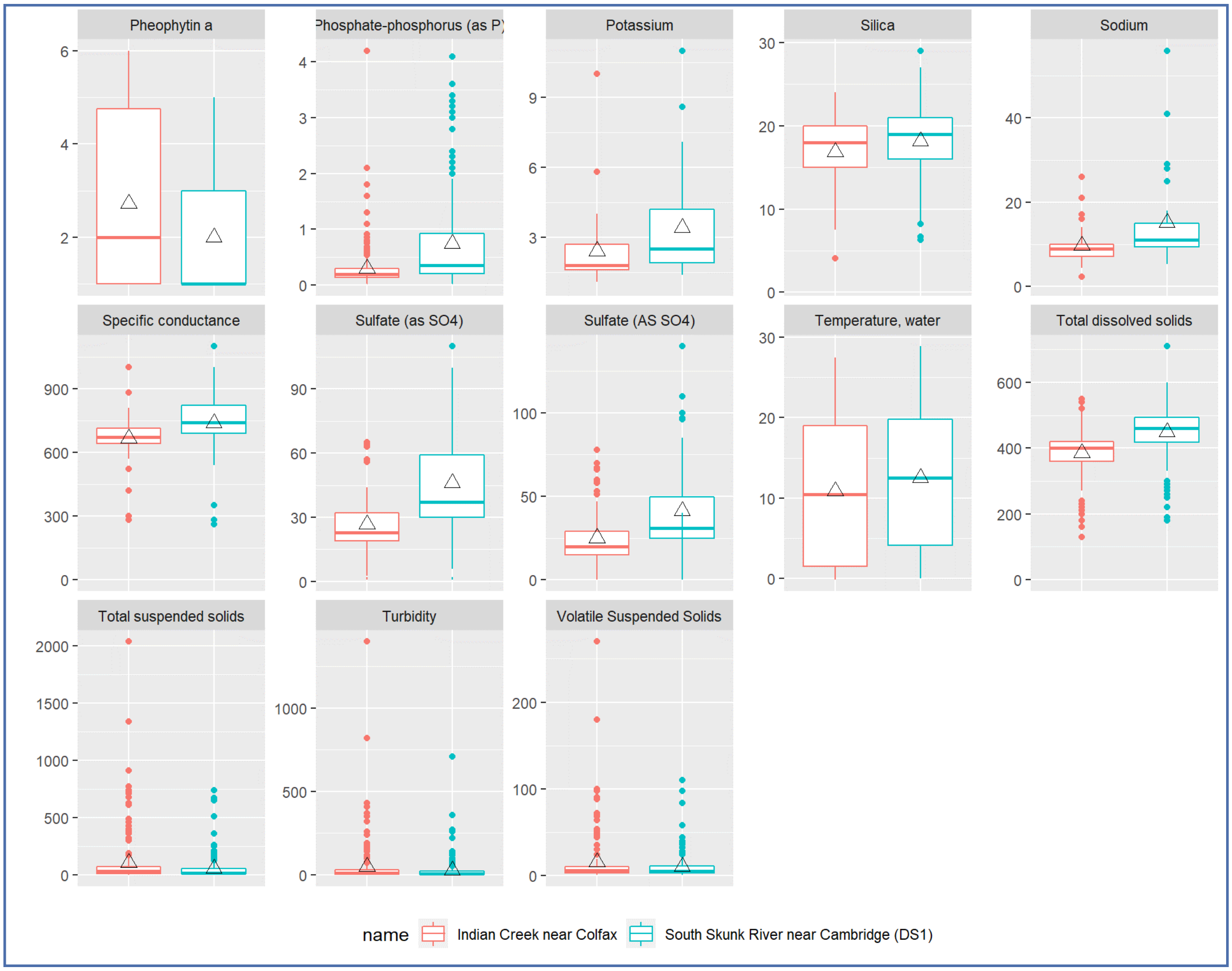
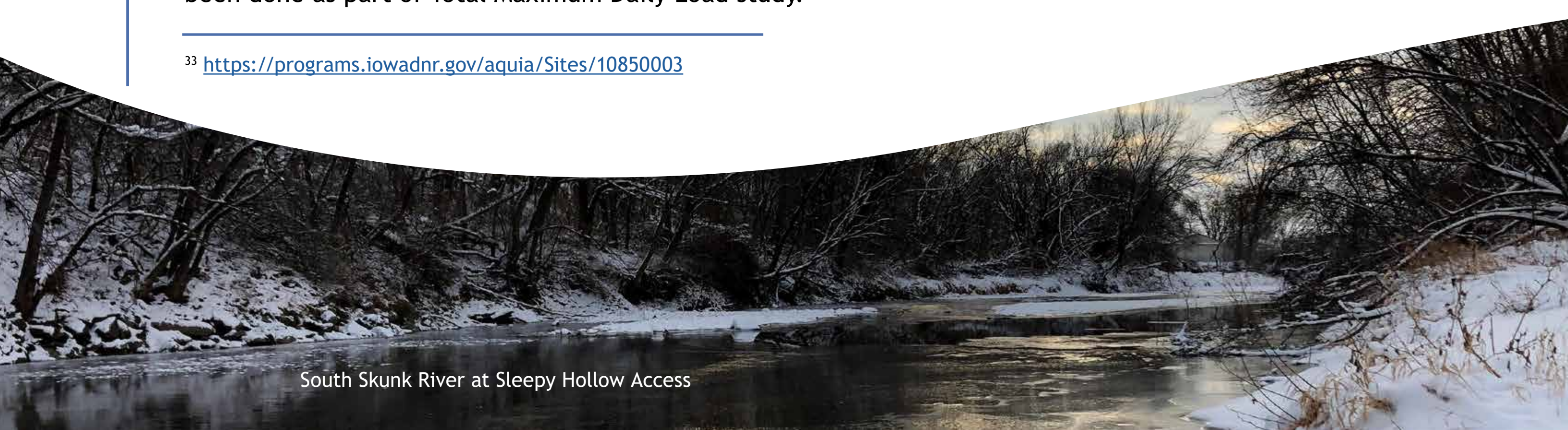


Figure 8: Examples of 1999-2000 water quality data from ambient stream monitoring sites. Data from these sites can be compared to tributaries monitored by local partners.

(8068 records) A second site on the South Skunk[33], at Sleepy Hollow Access north of Ames, was formerly part of the ambient stream monitoring network and a study on urban impacts to water quality, but is no longer being monitored by the DNR. Sampled monthly from October 1999 to September 2014, it will be a rich source of data to support the Headwaters of the South Skunk River WMA in watershed planning.

(1500 records) Hickory Grove Lake is one of 138 publicly owned lakes in the Ambient Lake Monitoring Program. Lakes are tested three times a year between May and September for dozens of indicators of trophic state and lake health, including nutrients, secchi depth, and chlorophyll (excluding the past few years when the lake was drained for restoration). Additional testing of Hickory Grove Lake has been done as part of Total Maximum Daily Load study.

[33] https://programs.iowadnr.gov/aquia/Sites/10850003



South Skunk River at Sleepy Hollow Access

A screenshot of DNR's interactive map of AQuIA sites is shown below. Some sites around the county have been monitored once or infrequently for various purposes.

- Surface water is tested following reported fish kills to determine whether the stream should be placed on the Impaired Waters List. For example, Long Dick Creek was tested biweekly for the first half of 2009, while Walnut Creek was tested once in 2011.

- When fish or invertebrates are surveyed as part of the ambient biological monitoring program, water quality is also tested, on that day only. For example, sites on Walnut Creek, Ditch 81, Dye Creek, Bear Creek, Worrell Creek, Onion Creek, and Ballard Creek each were tested once or twice for over 20 parameters as part of this program.

- Lab testing *(E. coli*, nitrate, phosphate, and ammonia) to support volunteer snapshot events in the Ioway (Squaw) Creek watershed. This was done between 2006-2013 as a partnership between the Iowa DNR's IOWATER program, the Squaw Creek Watershed Coalition, and the Iowa Geological Survey.

- Monitoring of fish tissue for mercury and other persistent contaminants. Despite other water quality concerns, fish caught in most Iowa waters (including the South Skunk River and Hickory Grove Lake in Story County) are safe to eat.[34]

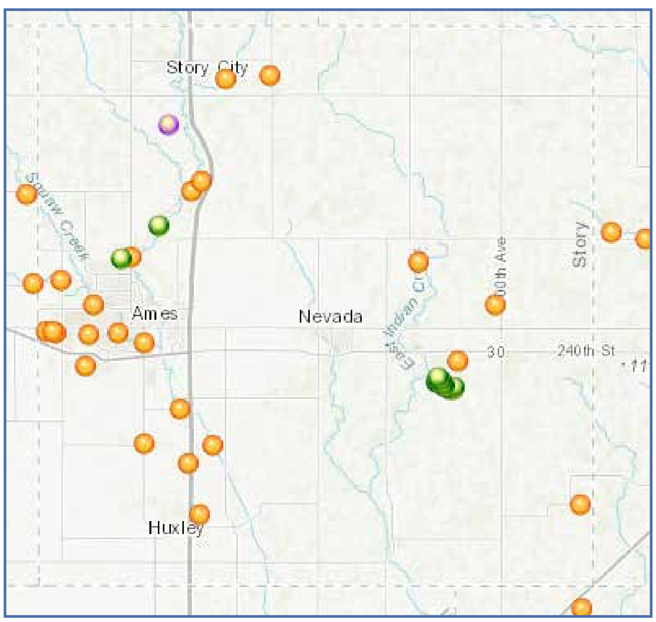


Figure 9: Map of DNR monitoring sites from AQuIA database

[34] https://iowadnr.gov/environmental-protection/water-quality/water-monitoring/fish-tissue

Water Quality Portal

The Water Quality Portal[35] is a cooperative service that integrates data from the Environmental Protection Agency (EPA), the United States Geological Survey (USGS) and the Agricultural Research Service (USDA-ARS).

State and local organizations can also submit water quality data to the EPA and make it available via the Portal using the Water Quality Exchange[36]. WQX is both a consistent way of structuring the data, and a set of tools for submitting data to the EPA. For example, Polk County Conservation uses a spreadsheet template and a web portal to upload data collected by staff and volunteers twice a month.

As a result of these submissions, the Water Quality Portal is the nation's largest source for water quality monitoring data, using the WQX format to share over 380 million data records from 900 federal, state, tribal and other partners.

Unfortunately, the Water Quality Portal cannot be our only stop for data, as state and local entities that monitor water may not have uploaded data, or only upload data every 2 years as part of required reporting. For example, the most recent data from Iowa DNR's surface water monitoring program is from September 2018, while the most recent volunteer data from the IOWATER program is from November 2011.

> *"Hubs that open data without any community engagement will struggle with attracting end users to create value from the data. Indeed, public agencies that have tried this approach found that the "if you build it, they will come" mentality does not work for water data. These agencies have found that they must develop analytics and information services with the data to create value to their citizens."*
>
> *-from The Internet of Water Revisited*[37]

The portal is an indispensable source of information, but is challenging to use for the first time. As such, we no longer consider it as our primary means to share data with the public, though we do hope to periodically upload some of our data[38]. A web application allows users to query the database and download a spreadsheet, but given the number of records in Story County alone, it's important to further narrow down the location, sampling parameters, or site parameters. There is a map view, but it does not consistently zoom to the right state. Once downloaded, the spreadsheets require some processing to be easily read, graphed, or summarized. Aside from the site number, all the location information is stored in a separate table from the results. Each measurement is a separate row, and each row contains 35 columns of metadata in addition to the numeric result, most of it blank. An abbreviated example of the WQX data format is shown on the next page.

[35] https://www.waterqualitydata.us/wqp_description/

[36] https://www.epa.gov/waterdata/water-quality-data-wqx

[37] Patterson, Lauren, Martin Doyle, and Greg Gerhuny. 2019. Building an Internet of Water – A Report from the 2017 to 2019 Internet of Water Roundtables. https://www.aspeninstitute.org/publications/internet-of-water-revisited

[38] For example, the Izaak Walton League plans to eventually upload data from the Clean Water Hub to the Water Quality Exchange

Table 9: Example of WQX data format (5 of 35 columns, water quality results table)

Monitoring Location Identifier	Activity Start Date	Characteristic Name	Result Measure Value	Result Measure/ Measure Unit Code
ARS-IAWC-IAWC122	1992-09-16	Nitrate-N	15.9	mg/L
ARS-IAWC-IAWC122	1992-09-16	Orthophosphate	0.03	mg/L

A desktop application based on R, the WQP Data Discovery Tool[39], can streamline the process of querying the database and dealing with non-detects and duplicates. R users can import data with the "dataRetrieval" package[40].

As of December 2020, Water Quality Portal includes the following surface water[41] data for Story County.

Table 10: Story County data available on the Water Quality Portal, as of December 6, 2020

Agency	Records (measurements)	Stations (sites)	Characteristics (analytes)	Date Range
Agricultural Research Service	70,045	6	10	06/1990 - 05/2015
Agricultural Research Service	19,750	16	240	10/1999 - 09/2018*
Iowa Volunteer Water Monitoring Program	10,097	78	14	05/2000 - 11/2011*
USGS Iowa Water Science Center	7,513	16	421	12/1955 - 07/2019
Iowa Geological Survey[42]	368	33	4	10/2006 - 05/2009*

*More recent data is available from other sources.

Prairie Rivers of Iowa prepared an interactive map[43] showing the location of monitoring stations included in the Water Quality Portal. Screenshots are shown on the next page. Darker red indicates sites with more records.

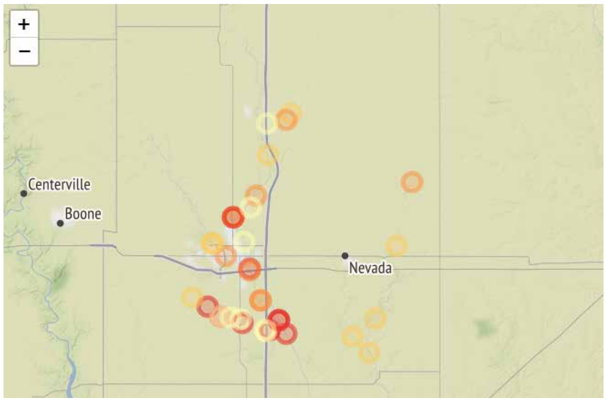
[39] https://www.epa.gov/waterdata/water-quality-portal-data-discovery-tool

[40] https://cran.r-project.org/web/packages/dataRetrieval/vignettes/dataRetrieval.html

[41] The portal results for Story County also include 17,327 records of water quality in wells, and 263 samples of chemicals in lake/river sediment, and small number of records for other types of data

[42] The Geological Survey did lab testing (E. coli, nitrate, phosphate, and ammonia) to supplement volunteer monitoring at watershed snapshot events (in this case, Squaw Creek watershed)

[43] https://rpubs.com/dhaugprrcd/WQP



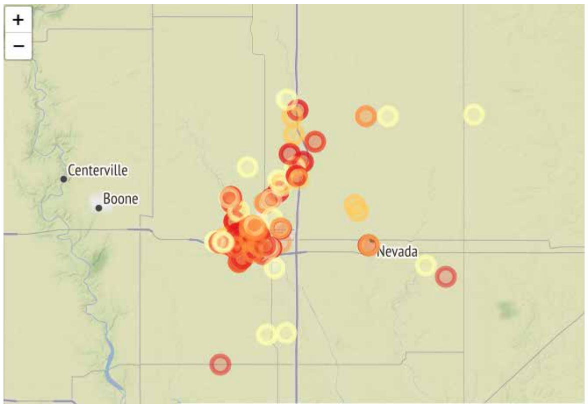


Figure 10: Locations of streams with data on the Water Quality Portal, collected by government agencies (left) and volunteers (right).

Not including monitoring by the Iowa DNR described under AQuIA, the sites with the most data include:

- (Over 61,000 records) 4 locations on Walnut Creek[44] were monitored by the USDA-ARS for nutrients, sediment, and selected pesticides as part of the Conservation Effects Assessment Project (CEAP)[45].

- (over 8,000 records) As part of the same study, two locations on the South Skunk River (above and below the confluence with Walnut Creek) were also monitored.

- (3765 records) An unnamed tributary of East Indian Creek near Zearing was included in the Midwest Regional Stream Quality Assessment[46]. The site was monitored 33 times in 2013 and 2016 for a variety of parameters including nutrients and pesticides.

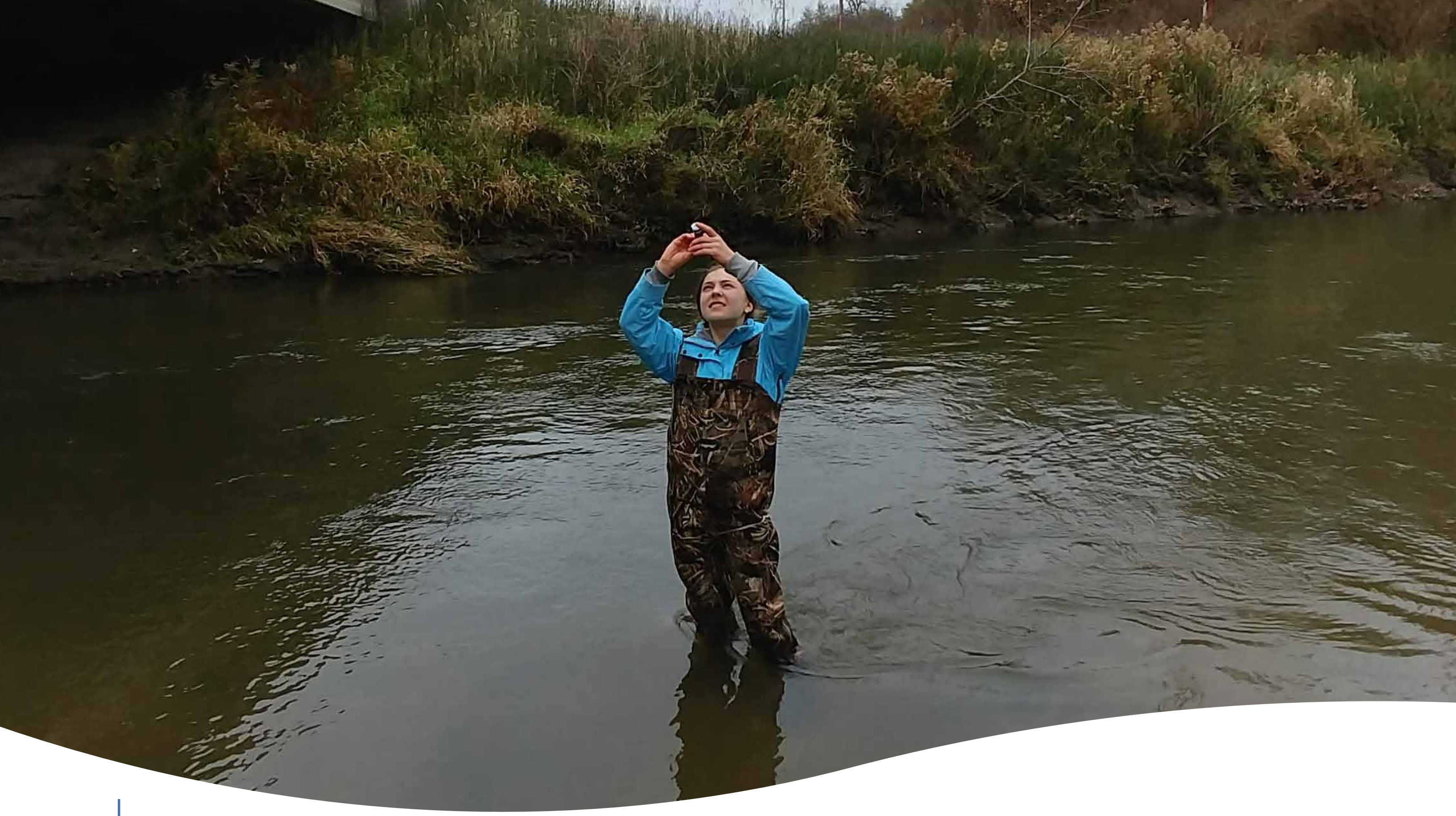
- (over 3000 records) The USGS takes regular measurements of temperature, flow, and specific conductance to calibrate gaging stations, and sometimes measures other parameters. Three stations are located on the South Skunk River (at E18, S Riverside Rd, and S. 16th St) and one on Ioway (Squaw) Creek at Lincoln Way. This dataset includes nitrate measurements from the 1950s, which could be useful for historic comparisons.

- (1225 records) Squaw Creek at Duff Ave, monitored by volunteers with the IOWATER program.

[44] https://www.ars.usda.gov/anrds/ceap/iowa-walnutcreek/

[45] https://www.ars.usda.gov/anrds/ceap/ceap-home/

[46] https://webapps.usgs.gov/rsqa/#!/region/MSQA



Volunteer Monitoring Data

The DNR shut down the IOWATER database shortly after the program was discontinued. Data collected from 2012-2017 was never added to the EPA's Water Quality Exchange. DNR has provided data formerly stored in the database on request, which Prairie Rivers of Iowa used to analyze the number and timing of sites in Story County.

Between May 2000 and May 2017, over 90 sites in Story County were monitored by volunteers with the IOWATER program, for a total of over 2770 records[47]. Intensity of monitoring varied and dropped off in the later years of the program: two sites on Squaw Creek were tested over 100 times, 7 sites were tested at least 50 times, and 45 sites were tested at least 10 times. While much of the effort has focused on the Ioway (Squaw) Creek watershed, some other sites were monitored monthly for several years, including the South Skunk River at 190th St, Bear Creek, Keigley Branch, and Long Dick Creek (See Figure 11). A full list of sites and charts showing the timing of sampling has been published online[48].

[47] Give or take a few. In some of my analysis, I have focused on the South Skunk River basin (HUC8: 07080105) and omitted a stream inflow to Dakins Lake (monitored 3 times) and site at the start of Fourmile Creek in Slater (monitored over 26 times) that is included in the Polk County Snapshot

[48] https://rpubs.com/dhaugprrcd/iowater_overview

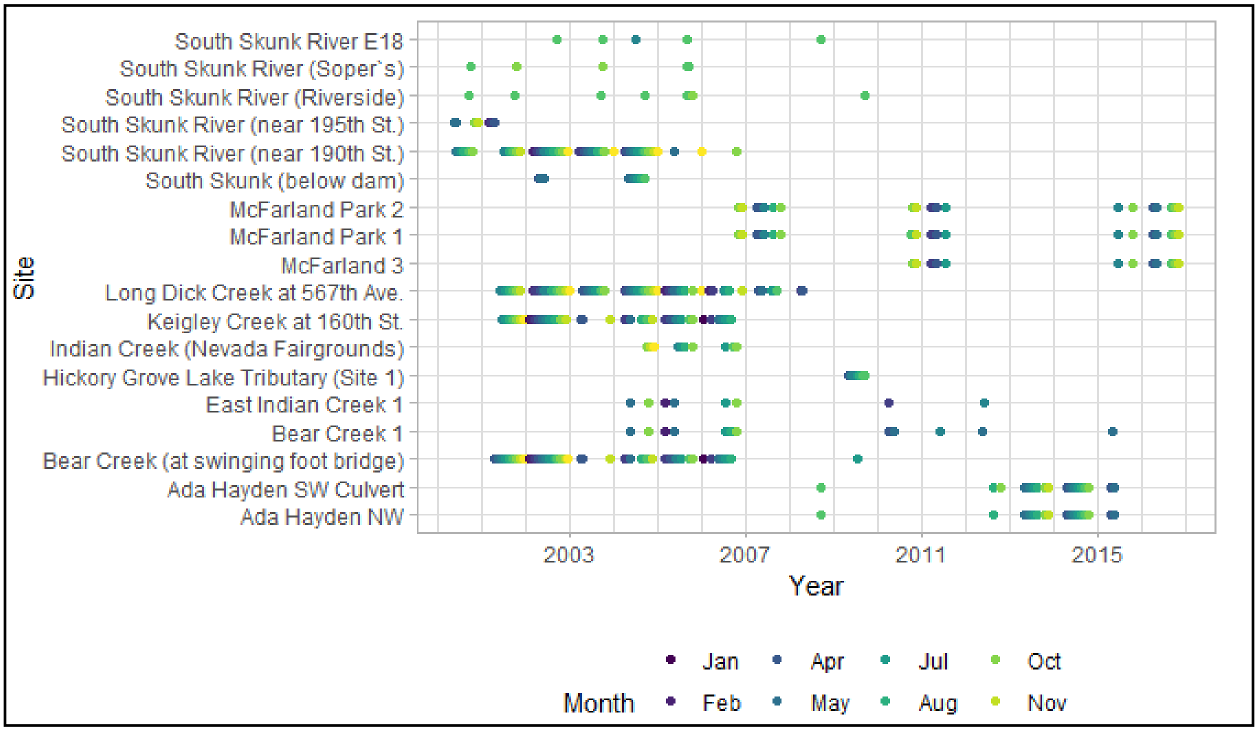


Figure 11: Frequency of sampling at IOWATER sites in Story County monitored at least 6 times, excluding Squaw Creek Watershed

> *"Locally-led programs have the freedom to store and use their volunteer-generated water monitoring data as they see fit." - Iowa DNR[49]*

Some local programs, like Polk County Conservation, have made use of the EPA's Water Quality Portal, described above.

Prairie Rivers of Iowa set up an ArcGIS webmap in 2018 to maintain access to IOWATER data[50], but it was not well-publicized and there was not a good way to allow volunteers to enter new data. For water quality snapshot events, Prairie Rivers of Iowa and the Squaw Creek Watershed Coalition used paper data sheets and spreadsheets.

To provide a platform for data entry moving forward, the University of Northern Iowa's GEOTREE program received a grant to develop a mobile app, which has been used by some local groups, but it did not provide a way to access historic data.

The most successful effort so far has been the Izaak Walton League's Clean Water Hub[51], which now hosts all the chemical monitoring data collected by the IOWATER program from 1998-2017. As described in Chapter 5, volunteers with Story County Conservation will be using this platform moving forward.

[49] https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Volunteer-Water-Monitoring

[50] https://arcg.is/4DC9q

[51] https://www.cleanwaterhub.org/community

Damselfly nymphs collected in Grant Creek

It may take some time to incorporate all the following loose ends into the Clean Water Hub.

- Biological (invertebrate) monitoring results that were formerly stored in the IOWATER database.

- Data collected by the Squaw Creek Watershed Coalition[52] at snapshot events in October 2017, May 2019, Oct 2019, May 2020, and Oct 2020.

- Data collected by schools since 2017. For example, Cara Rinehart's Gilbert High School biology class did biological and chemical monitoring of College Creek and Keigley Branch in 2017.

While the platform is a good home for the data from the IOWATER program and a user-friendly way for volunteers to enter data moving forward, it is currently missing some features we might like for summarizing and analyzing data.

- Query and download capabilities are limited to administrators
- No ability to search sites by county or watershed
- Not currently able to store lab results
- A maximum 100 records are displayed (we have two sites in Story County with more!)
- No summary statistics to allow for comparisons between sites
- Graphs become unreadable with a large number of records
- Auto-scaling of graphs that make it difficult to spot gaps in the record or changes in sampling schedule that could influence interpretation of seasonal patterns or trends

Unfortunately, **there is no single database that can manage or view all the data that is relevant to water quality in Story County.** We will need to get comfortable working with and summarizing data from multiple sources.

[52] http://www.squawcreekwatershed.org/watershed.html for tables, maps, and summaries of snapshot events dating back to 2006

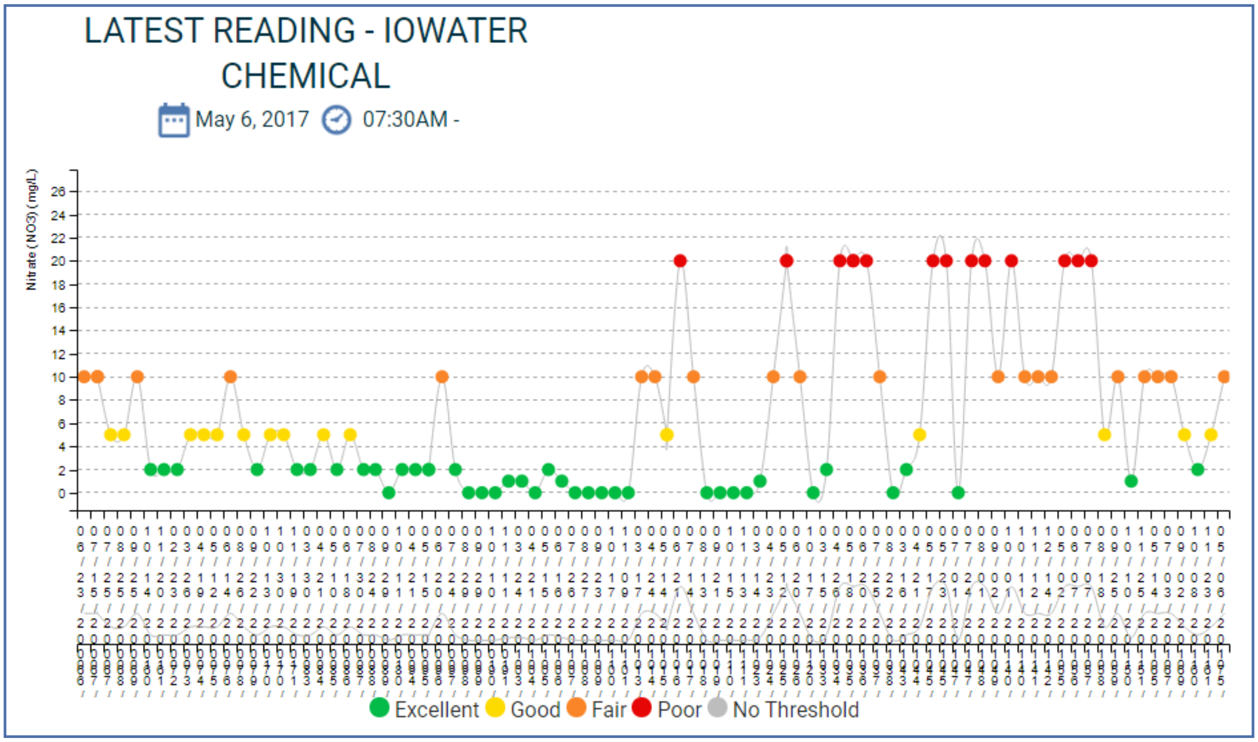


Figure 12: Example graph of volunteer data from the IWLA Clean Water Hub

National Water Information System

The National Water Information System provides access to stage and discharge (flow) data from stream gages maintained by the US Geological Survey.

- 05471000 South Skunk River below Squaw Creek near Ames, IA
- 05470500 Ioway (Squaw) Creek at Ames
- 05470000 South Skunk River near Ames
- 05469990 Keigley Branch near Story City (stage only)

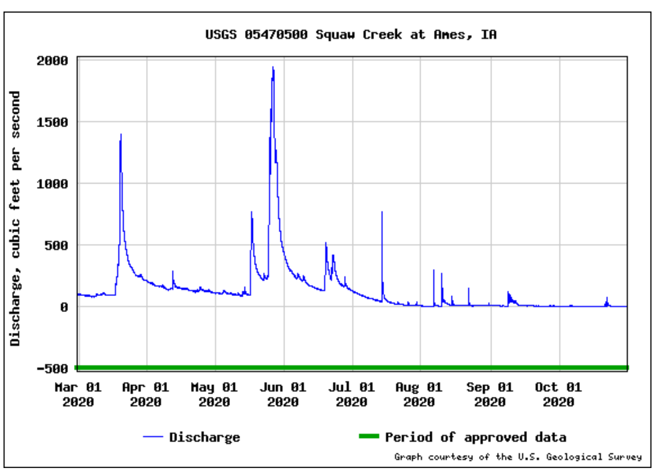


Figure 13: Example of flow data from a USGS gage

Iowa Flood Information System

The Iowa Flood Information System (IFIS) is a web platform developed by the Iowa Flood Center (IFC) at the University of Iowa. While primarily focused on helping Iowa communities forecast flooding and visualize flood-related data, it also is a source to understand current weather and flow conditions that can be helpful for interpreting water quality data. In addition to the USGS flow gages mentioned above, and weather data from various sources, the site provides access to real-time stage data from sensors installed by the Iowa Flood Center or local partners. Mounted on bridges, the solar-powered sensors measure water level (stream stage) using a sonar signal[53]. Converting this information to flow would require additional measurements and surveys to develop a rating curve.

> 10 stream sensors are located in Story County or on the county line. 8 are currently active.

Figure 14: Bridge-mounted stage sensor (City of Ames) on Ioway Creek

Iowa Water Quality Information System

The Iowa Water Quality Information System (IWQIS) offers access to real-time water quality data from sensors that measure nitrate, pH, dissolved oxygen, or temperature. The sensors are maintained by IIHR—Hydroscience & Engineering (IIHR) at the University of Iowa, the Agricultural Research Service (USDA-ARS) and United States Geological Survey (USGS).

[53] https://iowafloodcenter.org/projects/iowa-watershed-approach-hydrologic-network-4-3/

[54] https://iwqis.iowawis.org/

Three nitrate sensors are located in Story County. Nitrate-N concentrations are logged every hour, but there can be gaps when equipment needs maintenance or is removed for the winter to prevent damage.

- WQS0038. Ioway (Squaw) Creek, located at Moore Park in Ames. IIHR water quality gage: nitrate concentrations and loads. 2016 to present, generally removed from Dec thru March or April.
- WQS0054. Drainage tile of Walnut Creek, located on 270th St near Kelley. USDA water quality gage. Nitrate concentrations. Jun 2016 to present, sometimes deployed all winter.
- WQS0053. Walnut Creek, located at 530th Ave, near Kelley. Sept 2016 to present, sometimes deployed all winter.

In addition, a set of three nitrate sensors in neighboring Hardin County have been useful for understanding nitrate movement from tile to creek to river in watersheds with similar characteristics[55].

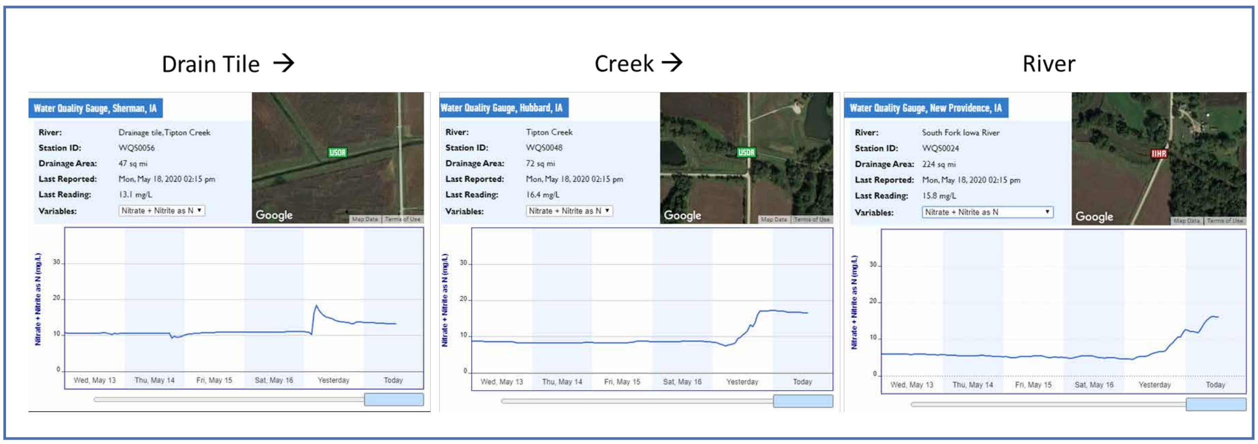


Figure 15: Example of real-time nitrate data from IWQIS, showing hourly water quality changes

IWQIS is built on a similar platform to the Iowa Flood Information System and includes much of the same information about weather and water quantity. There are several ways to view nitrate data from a given site, including as a “widget” on your own website. Administrators will supply data in a spreadsheet form on request.

[55] A PRI blog post used data from IWQIS. https://www.prrcd.org/may-showers-bring-awesome-graphs/

BioNet

BioNet[56] provides access to fish and benthic macroinvertebrate surveys collected by the Iowa DNR and State Hygienic Laboratory in rivers and streams. Biological assessments are an important part of the 305(b) water quality reporting process, to determine whether streams are meeting their designated uses. IDNR uses 12 metrics to calculate an index for both fish and macroinvertebrates, which are then compared to index values from relatively good quality reference sites in the same ecoregion.

- 40 sites in Story County have been surveyed since 1994, some multiple times.
- The South Skunk River near Soper's Mill is one of several reference sites that are used to benchmark and interpret assessments done in other streams in the ecoregion. Due to the greenbelt and lack of known sources of pollution, it represents a healthy aquatic community. It has been surveyed five times, most recently in 2017.
- Other recent surveys include Bear Creek at the Skunk River Greenbelt (2017), Dye Creek at Twin Anchors Golf Course (2019), Onion Creek in Ames (2018), and the South Skunk River near Cambridge (2016), Ioway (Squaw) Creek in Ames (2017).
- Downstream sites in neighboring counties include Minerva Creek near St. Anthony, South Minerva Creek near St. Anthony, Indian Creek near Colfax, and the Iowa River near Marshalltown.

Local Data, Not Available from Online Databases

For evaluating long-term trends in the South Skunk River, our best source of data does not appear in any public database but has been provided by a local partner.

The City of Ames has monitored water quality in the South Skunk River above and below the Water Pollution Control facility (WPC) on an almost weekly basis for 18 years. Three locations are monitored.

- Upstream of the WPC (at 265th St, same as short-term former DNR monitoring site)
- 0.3 Downstream of the WPC (at 280th St, same as long term DNR monitoring site)
- 1.3 Downstream of the WPC(at 580th Ave, below the confluence with Walnut Creek)

Parameters measured weekly include nitrate, total phosphorus, ammonia, biological oxygen demand, temperature, and total suspended solids. A smaller subset of parameters (including orthophosphate and *E. coli*) are measured quarterly or yearly.

The City of Ames has also monitored fecal indicator bacteria in 5 urban streams since 2001, as described in Chapter 5.

[56] https://programs.iowadnr.gov/bionet/Docs/About

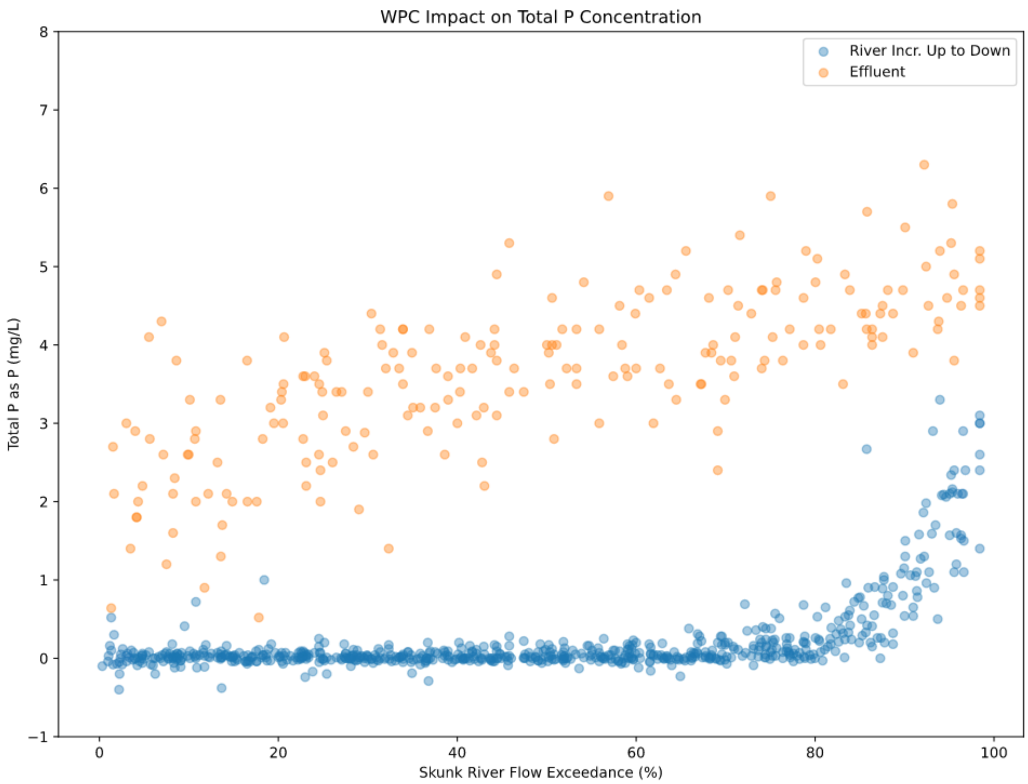


Figure 16: Stream and effluent monitoring by the City of Ames show how the Water Pollution Control Facility can influence phosphorus concentrations in the South Skunk River when water levels are low. Figure by Andrew Curtis, Ames Water & Pollution Control.

Several streams have been monitored as part of research projects by faculty at Iowa State University. If monitoring at these locations resumes, this data could help reveal trends.

- Onion Creek[57] was monitored at multiple locations from 2016-2019 to study the role of streambank erosion on sediment and phosphorus export.

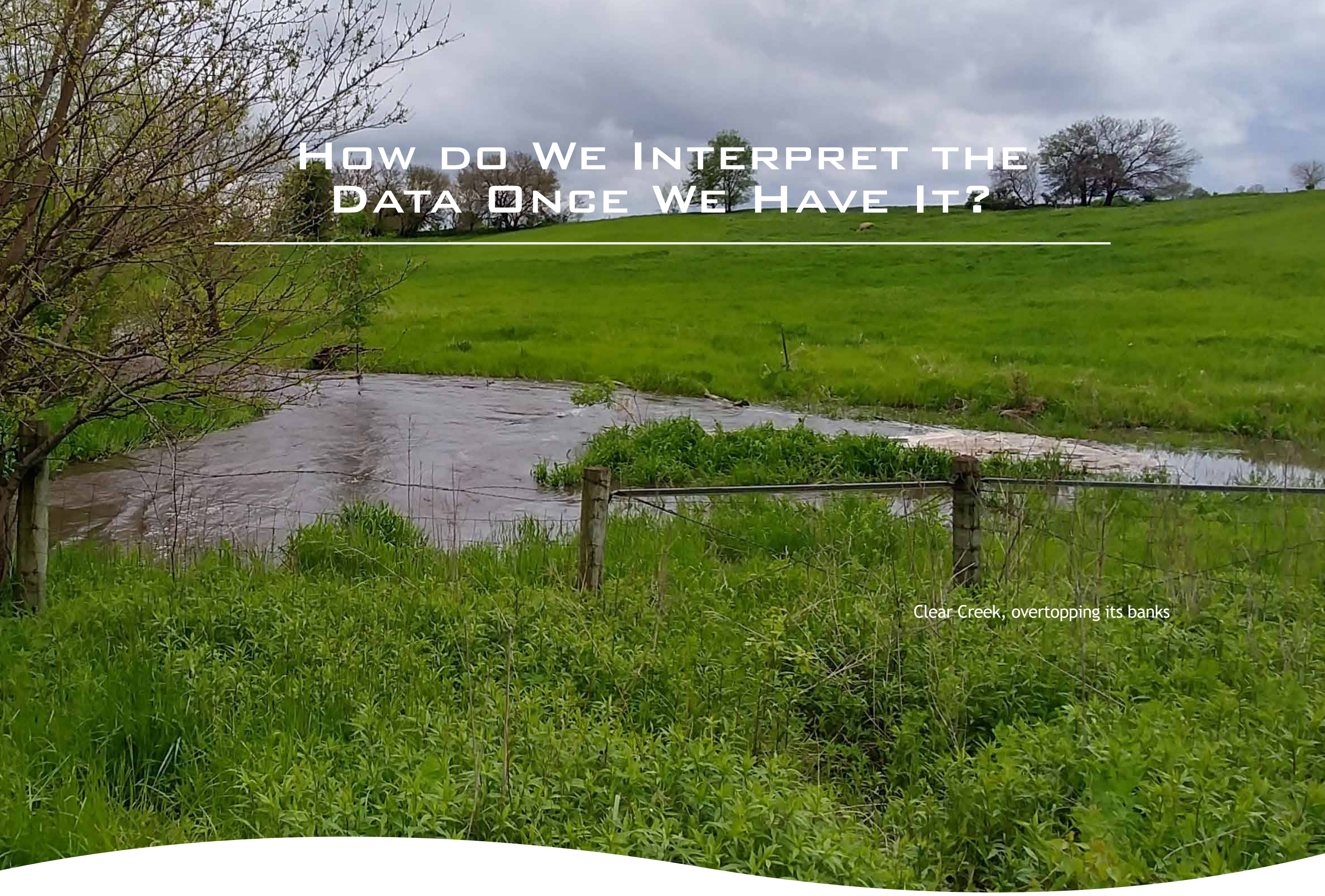
- Bear Creek[58] has been a site of pioneering research on riparian buffers and saturated buffers since the 1990s. Extensive nitrate data was collected from shallow wells to assess the effectiveness of the practices, but data may also be available from the stream.

- A tributary of Worrell Creek at the new Tedesco Environmental Learning Corridor in Ames was monitored monthly May 2017 through October 2020 with a combination of IOWATER field tests and lab tests for nutrients and bacteria. The project involved a partnership between ISU faculty, Story County Conservation, Iowa DNR, and Prairie Rivers of Iowa.

[57] https://www.cals.iastate.edu/inrc/phosphorus-contributions-eroding-streambanks

[58] https://www.extension.iastate.edu/news/explore-bear-creek-saturated-buffer-during-learning-farms-field-day

How do We Interpret the Data Once We Have It?



Clear Creek, overtopping its banks

> *"Stream and lake monitoring provides information to compare monitored conditions to stream and lake standards and criteria, detect changes over time, and support future watershed rehabilitation efforts. The ability of a monitoring program to detect such changes and the reliability of the comparisons depend upon the nature and design of the monitoring program." –Story Countywide Watershed Assessment, p 142*

The mere presence of water quality data is helpful for grant applications, because it demonstrates that there are committed local stakeholders who have studied the issues. But what does that data actually tell us? There are three kinds of comparisons we can make, once we have a complete season of data from a given site.

1. **Compare to state standards and criteria, to determine if the lake or stream is supporting recreation and aquatic life**

2. **Compare to the same site across time, to determine if water quality has changed**

3. **Compare to other sites measured during the same period, to understand how land management and other influences in the watershed affect water quality**

Once the data has been compiled it can be compared to the state standards and criteria, to determine if the water body supports its designated uses. For example, Figure 17 shows *E. coli* data for streams monitored by local partners in 2020. Of the ten sites with sufficient data to evaluate[59], nine exceeded the primary contract recreation criteria of 126 colonies per 100 mL.

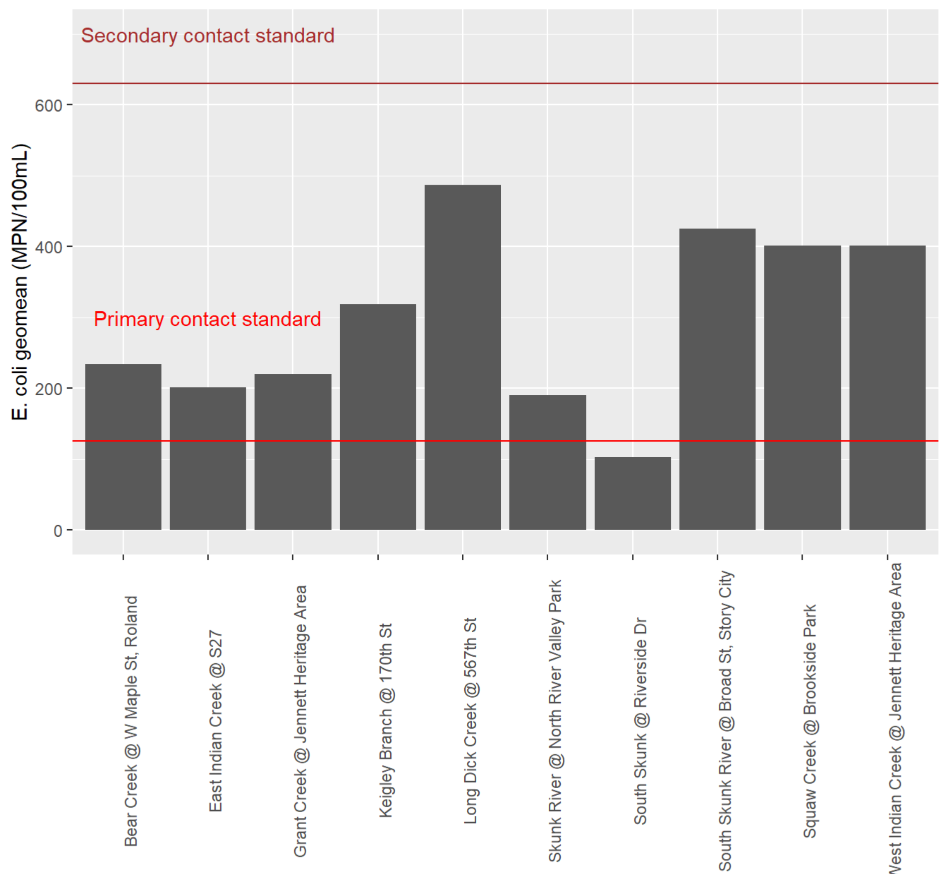


Figure 17: E. coli bacteria in Story County streams in 2020, as compared to recreational criteria

In some cases, as with the nitrate data in Figure 18, there is no relevant standard. While a 10 mg/L criteria is used to evaluate nitrate in drinking water, these streams are not used to supply drinking water. However, by comparing water quality data from streams with different land use or land management in the watershed, we can begin to understand and test our assumptions about what factors influence water quality. For example, here we can see that the lowest nitrate concentrations are found in College Creek, which has a mostly urban watershed. Bear Creek has slightly lower nitrate levels than nearby Long Dick Creek; riparian buffers could be a factor. **These kinds of comparisons can help us educate the public and direct outreach and conservation efforts to areas where it can be most effective.**

[59] Fifteen streams were monitored in 2020, but because of dry conditions, only ten had enough data to compare to this criteria. A complete report on the 2020 monitoring season can be found here. https://rpubs.com/dhaugprrcd/newsletter-2020-09

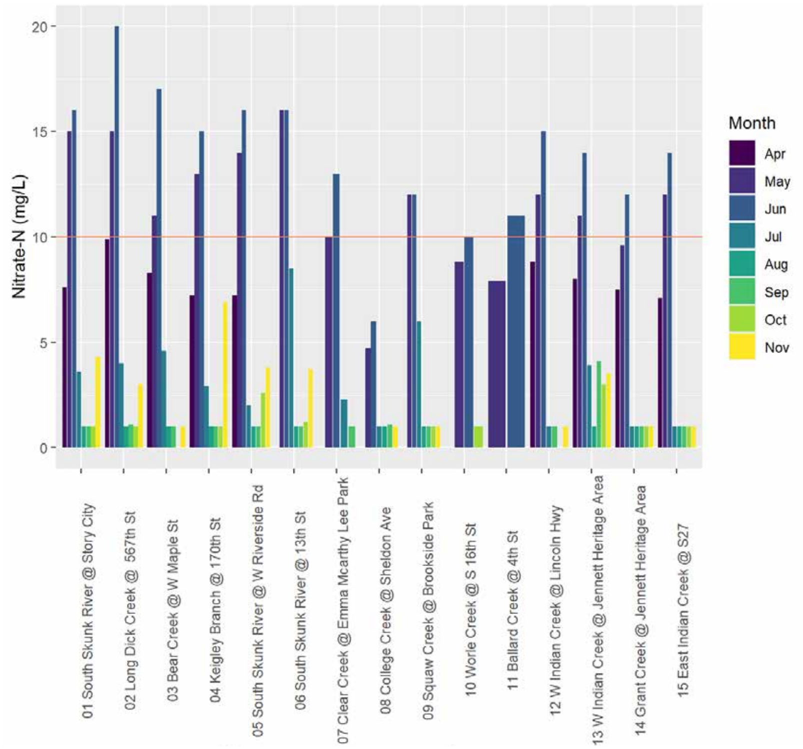


Figure 18: Nitrate data from Story County streams, 2020

With nitrogen and phosphorus, often our primary concern is not their effect on aquatic life in a local stream, but the consequences for the Gulf of Mexico. In this case, it does not much matter whether nitrate is above or below 10 mg/L, but whether we can reduce it from the levels that were seen in 1980-1992 (when the Hypoxia Action Plan was developed) or relative to 2006-2010 (when the Iowa Nutrient Reduction Strategy was developed). With a long enough data record, it is possible to detect trends.

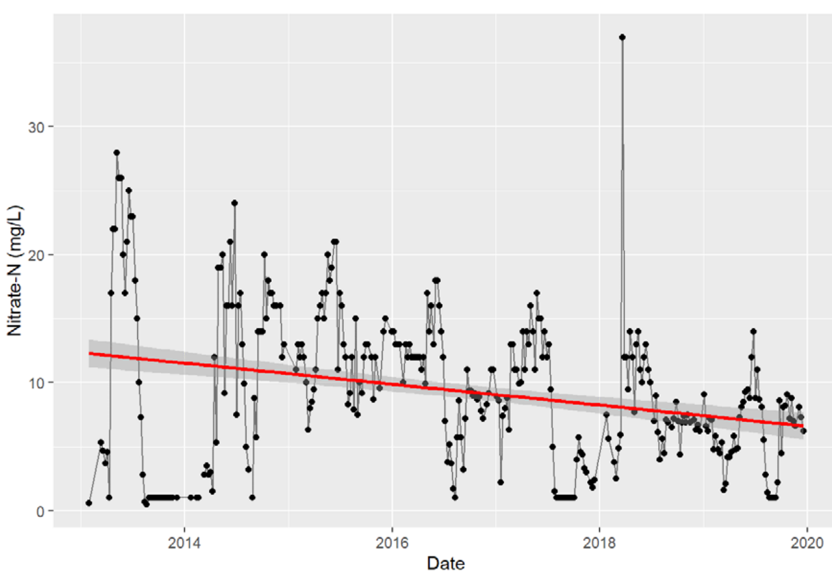


Figure 19: Trends in nitrate in the South Skunk River, based on weekly data collected above the WPC facility by the City of Ames

However, the length of data collection is only one piece of the puzzle. If the magnitude of the trend is small, it can be washed out by short-term variation. Figure 20 illustrates sampling error by showing four different subsets of a weekly phosphorus dataset. Depending on which week of month sampling occured, phosphorus concentrations could appear to have tripled or to have remained constant over the six year period. Quantifying the uncertainty associated with trends and averages[60] can help us be confident in our conclusions and can help set realistic expectations for monitoring.

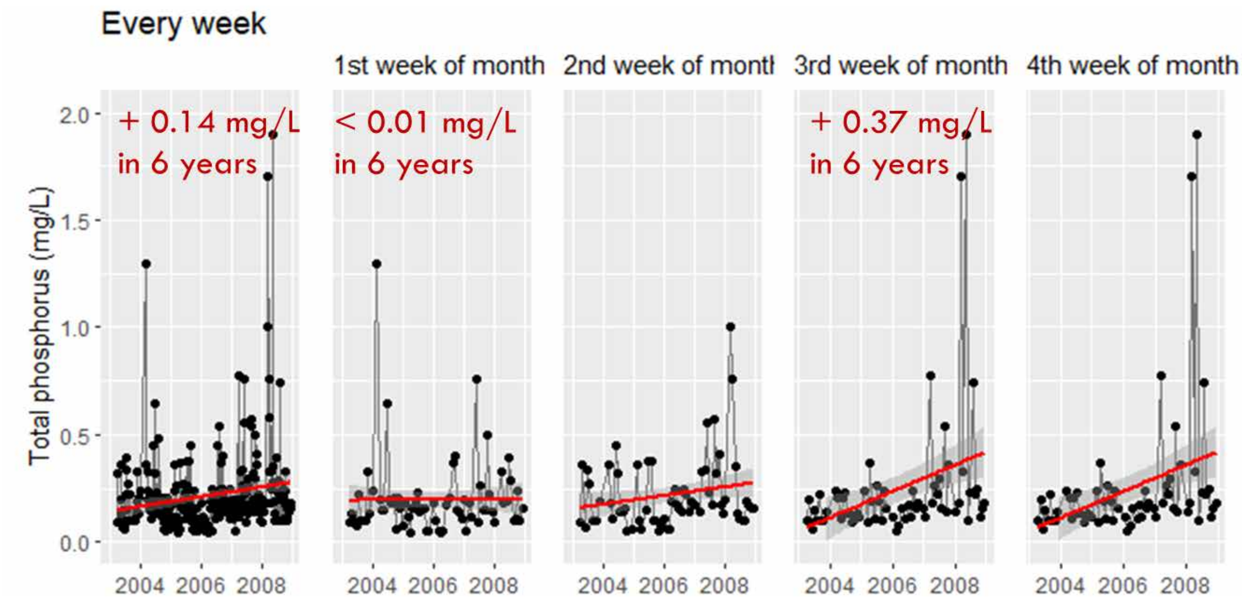


Figure 20: Phosphorus trends in the South Skunk River, depending on which week of the month was sampled, 2003-2008

By paying more attention to how data will be interpreted, and working to interpret the data that we already have, we can ensure that the data we collect over the next 10 years will meet our objectives.

Compare to Standards and Criteria

The Clean Water Act required that states establish water quality standards to ensure that rivers and lakes are swimmable and fishable. Standards have three parts[61]: a designated use, criteria to determine whether that use is fully supported, and anti-degradation policy to protect existing uses. For example, Squaw Creek in Story County designated for Primary Contact Recreation. In assessing whether that use is supported, we can compare *E. coli* data to two numeric criteria: 235 colonies per 100 mL for a single sample, or 126 colonies per 100 mL for a seasonal geometric mean. Antidegradation policy comes into play when a wastewater permit is reviewed—for example, the City of Gilbert and Squaw Valley Homeowners Association have both recently installed UV disinfection systems to protect recreational use of Ioway (Squaw) Creek as a condition of their permits.

Iowa DNR conducts monitoring to support assessments, but does not have the resources to monitor and assess about half the water bodies in Story County (see Table 13). In principle, locally-led monitoring could help fill the gap in understanding whether these waters are supporting aquatic life and recreation.

[60] In Figures 19 and 20, while the red trendlines measured with once-a-month subsets vary, the gray bands (90 percent confidence intervals) include the 0.14 mg/L trend found in the full once-a-week dataset.

[61] Killam, Gayle. 2005. The Clean Water Act Owner's Manual (second edition), Chapter 1. The River Network.

> *Data is not credible data unless the data originates from studies and samples collected by the department, a professional designee of the department, or a qualified volunteer.*
>
> *-Section 455B.193 of Iowa Code*

In practice, Iowa DNR is unlikely to use data collected by our locally-led water monitoring program to assess whether waters are meeting their designated uses[62]. Iowa's Credible Data Law[63] requires that data used for regulatory purposes be collected by the DNR or its designees. While there is an exception for data collected by trained volunteers under a DNR-approved quality assurance plan, the Department has been reluctant to make use of this provision. As recently as December of 2019, DNR's assessment database described recreational uses of Squaw Creek in Story County as "not assessed." This despite the following data being available:

- 80 samples collected at South Duff Ave from 2004 to 2013 by IOWATER volunteer Erv Klaas, tested using IOWATER's E. coli protocol (EasyGel Coliscan kits) .
- An incident in which raw sewage had been detected leaking into Ioway (Squaw) Creek, leading to the fix of a flood-damaged sanitary sewer trunk main.
- Summaries of volunteer data in the Squaw Creek Watershed Management Plan (2014), stating that E. coli in Squaw Creek was "well above" the standard.
- Samples collected by volunteers from multiple sites at 12 Ioway (Squaw) Creek Watershed Snapshot events between 2008-2013, and tested by a certified lab.
- 47 samples collected by the City of Ames and partners from 2016-2018, and tested by a certified lab.

After a comment from Prairie Rivers of Iowa on the draft 2018 Assessment this was changed to "Use potentially impaired based on an evaluated assessment", and our lab results from 2016 are now included in the Assessment Database[64]. Adding a creek to the "Waters in Need of Further Investigation" list does not guarantee it will be investigated, but it does provide the public with better information.

Regardless of what DNR does with the information, our locally-led monitoring project could still refer to Iowa water quality standards and criteria to help interpret the data for our own purposes, such as education. DNR documents and updates its ambient water monitoring strategy every 5 years[65]. It updates its assessment methodology every 2 years[66].

[62] Assessment in this context means reporting to the EPA every two years under section 305b of the Clean Water Act and development of an Impaired Waters List under section 303d

[63] Section 455B.193 thru 455B.195 of the 2001 Iowa Code. See https://programs.iowadnr.gov/adbnet/Docs/Codex/credible%20data%20law

[64] See https://programs.iowadnr.gov/adbnet/Segments/954/Assessment/2018 for Squaw Creek and https://programs.iowadnr.gov/adbnet/Segments/947/Assessment/2020 for East Indian Creek. Note that the 2018 assessment for streams is based on 2016-2018 data.

[65] Ambient Water Monitoring Strategy for Iowa: 2016-2021. http://publications.iowa.gov/23682/

[66] Draft Methodology for Iowa's 2020 Water Quality Assessment. https://programs.iowadnr.gov/adbnet/Docs/Publications

Recreational Uses

E. coli, a bacteria present in the guts of warm-blooded animals, is an indicator of fecal contamination from human waste, wildlife, or livestock manure. *E. coli* in the water is linked to a risk of waterborne illnesses. For evaluating whether recreational uses of lakes and rivers are impaired by fecal contamination, the following criteria are used (Table 11). The geometric mean is calculated to represent typical conditions across the recreational season. A separate criteria is used for evaluating a single sample.

Table 11: Water quality criteria for indicator bacteria, from Iowa DNR (2020 draft methodology)

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

Secondary contact recreation involves incidental or accidental contact with water, where the risk of ingesting water is minimal. In addition to waters used for fishing and shoreline activities, this designated use has been applied to rivers that are used for canoeing and kayaking if the water is too shallow for sustained contact with water. Secondary contact recreation is the most permissive designated use that can be applied to a perennial stream. Stricter criteria are applied to waters designated for primary contact recreation such as swimming and water skiing, and waters used for recreation by children.

The same criteria can apply to both rivers and lakes, however the amount of data required varies (Table 12): beaches are monitored weekly, while rivers and non-beach parts of lakes only need to be monitored monthly. DNR and EPA has data completeness guidelines for determining whether there is sufficient data to make an impaired waters determination. If water quality does not meet the criteria, but there is insufficient data to make a determination, or data is not considered "credible," the water body may be placed on the Waters In Need of Further Investigation (WINOFI) list. It's unclear whether a locally-led water monitoring effort should expect to acquire this much data before interpreting results for non-regulatory purposes.

As shown in Table 12, recreational use of lakes is also assessed using trophic state index, an indicator of excessive algae growth. Recreational use of both rivers and lakes can be impaired by extremely acidic or alkaline water, as measured by pH in excess 9 or below 6.5. Both of these criteria are also used to evaluate aquatic life and are described in more detail in the next section.

South Skunk River

Table 12: Data completeness guidelines for evaluating recreational uses, from Iowa DNR (2020 draft methodology)

Designated Use	Type of Information	Data Required
Primary Contact Recreation	Data for levels of indicator bacteria (*E. coli*) from river waterbodies or non-beach areas of publicly-owned lakes or flood control reservoirs	Data collected monthly or more frequently during recreation seasons (March 15 through November 15); at least 7 temporally independent samples need to be collected per recreation season.
	Data for levels of indicator bacteria (*E. coli*) from beach areas of publicly-owned lakes and flood control reservoirs	Data collected approximately weekly during recreation seasons (March 15 through November 15).
	Data from the Iowa DNR-sponsored statewide lake surveys for chlorophyll a and Secchi depth	Data collected at least 3 times per summer for at least 3 years (minimum of 9 samples).
	Data from Iowa DNR-sponsored snapshot monitoring	Data from at least 10 recreation season sampling events (i.e., 10 independent samples) over a five-year period.

Two lakes in Story County have public swimming beaches.

- Hickory Grove Lake
- Peterson Park Lake

Hickory Grove Lake is on the Impaired Waters List due to high bacteria and algal growth. After completion of restoration work, monitoring by Iowa DNR will resume to evaluate progress toward its Total Maximum Daily Load (cleanup plan). Peterson Park Lake was last monitored in 2007, but this was discontinued because *E. coli* counts were quite low. This lake is mostly fed by groundwater rather than surface runoff, which may explain the good water quality. In order to meet the same data completeness guidelines as the Iowa DNR, we would need to monitor weekly. However, even infrequent monitoring might be reassuring for the public, and preferable to no monitoring.

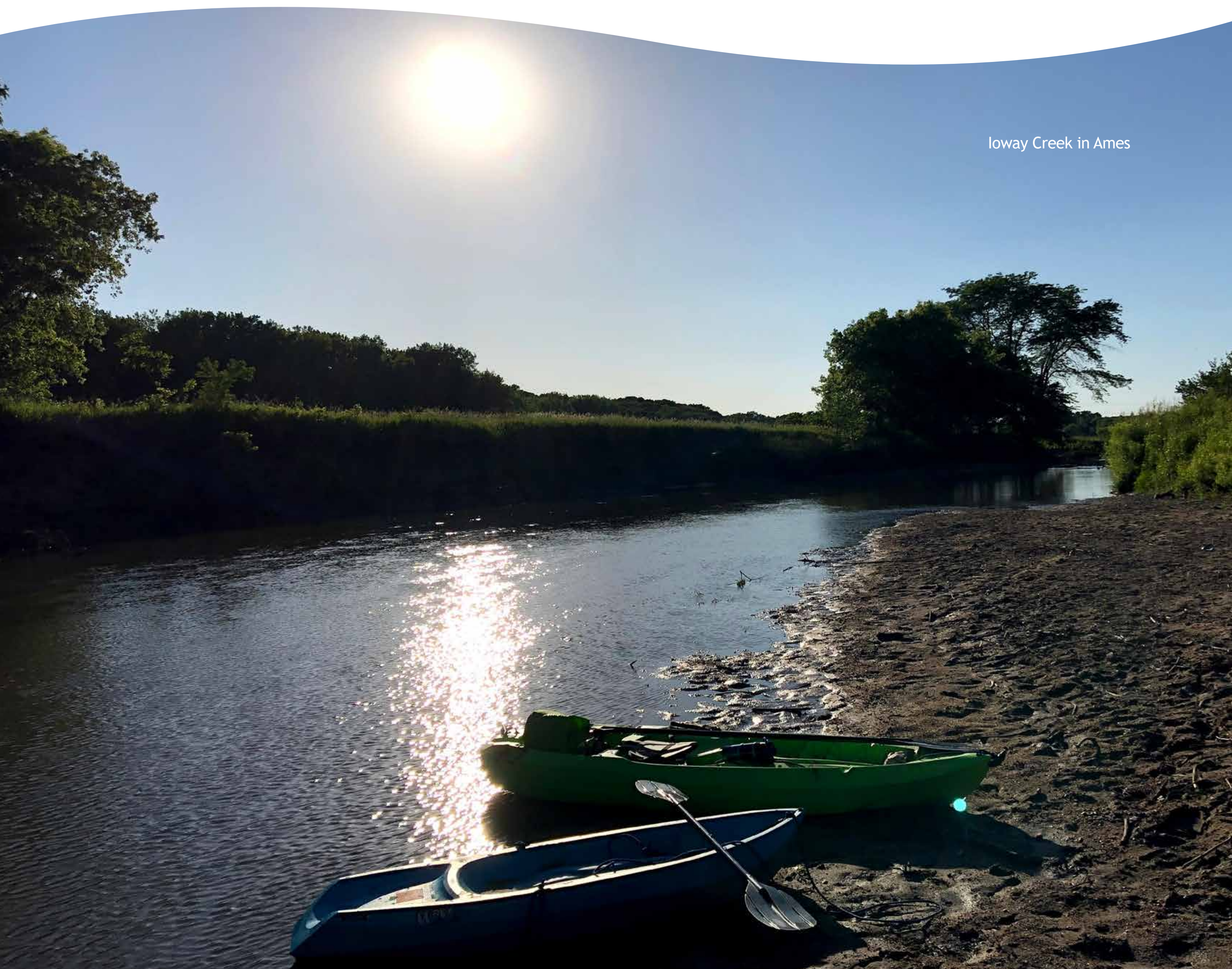
For rivers and lakes without a swimming beach, to evaluate recreational uses with the same completeness guidelines as the Iowa DNR, we would need to collect 7 monthly samples between March 15 and November 15 of a given year.

Up until the 2018 Impaired Waters List, the Iowa DNR had monitored and assessed *E. coli* in only three Story County water bodies. As of December 2020, local partners have collected enough *E. coli* data to evaluate recreational use in 9 additional stream reaches that were never previously assessed (Table 13). All 9 exceed the criteria for primary contact recreation.

Ioway (Squaw) Creek and East Indian Creek were monitored biweekly in 2016, 2017, and 2018. This data was submitted to DNR for incorporation into the 2018 and 2020 assessment cycles. The City of Ames collected 7 monthly samples in 2019 for Clear Creek, College Creek, and Worrell Creek[67]. In 2020, local partners collected 7 monthly samples for Keigley Branch, Bear Creek, Long Dick Creek, and two locations on West Indian Creek[68]. Results are shown in Figure 17. Fewer than seven samples were collected from Ballard Creek, Clear Creek, and Worrell Creek in 2020 due to dry conditions, but single samples did sometimes exceed the primary contact recreation criteria. This data can be submitted to DNR for inclusion in the 2022 Integrated Report. More importantly, it can be used by local partners to educate the public and inform conservation efforts.

[67] https://www.cityofames.org/government/departments-divisions-i-z/water-pollution-control/urban-stream-monitoring

[68] https://rpubs.com/dhaugprrcd/newsletter-2020-09



Ioway Creek in Ames

Table 13: Monitoring and assessment of Story County waters for recreational uses

HUC12	ABDNet Segment	Geographic Name	Designated Use[69]	Monitored and assessed by DNR	Monitored by local partners
070801050305	6295	Onion Creek	*		
070801050307	6286	Worrell Creek	*		2019
	954	Squaw Creek	A1		2016-2020
	955	College Creek	*		2019-2020
	956	Clear Creek	*		2019
070801050401	960	Long Dick Creek	*		2020
070801050403	958	Bear Creek (lower)	A2		
	959	Bear Creek	*		2020
070801050405	957	Keigley Branch (lower)	*		2020
	1791	Keigley Branch	*		
070801050406	933	South Skunk River	*		
	934	South Skunk River	A1	2012-2014	
	939	McFarland's Pond	-		
070801050502	949	West Indian Creek	A2		2020
070801050602	6298	Drainage Ditch #81	*		
	6629	Unnamed Tributary to East Branch Indian Creek	*		
070801050603	6249 6466	Unnamed Tributary to Dye Creek	*		
		Dye Creek	*		
	948	Dye Creek (lower)	A1		
070801050604	947	East Indian Creek	A1		2016-2020
	950	Hickory Grove Lake	A1	2014-2018	
070801050701	6502	Clear Creek	*		
	6503	Willow Creek	*		
	6504	Unnamed Tributary to Willow Creek	*		
070801050702	946	Mud Creek	*		
070801050801	943	Indian Creek	A1		
070801050802	6626	Wolf Creek	*		
070801050901	953	Walnut Creek	*		
070801050902	952	Ballard Creek (lower)	A3		2020*
	3053	Ballard Creek	A2		
070801050903	932	South Skunk River	A1		
	931	South Skunk River	A1	2016-2020	
070802070802	6284	South Minerva Creek	*		
070802070803	740	Dakin Lake	-		
070802070804	739	Minerva Creek	A2		
070802080101	733	Linn Creek	*		
071000080101	3031	Fourmile Creek	A2		

[69] A1 – Primary contact recreation, A2-Secondary contact recreation, A3- Children's recreation, * presumed A1

Aquatic Life Uses

The following categories of information are used to evaluate aquatic life in lakes or streams (Table 14).

Table 14: Data completeness guidelines for evaluating aquatic life uses, from Iowa DNR (2020 draft methodology)

Designated Use	Type of Information	Data Required
Aquatic Life	Data for toxic parameters in waterbodies	A minimum of 10 samples is needed for Fully Supported. A minimum of 2 samples is needed for Not Supported.
	Data for conventional parameters (DO, pH, temp., ammonia)	A minimum of 10 samples is needed.
	Data from Iowa biological sampling	At least two valid fish index of biotic integrity (IBI) or macroinvertebrate IBI's for calibrated segments sampled during the most recent 5 complete calendar years (see Attachment 2 for more information).
	Data from Iowa DNR-sponsored statewide lake survey	Data collected at least 3 times per summer for at least 3 years (minimum of 10 samples).

DNR primarily assesses aquatic life directly by surveying fish and aquatic macroinvertebrates, calculating an index, and then comparing the index to high quality reference sites in the same region[70]. The procedures and indexes used are more complicated than the volunteer invertebrate sampling protocol used by the Save Our Streams programs, but the principle is the same. Note that DNR has not yet set guidelines and benchmarks for interpreting data from headwaters streams—defined as having a watershed area of less than 10 square miles, and small enough to sample with one backpack shocker—and so aquatic life uses for many of these streams are categorized as "potentially impaired, based on an uncalibrated index." Regardless of water quality, small streams tend to support a more limited variety of fish and aquatic life due to lack of habitat or limited flow for at least part of the year.

There are aquatic life criteria for several of the water quality parameters routinely monitored by volunteers (Table 15). The thresholds generally represent levels that are chronically or acutely toxic for aquatic life, and are rarely encountered in the field. Dissolved oxygen is the parameter that most commonly falls below the criteria. However, it is important to understand that dissolved oxygen has a daily and seasonal cycle—problems are only likely to be detected if monitoring occurs in the morning during the late summer and fall. While volunteers do measure water temperature, the criteria deal with temperature changes caused by effluent, and so would require a special monitoring setup to evaluate.

[70] https://programs.iowadnr.gov/bionet/Docs/About

Table 15: Aquatic life criteria for water quality parameters included in Save Our Streams protocol

Parameter	Criteria	Number of Story County samples in IOWATER database not meeting criteria
pH (acidity/alkalinity)	< 6.5 or > 9	5 of 2778 have a pH of 4 or 5 45 of 2778 have pH of 6
Dissolved oxygen (24 hour minimum)	<= 4 mg/L (B-WW2) <= 5 mg/L (B-WW1 and BLW)	29 of 2362 61 of 2362
Chloride	389 mg/L	5 of 2203

The secchi tubes used by volunteers to monitor water clarity in streams are not linked to any formal water quality criteria. However, water clarity in lakes (as measured with a secchi disk) and total suspended solids (a laboratory measure of sediment load) are used in combination with other factors to evaluate aquatic life in lakes.

Toxicity criteria for aquatic life include 10 metals (such as copper) and 5 banned pesticides (such as DDT).

Ammonia criteria are dependent on the pH and temperature of the water body and will not be reproduced here. Ammonia and biological oxygen demand are associated with wastewater and often monitoring by wastewater treatment plants as a condition of permits. High levels of ammonia and biological oxygen demand can also be associated with manure, but spills and runoff-producing events are typically short-lived and difficult to monitor.

Fish collection and identification at a DNR training event


Algae bloom in Keigley Branch

Algae blooms and algal toxins caused by nutrient enrichment are a concern in many lakes. Iowa has not established numeric criteria for either phosphorus (a cause of algae blooms) or microcystin (a toxin produced by cyanobacteria). However, criteria have been developed for trophic state index (TSI), to evaluate whether excessive algae growth is limiting A1 (primary contact recreation) and BLW (Lake Aquatic Life) uses in shallow lakes. Trophic state index incorporates *chlorophyll a* (a measure of algae growth), total phosphorus (a plant nutrient that leads to algae growth) and secchi depth (a measure of water clarity). This data is already being collected for Hickory Grove Lake as part of the Ambient Lake Monitoring Program. Detailed studies have also been conducted at Ada Hayden Lake. In order to calculate and evaluate trophic state for McFarland Lake, Peterson Lake, or Dakins Lake using the same data completeness guidelines as the DNR, we would need to measure *chlorophyll a,* total phosphorus, and secchi depth at the deepest point in the lake at least 3 times a year for three years.

> *The threshold levels at which plant nutrients cause problems in Iowa's surface waters have not yet been identified. Thus, the Iowa Water Quality Standards does not contain water quality criteria for either levels of phosphorus or nitrogen related to protection for primary contact recreation (Class A) or for aquatic life (Class B) beneficial uses.*
>
> – Iowa DNR, 2020 Draft Assessment Methodology, p. 93

The 10 mg/L nitrate criteria only applies to surface waters that are used as a source of drinking water. The South Skunk River and other surface waters in Story County are not used for drinking water. Iowa has not established numeric nutrient criteria to evaluate aquatic life and recreational uses in lakes and streams. This has been a controversial topic, in part because the science questions about the biological relevance of the criteria are mixed up with policy questions about how criteria can and should be enforced.

There is good science showing the connection between nutrients and algal growth in lakes, but the situation in streams is more complicated.

- Algae growth in streams is not well correlated to nutrient concentrations in part because light and temperature are usually the limiting factors, in part because algae use up nutrients in the stream as they grow. The Nutrient-Algal Biomass Conceptual Model can help explain this variation[71].

- Fish and invertebrate diversity in streams is only weakly correlated to nutrient concentrations, in part because habitat, sediment, and pesticides can be a greater influence[72].

- EPA proposed draft criteria[73] in 2000 for nutrients in rivers and streams, by ecoregion. Criteria are based on the 25th percentile of all waters and years monitored. This is intended to represent "conditions in surface waters that are minimally impacted by human activities and are protective of aquatic life and recreational uses." They are not necessarily a threshold at which something changes, or a goal that could be realistically achieved in a heavily developed or agricultural watershed.

- In 2013, the Iowa DNR studied the connections between nutrient enrichment and aquatic life in Iowa streams and found several factors that, in combination, indicated nutrient enrichment and a degraded aquatic community. Draft criteria[74] were proposed for several classes of streams. These were rejected for official use, but could still be useful for reference. No criteria were proposed for headwater streams (with a watershed of less than 10 square miles) because biological indexes have not yet been set for comparison.

[71] USGS Circular 1437. Understanding the influence of nutrients on stream ecosystems in agricultural landscapes. https://pubs.er.usgs.gov/publication/cir1437

[72] The Midwest Stream Quality Assessment, 2012. https://pubs.er.usgs.gov/publication/fs20123124

[73] For the ecoregion including central Iowa, these are found at https://www.epa.gov/sites/production/files/documents/rivers6.pdf

[74] https://www.iaenvironment.org/webres/File/Appendix%20B(1).pdf

- Both DNR and EPA draft criteria were based on total phosphorus. Volunteers typically measure only orthophosphate, so could check whether a stream exceeds the criteria, but not whether streams met the criteria, as they would not be measuring organic-bound or sediment-bound forms. A similar situation exists for nitrate vs total nitrogen[75]. Given the high levels of nitrate and phosphorus in our area, this may not be an issue, at least in the next 10 years.

- DNR proposed that a combination of nutrients (i.e. total phosphorus) and response variables (i.e. algae coverage) be assessed using the median of monthly samples collected from June 15 to October 15. EPA did not include guidelines for number or frequency of samples, as they intended that States or Tribes would fill in these gaps.

Stream Designation	Parameter	Acceptable Level	Season
B(WW1), B(WW2), (Watershed Area 10-700 mi^2)	Total Kjeldahl Nitrogen (TKN)	Median sample value $\leq$ 0.80 mg/L	June 15 – Oct. 15
	Total Phosphorus (TP)	Median sample value $\leq$ 0.10 mg/L	June 15 – Oct. 15
	Dissolved Oxygen Diel Range	Median daily range (maxima-minima) $\leq$ 5 mg/L	July 1 – Sept. 15
	Filamentous Algae Coverage Rating	Median rating $\leq$ 3 (50-75%)	June 15 – Oct. 15
	Seston Algal Chlorophyll A	Median sample value: $\leq$ 5.0 µg/L (Watershed Area $\geq$10-25 mi^2) $\leq$ 10.0 µg/L (WA >25-100 mi^2) $\leq$ 15.0 µg/L (WA >100-300 mi^2) $\leq$ 20.0 µg/L (WA >300-700 mi^2)	June 15 – Oct. 15

Figure 21: Draft nutrient enrichment criteria[76] for wadeable warmwater streams

However, there are related metrics that can be compared to state standards.

- In streams, swings in dissolved oxygen can be measured by sampling multiple times in a day, or by deploying a continuous sensor. Aquatic life uses are not fully supported if the daily swings are greater than 5 mg/L, or dissolved oxygen drops below 5 mg/L.

Our best understanding of how water quality influences aquatic life in streams comes from the Midwest Regional Stream Quality Assessment[77]. This detailed study by the USGS and EPA examined dozens of different metrics in 100 streams across the Midwest (including one stream in Story County) to determine which best predicted the composition of the fish, invertebrate, and algae communities.

[75] EPA included reference criteria for total nitrogen, inorganic nitrogen (nitrate + nitrite), and total kjeldahl nitrogen. DNR draft criteria focused on Total Kjeldahl Nitrogen (organic nitrogen plus ammonia).

[76] Iowa DNR drafted recommendations for numeric nutrient criteria in August 2013 that were not adopted. https://www.iaenvironment.org/webres/File/Appendix%20B(1).pdf

[77] https://webapps.usgs.gov/rsqa/img/region/MSQA/factsheet2.pdf

- Fish species loss was best predicted by total nitrogen and fine sediment covering the streambed.
- Invertebrate species loss was best predicted by habitat degradation (including fine sediment, riparian condition, and channel shape), ammonia, and pesticides (in particular bifenthrin, a pyrethroid insecticide).
- Sensitive algae species were lost in streams with more fine sediment, warmer water, and herbicides like atrazine.

For educating the public or improving fisheries, a scorecard approach that looks at multiple factors might be better than trying to interpret single metrics in isolation. We can certainly use the scorecard from the Story County stream included in the study to help educate the public (Figure 22). However, we would need to consult with USGS scientists to determine if and how their complex methods could be adapted for use by a locally-led monitoring program in evaluating other streams.

Site Scorecard

Unnamed Trib To East Br Indian Creek near Zearing, IA

Site Sampled May 2013 - Oct 2013

	Metric	Value	Unit	Score
Water - Nutrients and Dissolved Oxygen				
Info	Total Nitrogen	19.35	mg/L	High
Info	Total Phosphorus	0.25	mg/L	High
Info	Daytime Dissolved Oxygen Minimum	4.85	mg/L	Low
Water - Contaminants				
Info	Predicted pesticide toxicity to invertebrates/cladocerans (PTI)	0.05	Normalized toxicity units	Low
Sediment - Contaminants				
Info	Benchmark quotient (BQ5)	0.69	Normalized toxicity units	Medium
Info	Pyrethroid pesticides	Medium	See Info	Medium
Habitat				
Info	Riparian Developed	22%	Percentage of riparian buffer	Medium
Info	Percent Fine Sediment	73%	Percentage of ecological reach	High
Ecology				
Info	Macroinvertebrate MMI	39.27	Scaled 1 to 100	Fair
Info	Fish MMI	46.06	Scaled 1 to 100	Poor

Figure 22: Scorecard for a Story County stream in the Midwest Stream Quality Assessment

Other Uses

Iowa DNR assesses the safety of fish consumption by testing fish tissue for mercury, PCBs, and other harmful chemicals that have the potential to accumulate[78]. Bacteria in the water does not pose a risk if fish are properly handled and cooked. Nitrate in the water is not a concern for fish consumption. Of the three water bodies in Story County designated Human Health (HH) for regular fish consumption, only one (Hickory Grove Lake) has recently been monitored. Fish in the South Skunk River were safe the last time they were tested, but the data is now over 10 years old. Fish have not been tested in Dakins Lake.

Additional water quality criteria are used to evaluate lakes and rivers that supply drinking water, but no water bodies in Story County have this designated use (Class C).

[78] https://www.iowadnr.gov/environmental-protection/water-quality/water-monitoring/fish-tissue

Detecting Changes Over Time

Measuring Changes in Water Quality

In order to determine whether water quality is improving, we need a baseline measure of water quality. However, since water quality monitoring typically involves small samples (12-24 measurements per year) that baseline may not be very precise[79].

> **The margin of error associated with most water quality averages after 2-5 years of monitoring exceeds 10 percent. As a result, we cannot reasonably expect to detect changes in water quality unless those changes are very large, monitoring is sustained over a long period, or both.**

For example, based on 43 samples collected from 2016-2018, nitrate in East Indian Creek averaged 6.7 mg/L from 2016-2018, plus or minus 15%. If we monitor for another three years and measure an average of 6.0 mg/L nitrate, we cannot be certain there has been any improvement. Phosphorus and total suspended solids are even more variable, so have higher margins of error (Figure 23). Total phosphorus in East Indian Creek averaged 0.23 mg/L, plus or minus 25%. Total suspended solids in East Indian Creek is 177 mg/L, plus or minus 50%.

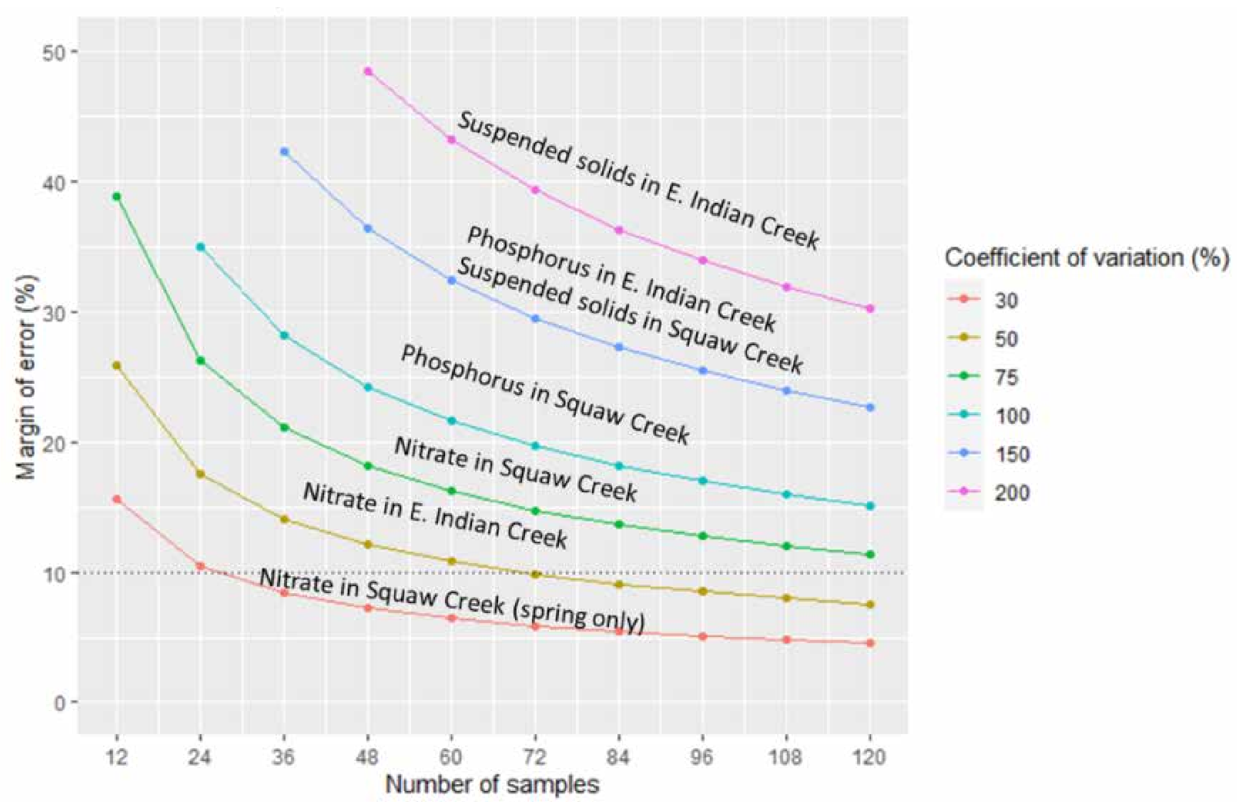


Figure 23: Precision of 2016-2018 water quality baseline, at 90% confidence level

[79] For a polling analogy that explains the statistical concepts involved, see https://www.prrcd.org/too-close-to-call/

The same statistical logic applies to detection of gradual trends. If we were on track to reduce nitrate in the South Skunk River by 40% in 10 years[80], it's unlikely we'd be able to measure a statistically significant improvement after 5 years, even with weekly sampling (see Figure 24). At best, we can distinguish between a large improvement and no improvement after 8-10 years. **While this will disappoint stakeholders who expect quicker and more conclusive results, long-term monitoring is still worth doing.**

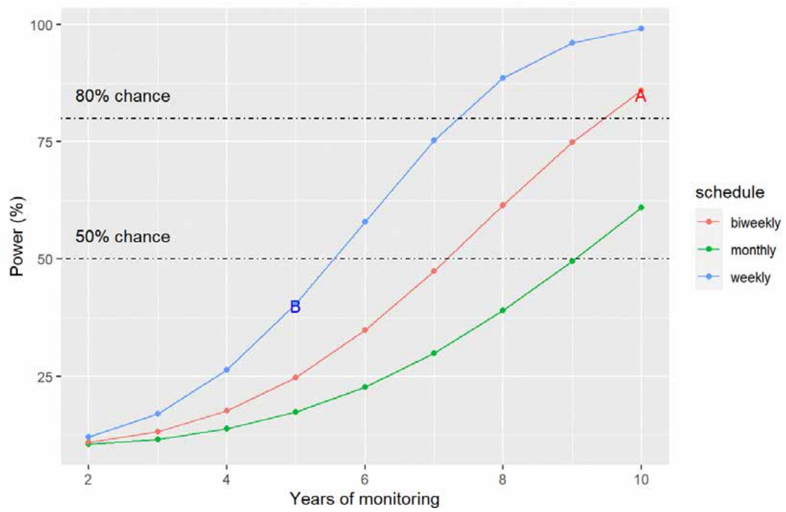


Figure 24: Power curve for nitrate in the South Skunk River. Chance of detecting a 0.36 mg/L per year trend (40% nitrate reduction in 10 years) at 90% confidence.

The statistical approach used here, called "power analysis," is mostly used to plan medical trials but has been adapted for water quality monitoring programs[81]. If trend detection becomes a priority for local partners, we can use this approach to evaluate the feasibility of site-specific monitoring proposals with one of two methods:

A. Determine what monitoring schedule (number of samples) is needed to reliably determine if water quality has improved, given some thresholds for trend size and certainty.
B. Determine how large a trend we can detect or how precisely we can measure a trend, given some monitoring schedule.

Water trends can be detected in less than a decade if the changes are large enough. For example, based on data collected by the City of Ames, nitrate in the South Skunk River has declined by 5.8 mg/L in the past 7 years. The trend is large enough to be statistically significant with monthly sampling. Unlike the phosphorus example in Figure 20, no matter which day of the week we happen to sample, a decline can be observed (Figure 25).

[80] At current rates of progress, we would not expect to meet Iowa Nutrient Reduction Strategy goals in 10 years. See Iowa Environmental Council. 2019. "The Slow Reality of the NRS." https://www.iaenvironment.org/newsroom/water-and-land-news/iec-analysis-the-slow-reality-of-the-nrs

[81] Jon B. Harcum and Steven A. Dressing. 2015. Technical Memorandum #3: Minimum Detectable Change and Power Analysis, October 2015. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 10 p. Available online at https://www.epa.gov/nps/nonpoint-source-monitoring-technotes

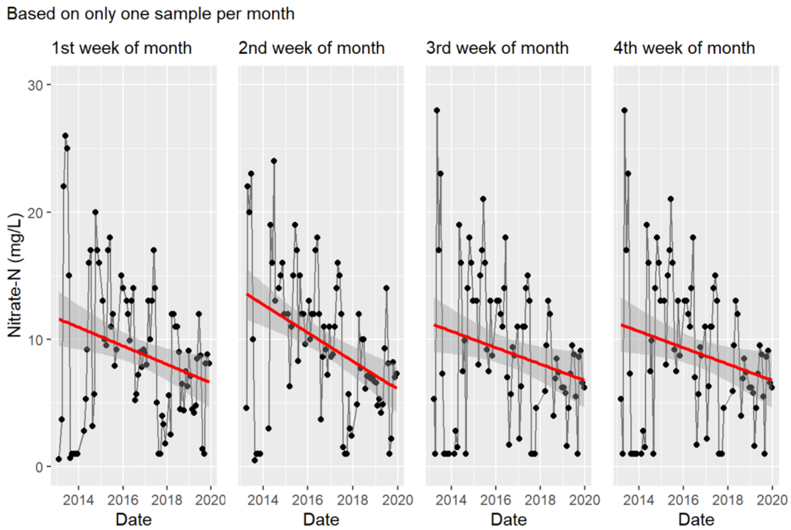


Figure 25: A decline in nitrate in South Skunk River, 2013-2020, holds up after accounting for sampling error

If trends are large enough, they can also be detected by volunteer monitoring. The IOWATER and Save Our Streams programs used test kits with coarse measurement scales—for example, Hach nitrate strips measure at increments of 1, 2, 5, 10, and 20 mg/L. In principle, this could further limit the ability to detect subtle trends—as a strip could not distinguish between 10 and 8 mg/L. However, after reviewing data from sites that volunteers with the Ioway (Squaw) Creek Watershed Coalition monitored monthly for at least 5 years, we found trends similar to those observed in the South Skunk River with lab tests (Figure 26). Trends from three of the six sites were statistically significant, at the 90% confidence level.

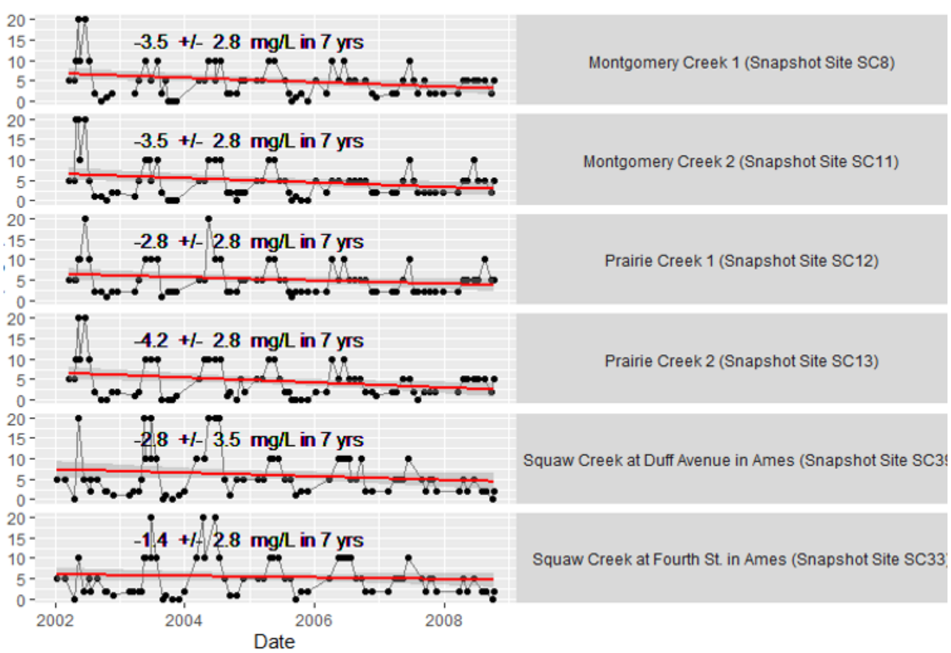


Figure 26: Nitrate trends and 90% confidence intervals, 2002-2008, as measured by IOWATER volunteers

Attribution of Changes in Water Quality

If water quality improves, is it because of conservation practices in the watershed, the weather, or some other factor?

Statistical analysis can help to isolate different influences. Prairie Rivers of Iowa used a multiple linear regression model to explain over half the variation in nitrate concentrations in the South Skunk River using the current year's weather, last year's weather, and season[82]. Nitrate concentrations are lowest in a drought (such as occurred in summer of 2012) and highest in a wet spring following a drought (such as spring of 2013). After accounting for those factors, there is still a 2.5 mg/L decline since the peak in 2013, but the longer-term trend disappears (Figure 27).

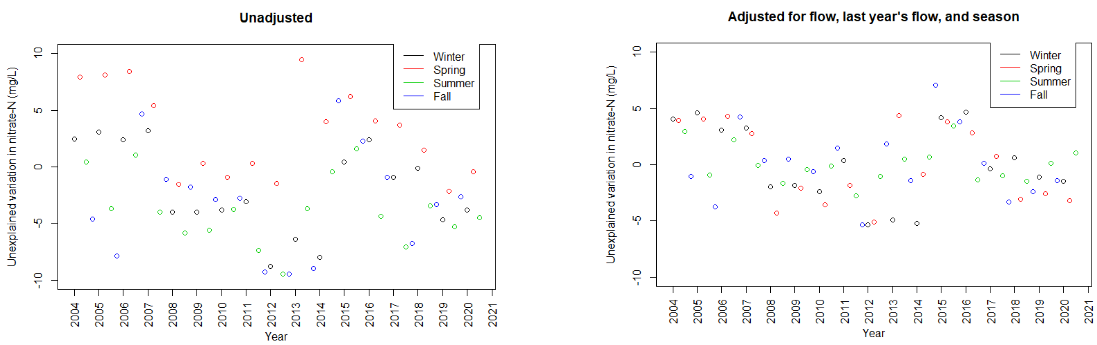


Figure 27: Attribution of trends in the South Skunk River using multiple linear regression

The gold standard for tracking changes and attributing them to conservation is a paired watershed study[83]. Much like a medical trial, water quality is measured in both a treatment watershed (which receives conservation practices) and a control watershed (which does not). If both watersheds get similar weather, and water quality in the treatment watershed improves more (or worsens less) than the control watershed, we can attribute that improvement to the conservation practices. This is not without challenges—for Lyon's Creek watershed in Hamilton County, baseline data from three drain tiles were collected, but the study could not be completed because so few conservation practices were installed. Iowa State University is completing a study of cover crops in paired watersheds of 500 to 1300 acres in size (Figure 28), including two sites in Story County[84].

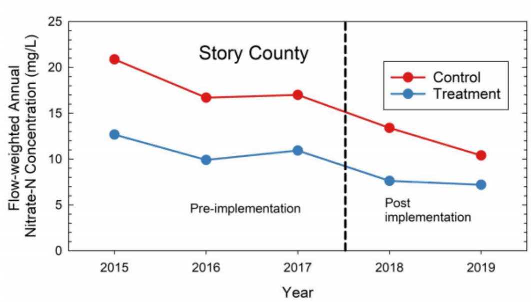


Figure 28: Preliminary results from paired watershed study by Iowa State University Conservation Learning Labs

[82] Blog Post: "Weather Whiplash." https://www.prrcd.org/weather-whiplash/

[83] Steven A. Dressing and Donald W. Meals. 2005. Designing water quality monitoring programs for watershed projects, Tech Notes 2, July 2005. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 20 p. Available online at https://www.epa.gov/nps/nonpoint-source-monitoring-technotes.

[84] https://www.iowalearningfarms.org/conservation-learning-labs

The difficulty in using water monitoring to track progress is acknowledged in planning documents for the Iowa Nutrient Reduction Strategy, but is still not widely appreciated. A water monitoring framework released with the Iowa Nutrient Reduction Strategy[85] suggests that measuring changes at the scale of HUC12 or larger watersheds will take decades. The paper cites the following challenges to watershed-scale assessments of management practices:

- "Legacy nutrients" accumulated in soils and groundwater
- Lag time between conservation practice adoption and water quality improvement
- Limited data on extent of conservation practices in the watershed
- Extreme weather events, exacerbated by climate change
- Selection of appropriate locations for monitoring in a watershed
- Variable precipitation and streamflow
- Sustaining long-term data collection

Understand the Influence of Land Use and Land Management

Comparing water quality at multiple sites can help us prioritize focus areas within a larger watershed conservation effort. Total Maximum Data Load (TMDL) studies are a good example of how this can be done. A TMDL is a cleanup plan that usually involves some combination of modeling and monitoring to narrow down sources of pollutants and determine how water quality goals could be achieved[86].

Computer models such as SWAT and SPARROW are helpful in formalizing our expectations for water quality based on the results of previous studies about the effects of land use, soils, and other influences in the watershed. Water monitoring can then test our expectations and reveal additional influences not captured in the model.

[85] Stream Water-Quality Monitoring in Support of the Iowa Nutrient Reduction Strategy. Aug 2016. Iowa DNR, IDALS, ISU, and IIHR. http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/Water%20Monitoring%20and%20the%20NRS%20_%20Final%208-24-16.pdf

[86] https://www.epa.gov/waterdata/surface-water-quality-modeling

For example, in the scientific literature, agricultural land has been found to release much more nitrogen and phosphorus to streams than urban land or woodland. Using landcover-based nutrient coefficients, as was done in the Story Countywide Watershed Assessment, we would expect a stream like Long Dick Creek with an intensively-farmed watershed to have higher nitrate and phosphorus concentrations than streams like College Creek and Worrell Creek with a more urban watershed (Figure 30). To some extent, the pattern in the water monitoring data from spring[87] of 2020 matches our expectations (Table 16).

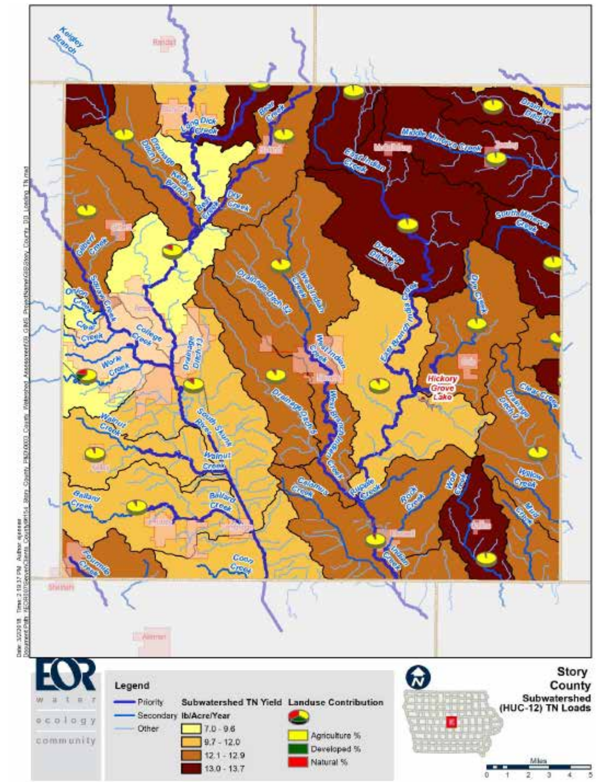


Figure 30: Modeled nitrogen loads based on landcover coefficients, reproduced from Story Countywide Watershed Assessment

Table 16: Monitoring data from spring 2020, compared to 2011 landcover in the watershed (using NHDPlus)

Site	% watershed in cropland	% watershed impervious surfaces	Nitrate Apr-Jun 2020	Phosphorus Apr-Jun 2020
Long Dick Creek @ 567th St	90	<1	15.0	0.14
West Indian Creek @ Jennett Heritage Area	83	2	11.0	0.34
Ioway Creek @ Brookside Park	83	1	12.0	0.18
Worrell Creek @ S 16th St	73	3	9.4	0.10
Clear Creek @ Emma McCarthy Lee Park	71	5	11.5	0.11
College Creek @ Sheldon Ave	24	23	5.3	0.10

However, West Indian Creek has much higher phosphorus concentrations than would be expected based on landcover alone—possibly because of the influence of treated effluent from the Nevada Wastewater Treatment Plant, bank erosion, or untreated stormwater. Water monitoring data helped to support a successful grant application by the City of Nevada in 2020 that could address some of these issues.

[87] In summer and fall of 2020, many streams dried up or were very low, so we have focused on the April to June period.

It is also important to recognize that HUC12 hydrologic units (while convenient for GIS mapping) are not always complete watersheds, and do not always match up with monitoring locations. Ioway (Squaw) Creek at Brookside Park drains about 140,000 acres which includes 6 upstream HUC12 units. Clear Creek, College Creek, and Worrell Creek are also located in the Worrell-Squaw Creek HUC12, but College Creek is a much more urban watershed and has much lower nitrate concentrations than the other two creeks (See Table 16). Fortunately, there are applications available that can analyze landcover, soils, and other information for a custom watershed that better matches a monitoring site[88].

A pitfall to avoid is making uncorrected comparisons between sites that were monitored on different schedules. While the streams in Table 16 were monitored during the same year and no more than a week apart, larger data sets can include streams that were monitored more or less often during certain seasons or weather conditions. For example, the Ioway (Squaw) Creek Watershed Management Plan included a table of all the volunteer data collected between 2000 and 2013. Some streams, especially those in the lower part of the watershed, were monitored regularly for the whole period. Other streams, especially those in the upper part of the watershed, were monitored for a shorter period, which happened to include years with lower-than-average nitrate concentrations. This apples-to-oranges comparison skewed the overall averages for some sites (See Figure 31) and perhaps explains why water monitoring results did not match the SWAT model, which predicted high nutrient loads in the upper part of the watershed.

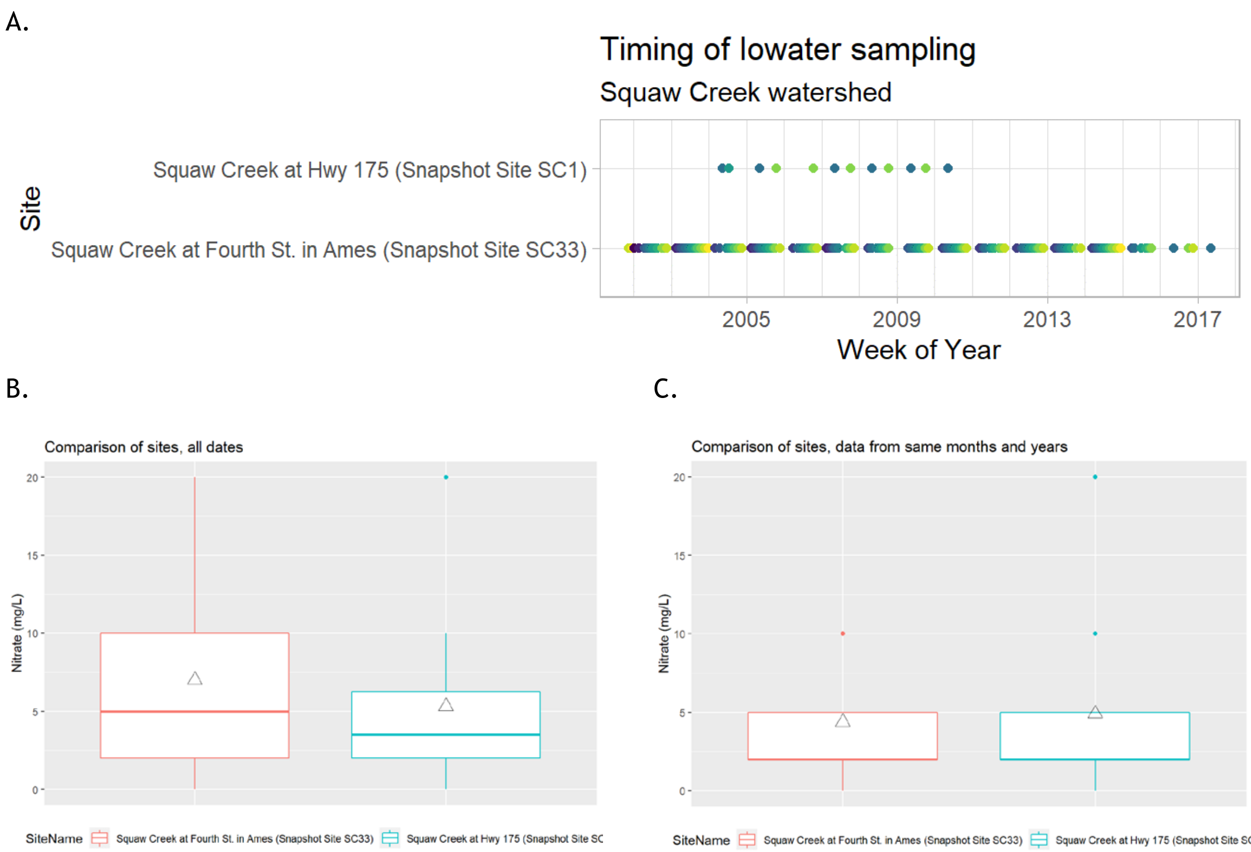


Figure 31: Comparisons between sites sampled on different schedules can be misleading. A) SC1 was monitored less often than SC33, and only during a period when nitrate concentrations were lower than average B) which makes both mean (triangle) and median (centerline of box) nitrate concentrations at SC1 appear lower than SC33 if we average all available data, C) but there is no difference if we look at only those months when both sites were monitored.

[88] https://modelmywatershed.org/ and https://www.epa.gov/national-aquatic-resource-surveys/streamcat-dataset-0

Long Dick Creek

Water quality monitoring can shed light on how particular land management practices within urban or rural areas can influence water quality. The planning committee felt that it was important that monitoring not be used to point fingers at individual landowners or businesses, as this could discourage participation in voluntary monitoring and conservation programs. However comparisons between urban and rural watersheds, or watersheds with more or less cover crops, streams with and without buffers, or watersheds with more or less livestock can help us to understand how the role of these factors in aggregate.

For example, a recent study found that differences in livestock populations and overall nitrogen application rates between the Floyd River and North Raccoon River watersheds could explain differences in water quality, as measured with 19 years of monthly nitrate samples[89]. Some of the streams we are monitoring (i.e. Long Dick Creek, Keigley Branch, West Indian Creek) have higher livestock populations in their watersheds than others (i.e. Grant Creek, Dye Creek) so it will be possible to make similar water quality comparisons to answer questions about the role of concentrated animal feeding operations without singling out individual farms. We may already have relevant data. Walnut Creek watershed in Story County was the subject of long-term monitoring for multiple research projects as part of the Conservation Effects Assessment Project by the USDA-ARS[90]. The watershed is intensively farmed but has almost no livestock. Another watershed in the research project, the South Fork of the Iowa River in neighboring Hardin County, is also located in the Des Moines Lobe but has a high concentration of swine facilities. One study comparing these two watersheds found higher concentrations of both indicator bacteria and pathogens in the South Fork[91]. The CEAP also has information about the impact of conservation practices in these watersheds.

[89] Jones, Christopher, Philip Gassman, and Keith Schilling. 2019. "The Urgent Need to Address Nutrient Imbalance Problems in Iowa's High-Density Livestock Regions." Agricultural Policy Review 2019 (3). https://lib.dr.iastate.edu/agpolicyreview/vol2019/iss3/3.

[90] https://www.ars.usda.gov/anrds/ceap/ceap-home/.

[91] Givens, Carrie E., Dana W. Kolpin, Mark A. Borchardt, Joseph W. Duris, Thomas B. Moorman, and Susan K. Spencer. 2016. "Detection of Hepatitis E Virus and Other Livestock-Related Pathogens in Iowa Streams." Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2016.05.123.


Bear Creek

While there is plenty of research on the benefits of cover crops and other conservation practices at the field scale, there are fewer examples of success at the watershed-scale[92]. It is easy to understand why. Locally, despite four years of outreach efforts and several thousand acres of cost-shared cover crops and no-till, conservation projects were applied to less than 2% of the cropland in the Ioway (Squaw) Creek watershed, so any change in water quality would be too small to detect against background variation. However, an Iowa State University study in Story County is currently monitoring very small watersheds (500 to 1400 acres) where it was possible to plant the majority of the treatment watershed to cover crops[93].

In urban areas, golf courses are often assumed to be a major contributor of nitrogen. In Story County, there are few streams where golf courses make up more than a fraction of a percent of the watershed, which would make it difficult to assess their influence without monitoring ditches or shallow groundwater in an individual golf course. This has been done: a study of six randomly selected Iowa golf courses[94] found that shallow groundwater below golf courses had low nitrate concentrations compared to streams.

Finally, as an example of how volunteer monitoring and water quality snapshots can be used to educate the public about the role of weather, land use, and land management on water quality, see Prairie Rivers' "Watershed Matchup" series of blog posts[95], released for Watershed Awareness Month in 2019. A key message of the series is that all land uses have some influence on water quality and everyone can be part of the solution.

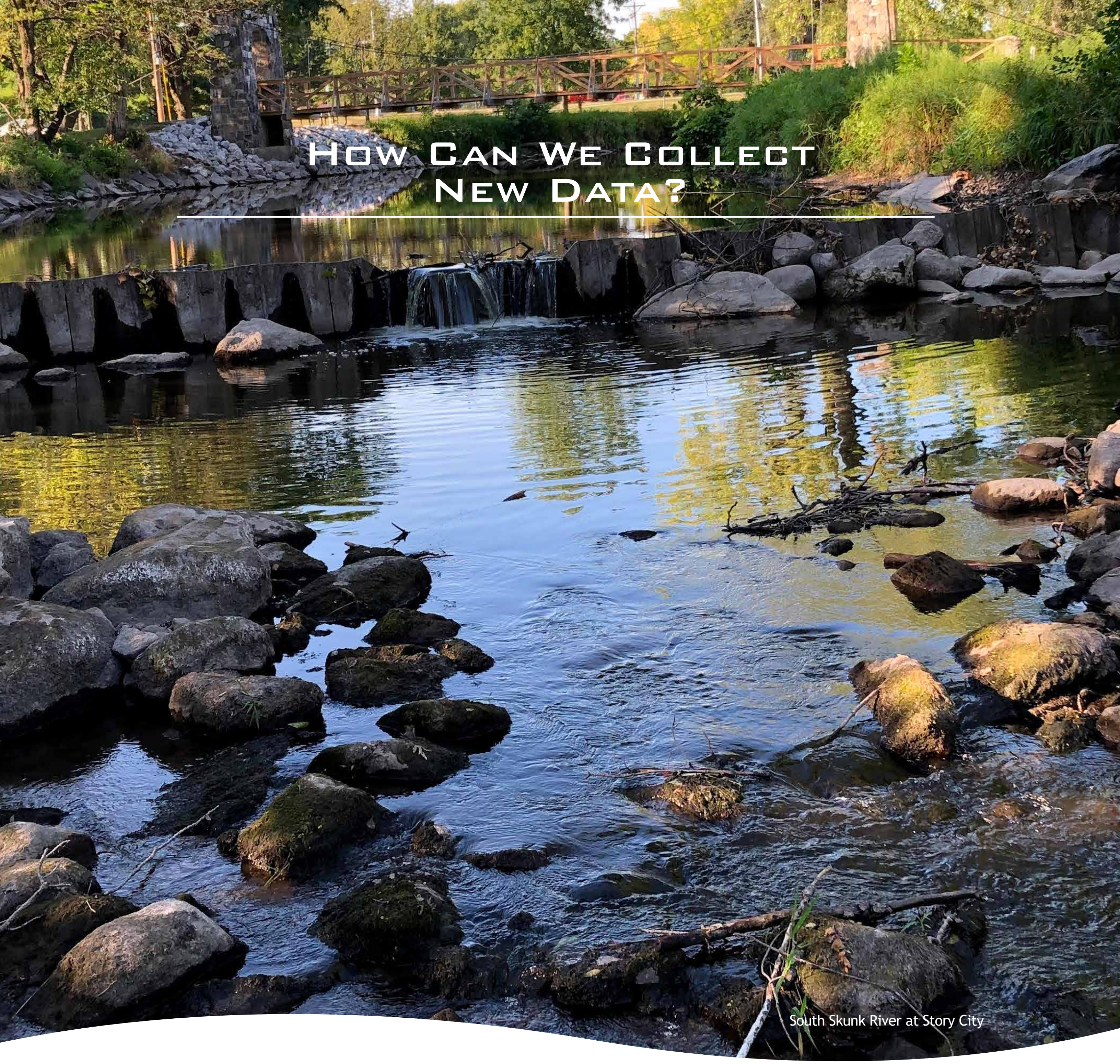
[92] Water Quality Targeting Success Stories. 2019. World Resources Institute. https://farmlandinfo.org/publications/water-quality-targeting-success-stories-how-to-achieve-measurably-cleaner-water-through-u-s-farm-conservation-watershed-projects/

[93] https://www.iowalearningfarms.org/conservation-learning-labs.

[94] Schilling, Keith E., and Matthew T. Streeter. 2018. "Groundwater Nutrient Concentrations and Mass Loading Rates at Iowa Golf Courses." JAWRA Journal of the American Water Resources Association 54 (1): 211–24. https://doi.org/10.1111/1752-1688.12604.

[95] https://www.prrcd.org/watershed-matchups/

How Can We Collect New Data?


South Skunk River at Story City

> *"Volunteer monitoring, lab testing, and data management all have to be part of the water monitoring program. It's like building a house, before you can hang the drywall, you've got to bring in subcontractors to lay the foundation and do the framing."*
>
> *-Jerry Keys, Environmental Education Coordinator, Story Conservation*

Monitoring by Conservation Agencies and Universities

As described in Chapter 3, the following sites are being monitored by other agencies. So long as this continues, our local efforts can focus elsewhere.

- South Skunk River at 280th Street is being monitored monthly by Iowa DNR for a large range of parameters as part of the Ambient Stream Monitoring Network.

- Walnut Creek has continuous nitrate sensors at two locations maintained by the USDA-ARS.

- Ioway (Squaw) Creek has a continuous nitrate sensor at Moore Park in Ames, maintained by IIHR—Hydroscience and Engineering.

Lake Monitoring

There are three elements to lake monitoring.

Beaches

To evaluate recreational safety at public swimming beaches, *E. coli* bacteria (an indicator of fecal contamination) is measured weekly during the recreational season (March 15 to November 15). Hickory Grove is monitored by Story County Conservation in partnership with the Iowa DNR. Story County Conservation will resume monitoring of Peterson Park Lake.

Trophic State

Hickory Grove Lake is monitored 3 times between May and September by Iowa State University on behalf of the DNR as part of the Ambient Lake Monitoring Program[96]. The Countywide Watershed Assessment called for monitoring other priority lakes using this same protocol.

The protocol includes the following three measurements at the deepest point in the lake. These are used to to calculate a trophic state index, which indicates whether recreational and aquatic life uses of lakes could be threatened by nuisance algae blooms.

- Secchi depth (a field measurement)
- Chlorophyll a (measured in the lab)
- Total phosphorus (measured in the lab)

[96] https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Ambient-Lake-Monitoring

Ada Hayden Lake

The City of Ames has commissioned detailed 2-year studies of the Ada Hayden Lake on a 5 year cycle[97]. The most recent study included biweekly water testing of both lake cells and three constructed wetlands from May thru October of 2017 and April thru September of 2018. Up to 26 water quality parameters were measured. Depth profiles were constructed for nutrients, temperature, and dissolved oxygen. Phytoplankton and zooplankton were also sampled and classified.

Streams Flowing to Lakes

Monitoring of streams, drainage systems, groundwater, and ditches flowing to lakes can reveal sources of pollution and opportunities for improvement to protect the lake. Intermittent streams flow to Dakins Lake, Ada Hayden Lake, Hickory Grove Lake, and McFarland Lake and all have been previously monitored by volunteers with the IOWATER program. Inflows to Hickory Grove Lake have also been monitored as part of the Total Maximum Daily Load study. Constructed wetlands that flow into Ada Hayden Lake have been monitored as part of studies commissioned by the City of Ames.

Volunteer monitoring of these lake inflows could resume with the support of Story County Conservation and other local partners. The Friends of Ada Hayden have already expressed interest in regular volunteer monitoring of wetland inflows and outflows at Ada Hayden Lake. If *E. coli* is a concern, lake inflows could be included in monthly monitoring routes for lab testing.

However, the timing and transport mechanism for pollutants needs further consideration. While nitrogen is commonly transported in baseflow, nitrogen is rarely the limiting nutrient in lakes. Phosphorus, sediment, and bacteria are usually carried in runoff. To effectively measure pollutants in runoff, it would be necessary to sample during rain events, or make use of samplers that can be retrieved after a storm.

In the case of Ada Hayden Lake, a previous study[98] found that a major source of phosphorus is dissolved phosphorus (orthophosphate) leaking into shallow groundwater. Shallow monitoring wells installed by Dr. Bill Simpkins at Iowa State University are still present. If there is interest, volunteers could be trained to collect water samples using a bailer, and either test for orthophosphate in the field, or deliver samples to a certified lab.

[97] https://www.cityofames.org/government/departments-divisions-i-z/water-pollution-control/ada-hayden-water-quality-monitoring

[98] Ada Hayden Heritage Park Water Quality Monitoring, 2009-2010. Iowa State University Limnology Laboratory.

Monthly Volunteer Testing Organized by Story County Conservation

The new Story County Water Quality Monitoring Program is a volunteer water quality monitoring program whose goals are to provide a balanced approach for citizens to become involved in protecting and improving water resources. Story County Conservation assembled 17 kits for water quality testing in the summer of 2020. As of December 2020, 16 volunteers have expressed interest in adopting a stream for regular monitoring, and 18 sites have been assigned to volunteers.

The following parameters will be tested, following the chemical monitoring instructions in the Izaak Walton League of America's Save Our Streams program. A Quality Assurance Plan is being developed.

- Dissolved oxygen, measured with a CHEMetrics dissolved oxygen test kit
- pH (acidity), measured with a Hach pH test strip
- Chloride, measured with a Hach Chloride Quantab titration strip
- Orthophosphate, measured with a CHEMetrics phosphate test kit
- Nitrate and nitrite, measured with a Hach nitrate-N/nitrite-N test strip
- Transparency, measured with a transparency tube
- Water temperature, measured with a thermometer

Volunteers will use the Izaak Walton League of America's Clean Water Hub to enter data.

Story County Conservation and Prairie Rivers of Iowa worked together on a web map that is being used by the planning team[99] to select sites in each HUC12 watershed with safe access for volunteer monitoring, and will keep track of sites that have been assigned to volunteers. Sites have been assigned to volunteers in each of the high priority HUC12 watersheds identified in the County-wide Watershed Assessment (Figure 32).

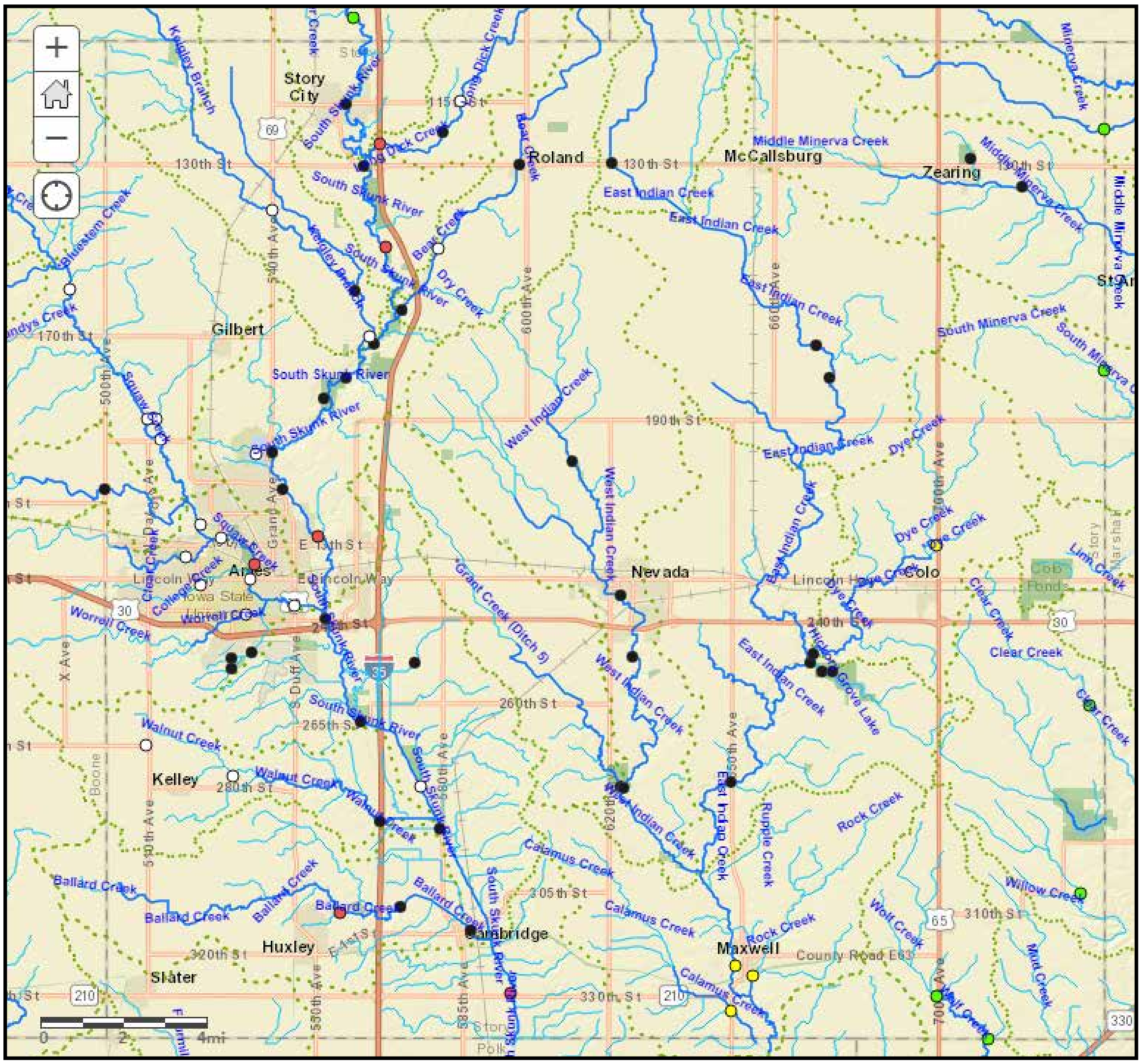


Figure 32: Sites assigned to volunteers are indicated in black

[99] Since login or security features would require that all participants own an ArcGIS license, at present, it cannot be shared publicly without risk of data loss.

Continued Volunteer Events for Ioway Creek and its Tributaries Organized by Prairie Rivers of Iowa

Water quality snapshot events involve the testing of multiple sites during the same weekend. As the name suggests, this is a "snapshot in time" of water quality that may not be representative of water quality over the whole year. However, snapshot events allow dozens of sites to be tested on the same day or two-day period, giving a better picture of where in the watershed pollutant concentrations are highest and lowest. Snapshots are also a good entry point for volunteers who have not previously done water monitoring or who cannot commit to more regular monitoring. Squaw Creek Watershed Coalition has been holding watershed snapshots in May and October since 2006. Up until 2016, this was done with equipment and training from the Iowa DNR through the IOWATER program.

To continue this tradition, Prairie Rivers of Iowa organized two socially-distanced water quality snapshots[100] in 2020.

- In May 2020, 28 volunteers tested water quality at 43 sites.
- In October 2020, 13 volunteers tested water quality at 16 sites, and surveyed invertebrates in Ioway (Squaw) Creek.

Recent snapshot events have used instructional videos and protocols from the Izaak Walton League of America's Save Our Streams program. Save Our Streams uses the same equipment as the IOWATER program. There are only minor differences in data sheets and instructions; the Save Our Streams data sheets omit nitrate, include a lookup table to calculate percent saturation for dissolved oxygen, and report weather differently. A Quality Assurance Plan is being developed.

E. coli monitoring was originally part of the IOWATER program. Volunteers applied stream water to Coliscan Easygel plates, cultured the plates in a homemade incubator, and counted colonies. This method had some notable successes—regular monitoring of Ioway (Squaw) Creek by Erv Klaas lead to the detection and fixing of a sewer leak. However, Iowa DNR found that inexperienced volunteers had difficulty achieving consistent results, and removed *E. coli* testing from the IOWATER protocol. In the October 2019 snapshot, volunteers collected water samples which were processed by a certified lab at Iowa State University, thanks to a partnership with ISU faculty member (Laura Merrick) and a mini-grant for translational research and community engagement[101]. As this shows, there is potential for overlap between volunteer monitoring and laboratory methods.

Samples Tested by City of Ames's Certified Lab

As described in Chapter 3, the City of Ames Water and Pollution Control Department continues to monitor the following sites on the South Skunk River on a weekly basis for nitrate, total phosphorus, total suspended solids, and several other parameters.

[100] https://www.prrcd.org/fall-2020-snapshot/ and https://www.prrcd.org/2020-spring-water-quality-snapshot/

[101] https://www.uturn.iastate.edu/project/coalition-building-in-an-urban-rural-watershed

- Upstream of the Water Pollution Control facility (at 265th St)
- 0.3 Downstream of the WPC (at 280th St)
- 1.3 Downstream of the WPC (at 580th Ave)

For 2020, the City of Ames Water and Pollution Control Lab agreed to process monthly samples from up to 15 sites for nitrate-N, total phosphorus, *E. coli* bacteria, and total suspended solids. We selected a preliminary list of sites to monitor, but this can be adapted to better meet our objectives in subsequent years. A Qualtity Assurance will also be developed.

City of Ames staff already test five streams in Ames for fecal indicator bacteria[102]. Monitoring began in 2001 following community concerns about poor water quality in College Creek and the discovery of illegal sewage discharges from two local businesses. Monitoring is done monthly during the warm weather months of April thru October. Fecal coliform was tested from 2001-2018, *E. coli* since August 14, 2018. As part of this project, these water samples were also tested for nitrate-N, total phosphorus, and total suspended solids in 2020.

- Ioway (Squaw) Creek @ 6th St (Brookside Park)
- College Creek @ Sheldon Ave (ISU Arboretum)
- Clear Creek @ Emma McCarthy Lee Park
- South Skunk River @ 13th St (River Valley Park)
- Worrell Creek @ S. 16th St

Ten additional sites were added around the county (Figure 33). Several streams were chosen because they flow through city or county parks that might see fishing or children's play. *E. coli* data can help inform us if these streams are safe for recreation. In addition to having public access, the South Skunk River at Sleep Holow Access was chosen because it has a stream gage and extensive baseline data, as it was a former DNR ambient monitoring site.

- Bear Creek @ W. Maple St, in Roland
- West Indian Creek @ Lincoln Hwy, in Nevada
- Ballard Creek @ 4th St, in Cambridge
- West Indian Creek @ 280th St (Jennett Heritage Area)
- South Skunk River @ Broad St, in Story City
- South Skunk River @ W. Riverside Rd (Sleepy Hollow Access)

Additional streams were chosen that could be covered as part of the same route. Currently we have two routes that can each be covered in about two hours.

- Keigley Branch @ 170th Street
- Long Dick Creek @ 567th St
- Grant Creek @ 280th St (Jennett Heritage Area)
- East Indian Creek @ S27

Prairie Rivers of Iowa has been using the software package "R Studio" to analyze the lab results, publish findings to the web, and update the graphs monthly[103].

[102] https://www.cityofames.org/government/departments-divisions-i-z/water-pollution-control/urban-stream-monitoring

[103] https://rpubs.com/dhaugprrcd/newsletter-2020-09

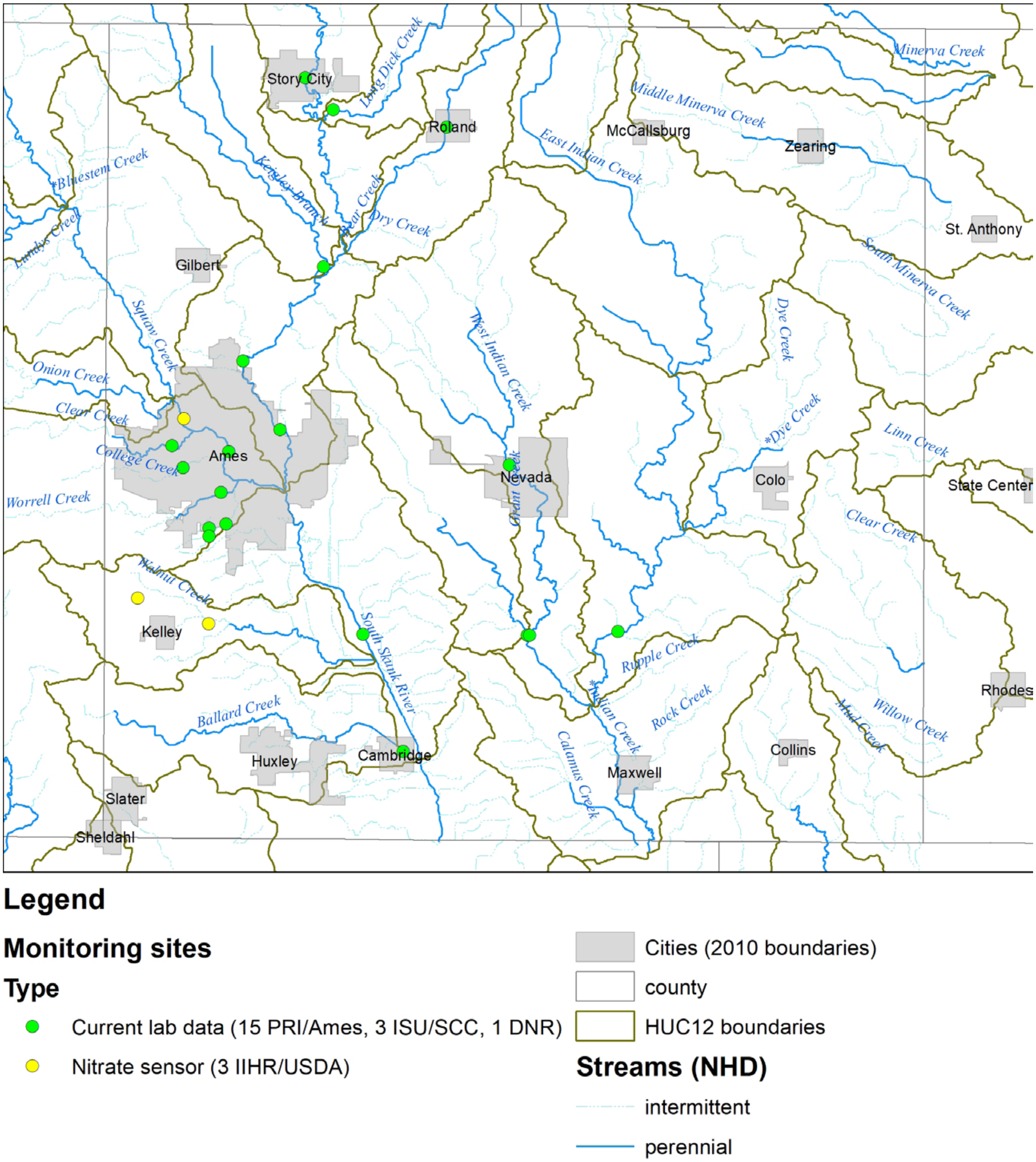
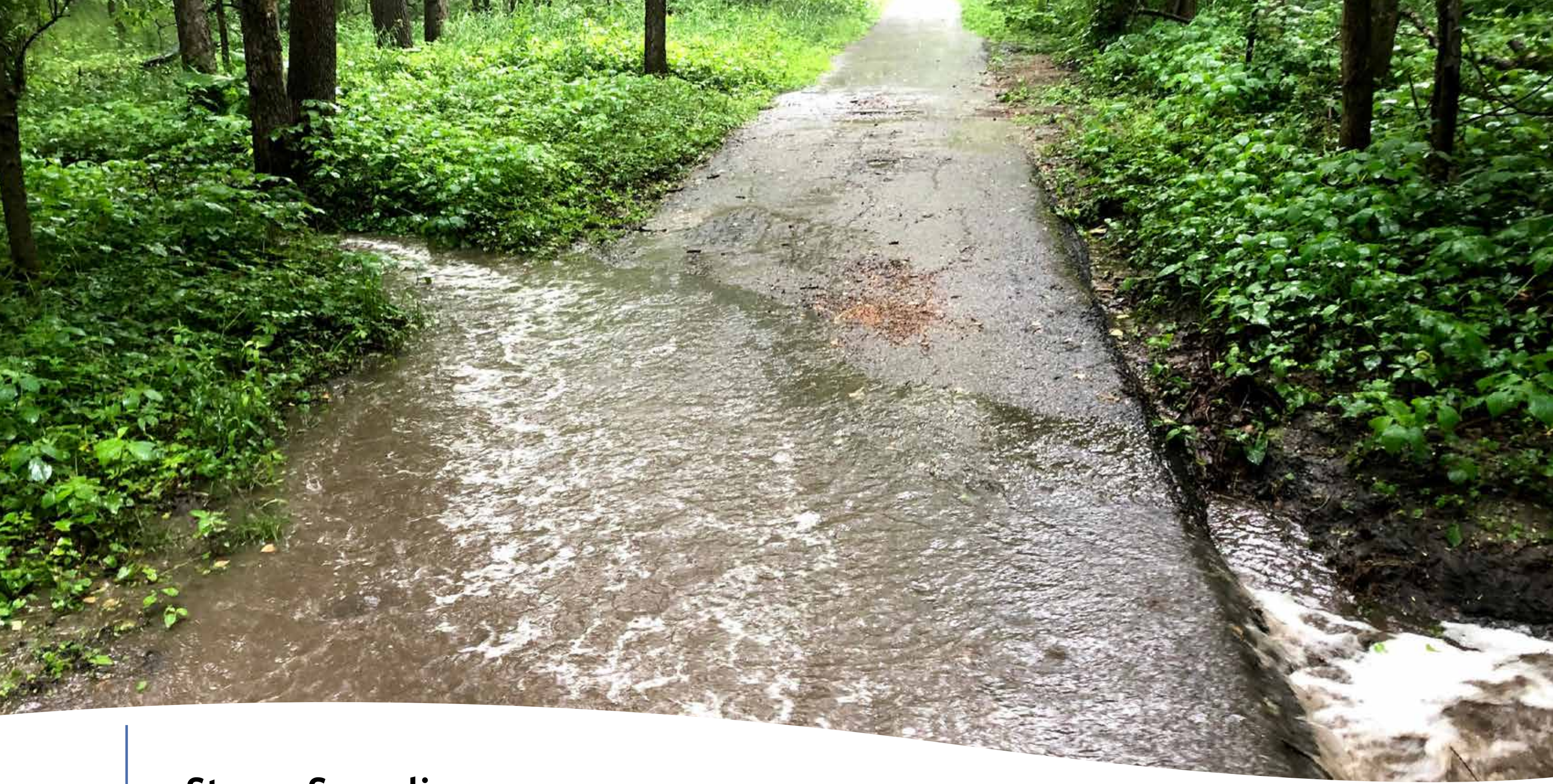


Figure 33: Locations of monitoring sites with lab testing or sensors, 2020



Storm Sampling

In the Ioway (Squaw) Creek Watershed Management Plan and in the Countywide Watershed Assessment, the consultant recommended biweekly monitoring with automated samplers at sites with a USGS gage. There's some sense to this. Flow monitoring is necessary to calculate loads. Storms account for the majority of phosphorus and sediment load. An auto-sampler makes it easier to get a sample when it's raining overnight, and makes it possible to collect a flow-weighted composite sample that is more representative when water quality is changing rapidly. However, as described in Chapter 4, even with storm sampling in Squaw Creek, it was not possible to estimate phosphorus and sediment loads precisely enough to detect trends of less than 20 percent.

Story County Conservation and City of Ames each have Teledyne ISCO 6712 portable samplers that can be deployed for monitoring. These could best be used in a small paired-watershed study or a field-scale assessment of wetlands or other conservation practices, where changes can be detected in a reasonable timeframe.

An alternative way to measure pollutants in runoff is to use a single-stage sampler that fills with water and seals shut when the water in a stream exceeds a certain level (stage). These can be retrieved the next day for analysis. While not suitable for trend monitoring and estimation of pollutant loads across a storm, they can characterize pollutant concentrations in runoff generated during the first part of a storm. Since they are inexpensive, they can be widely deployed to compare water quality in multiple streams, ditches, or drainage systems during storms. This could be useful for educating the public about pollutants carried in runoff, characterizing sources of phosphorus and sediment to a river or lake, or prioritizing watersheds for conservation.

Prairie Rivers of Iowa was given 30 Nalgene Storm Water Samplers[104] and 20 mounting kits from the South Fork Watershed Alliance. These can be mounted in a stream, in a ditch, in a drain tile intake, or suspended below a storm sewer grate (Figure 34). Each of these applications was tested by Prairie Rivers of Iowa and students at Ames High School in 2019, but they have not yet been used countywide.

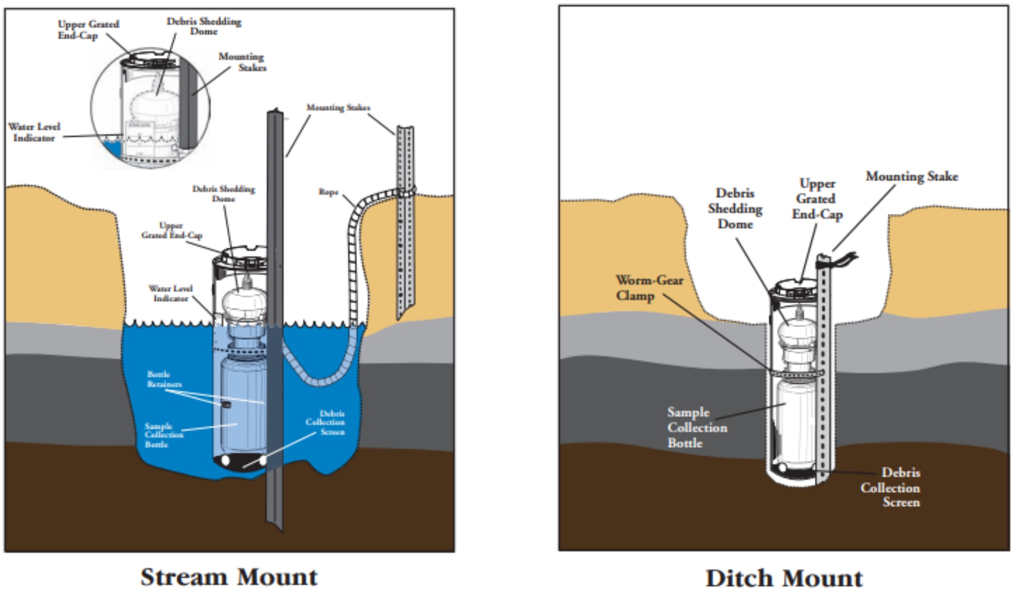


Figure 34: Diagram of single-stage samplers, reproduced from Nalgene

[104] https://www.thermofisher.com/order/catalog/product/1100-1000

Optical Brighteners

Given widespread *E. coli* impairments in central Iowa waters, there is a need for methods to narrow down potential sources of fecal contamination, especially human waste, so that problems can be addressed. In 2019, local partners were working with the State Hygienic Lab to pilot new laboratory protocols for microbial source tracking—using a gene from human *Bacteriodes* (fecal bacteria) to confirm human sources of waste. However, the Covid-19 pandemic demanded the full attention of the State Hygienic Lab, so this project has been postponed until further notice.

Optical brighteners found in laundry detergent are an indicator of wastewater contamination. Dr. Jacob Petrich, Iowa State University Department of Chemistry, will be using spectroscopy to test the sensitivity and longevity of these brighteners to better interpret data from the field. The project will get underway in early 2021, with financial support from the Leopold Center for Sustainable Agriculture and water samples submitted by Story County Environmental Health and City of Ames Public Works. We anticipate this will be a cost-effective way for local partners to narrow down locations of improperly maintained septic systems, illicit discharges, or leaking sewer lines.


Worrell Creek

Goals & Strategies for Years 2021 - 2030

Goal 1: To increase awareness of water quality in Indian Creek and South Skunk River, recognize progress, and engage stakeholders who can positively impact those watersheds.

Strategy 1: Promote and expand the Story County volunteer water monitoring program with at least 120 active volunteers participating over ten years.

Action 1:	Once a year, bring all current and interested water monitoring volunteers together for additional education, updates, and celebration.
Action 2:	Develop and publish a public-facing monitoring report during Watershed Awareness Month, highlighting work accomplished during each year and key findings.
Action 3:	Promote training events so that at least 15 volunteers become certified to identify benthic macro-invertebrates through the Save Our Streams program.

Strategy 2: Educate our targeted audiences at least twelve times/year.

Action 1:	Promote annually Izaak Walton League and other stream monitoring efforts including the programs of "Snap a Stream Selfie", Winter Salt Watch and Creek Critters.
Action 2:	Publish semi-annually for ten years, water monitoring articles and updates from data sampling activities, highlighting differences in watersheds that may explain differences in water quality.
Action 3:	Create opportunities for partners to promote the water monitoring efforts and reports on websites and in social media at least four/year.
Action 4:	Identify opportunities to educate Story County and upstream landowners on practices that can improve water quality.
Action 5:	Identify at least three separate opportunities to present to community groups within our targeted watersheds each year, on what the plan is about and how we are doing.
Action 6:	Connect and engage with educators at our local schools and community organizations to engage youth in water monitoring with at least one class or youth group participating each year.
Action 7:	Share real time monitoring data from Story County stream sites.

Strategy 3: Develop a water quality manager network for all communities in Story County to share knowledge and ideas promoting Source Water Protection.

Action 1:	Hold a joint meeting once per year for ½ a day that involves learning, sharing, and networking.
Action 2:	Apply for CEU credit from Iowa DNR to receive credit at this yearly joint meeting.

Strategy 4: Increase the public's engagement with our outdoor water recreation opportunities to enhance the quality of life.

Action 1:	Identify and promote the connections between water quality and healthy fisheries.
Action 2:	Identify and promote the connections between water quality and safe recreation.
Action 3:	Identify at least one family activity/year to encourage connections to our public waters.

Goal 2: Expand monitoring efforts to cover more of the county.

Strategy 1: Support volunteers in regular monitoring of streams using the Izaak Walton League's (IWLA) Save Our Streams protocols for chemical and biological monitoring.

Action 1:	Direct volunteers to stream sites with safe access and that will ensure good coverage of streams and watersheds around the county, using a shared web map to track site assignments.
Action 2:	Help volunteers use the Izaak Walton League's Clean Water Hub to record their data, and work with IWLA to retrieve data in bulk to analyze and incorporate into annual reports.
Action 3:	Monitor benthic macroinvertebrates in streams around the county (taking care not to disturb a site too often) as part of education and outreach events and enter data into the Clean Water Hub.
Action 4:	Continue twice yearly water quality snapshot events to engage the public.

Strategy 2: Collect monthly grab samples from streams around the county for analysis by the City of Ames Water and Pollution Control Laboratory.

Action 1:	In 2021, continue monitoring 15 sites around the county, prioritizing streams with public parks or relevance to the South Skunk River Water Trail.
Action 2:	Review the site list each year to ensure that it reflects current priorities.
Action 3:	Meet with City of Ames staff annually to ensure that the number and timing of samples received is manageable for the lab.
Action 4:	Continue to analyze results of lab testing and publish it to the web.
Action 5:	In 2022, consider adding to or amending the list of sites to include streams feeding into the five priority lakes of McFarland Park, Peterson Lake, Ada Hayden, Dakins Lake, and Hickory Grove Lake.
Action 6:	Consider developing a Quality Assurance Project Plan (QAPP).

Strategy 3: Coordinate regular monitoring of five priority lakes: McFarland Lake, Peterson Lake, Ada Hayden Lake, Dakins Lake and Hickory Grove Lake over ten years.

Action 1:	Story County Conservation will continue to coordinate monitoring of swimming beaches for E. coli with Iowa DNR.
Action 2:	Monitor trophic state (algae blooms) in all priority lakes either through special projects (Story County and/or City of Ames) or by local monitoring.

Strategy 4: Launch special monitoring projects to follow up on known issues in lakes and streams.

Action 1:	After a pilot project by Iowa State University, scale up testing of optical brighteners to narrow down sources of untreated wastewater in stream reaches with known *E. coli* problems.
Action 2:	Connect volunteers participating in IWLA's Winter Salt Watch with public works staff in Ames and other communities.
Action 3:	Beginning in 2021, work with volunteers to deploy passive samplers in developed streams to test for pollutants in the first flush of stormwater.
Action 4:	Look into real-time sensors and data loggers for dissolved oxygen and turbidity for follow-up monitoring of streams with poor biological scores.
Action 5:	Work with Iowa State University on projects related to Lake LaVerne.

Goal 3: To identify and promote actions that improve and sustain the water quality and system resiliency of the lakes and rivers through which water travels.

Strategy 1: To identify and promote best management practices (BMPs) to stabilize our watersheds and to achieve a more resilient system.

Action 1:	Promote the use of Agricultural Conservation Planning Framework (ACPF) maps to prioritize potential sites for wetlands and basins based on modeled flood storage and nutrient reduction.
Action 2:	Actively identify opportunities to install five wetlands and basins over ten years.
Action 3:	Identify and assist partners in implementation of river restoration toolbox methods for stabilizing 3500 of linear feet over ten years.
Action 4:	Identify at least four oxbow restoration projects on either public or private land in Story County.

Strategy 2: To impact long term water quality improvements by evaluating the efficiency of implemented practices and engaging decision makers in our findings.

Action 1:	Analyze and report yearly impacts of soil health restorations on flood reduction capacity and water quality.
Action 2:	Identify at least five urban BMPs and stream stabilization sites to monitor nutrient reduction efficiency.
Action 3:	Share with local, regional, and state decision makers monitoring information to build their awareness for developing policies and regulations related to water quality.

Goal 4: Strengthen the working relationships between current and future partners as we implement the monitoring plan.

Strategy 1: The planning team will meet quarterly to receive and provide updates on the progress of the plan and new ideas that are emerging over the ten years.

Action 1:	Develop a management process for the plan.
Action 2:	On the fifth year of plan, do a substantial review and update all goals and strategies.
Action 3:	Report annual progress on ten-year plan to all audiences including holding a press conference and develop press releases for our partners to announce annual progress on ten-year plan.

Strategy 2: Approve a working budget for the planning team every three years.

Action 1:	Budget will be reviewed yearly by the planning team for progress based on a fiscal year July 1 through June 30.

Strategy 3: Discuss and identify investments to the plan from organizations in the county, and state and federal grants.

Action 1:	Apply for new monies to support the plan and new monitoring needs at least once/year.