Final Report on Data Collection of In-Field Agricultural Practices: A 3-Year Pilot Project
Iowa State University College of Agriculture & Life Sciences
March 1, 2018

Executive Summary

In 2015, Senate File 494 established a three-year pilot project to enhance the state's ability to track progress on implementing the Iowa Nutrient Reduction Strategy and develop a secure method to gather information on in-field agricultural practices and analyze their impact on nutrient loss. It also called for the Iowa State University (ISU) College of Agriculture and Life Sciences to establish a public-private partnership to hold the confidential data. This is the final report that include findings and recommendations.

Findings

A full-time Measurement Coordinator has worked closely with the ISU College of Agriculture and Life Sciences, the Iowa Department of Agriculture and Land Stewardship (IDALS) and the Iowa Department of Natural Resources (IDNR). As a result, there has been increased collaboration with partners — public, private and nongovernmental organizations — to improve data-sharing for tracking conservation efforts in Iowa. Also, methods for managing data and streamlining processes for analysis have improved, reduced the potential for error, decreased the time needed for repeated analysis and expanded record-keeping. Specific examples of reports and reporting improvements are described below, including continuous improvement of the Iowa Nutrient Reduction Strategy annual report.

Through a competitive process, ISU selected the Iowa Nutrient Research and Education Council (INREC) as the private partner for the in-field data collection. INREC worked with Iowa State researchers to develop a data collection tool to gather objective data on in-field nutrient application and farming practices based on agricultural retailer records. INREC collaborated with the ISU Department of Statistics to develop a procedure for collecting a representative sample of fields across the state. The survey instrument, sampling procedure and retailer/farmer participation was developed over three phases. The final phase, currently underway, is a fully randomized and representative sample of in-field practices that will be aggregated and shared with ISU to calculate nutrient losses from in-field management practices for the state of Iowa. Findings from the process are outlined below.

Recommendations

- It is recommended that public-private partnerships be continued and be supported to not only collect and analyze farm-level data for progress measurement, but to also deliver outreach and educational programs targeted to agricultural retailers and crop advisers in Iowa with the goal of enhancing the rate of practice adoption by utilizing information learned from the INREC survey to focus efforts where they are needed most.

- It is recommended that the system developed be adopted as the official method for measuring, documenting and quantifying progress under the Iowa Nutrient Reduction Strategy.

- It is recommended that the Measurement Coordinator position continue to be supported to coordinate with IDALS and IDNR to report progress on the Iowa Nutrient Reduction Strategy, continually improve the reporting process and prepare annual reports.

Introduction

The Iowa Nutrient Reduction Strategy (INRS) is a research- and technology-based approach to assess and reduce nutrients delivered to Iowa waterways and the Gulf of Mexico. The strategy outlines opportunities for efforts to reduce nutrients in surface water from both point sources, such as wastewater treatment plants and industrial facilities, and nonpoint sources, including farm fields and urban areas, in a scientific, reasonable and cost-effective manner.

The INRS was developed in response to U.S. Environmental Protection Agency (EPA) recommendations provided in its March 16, 2011, memo, "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reduction."

Each year an INRS annual progress report provides updates on point source and nonpoint source efforts related to action items listed in the strategy and on implementation activities to achieve reductions in nitrogen and phosphorus loads. The INRS documents, including each year's annual progress report, can be accessed at http://nutrientstrategy.iastate.edu/documents.

Improved assessment of progress has been deemed crucial to the success of the INRS. Measurement of the barriers to and progress in INRS implementation will help inform management decisions in this multifaceted and highly collaborative approach to nutrient load reduction in Iowa.

The INRS calls for the development of a public-private reporting system capable of documenting the use of nutrient management and conservation practices within the state. Such a system would provide a way to calculate nutrient load reductions stemming from the measured levels of practice adoption. Elements of this system include a private-sector process to measure the scale of practice adoption and provide the aggregate information necessary for the Iowa State University Nutrient Science Assessment Team to make load-reduction calculations.

The inherent need for progress tracking is to create a system able to provide near-term assessments of the impact of efforts being carried out to implement the INRS. The INRS recognizes the need for a practice-based measurement approach for tracking progress, paired with known science on water-quality performance of conservation practices, to reliably and accurately quantify the impact of practices across Iowa in terms of mass load reductions of nutrient losses. This approach provides a measurement system that is confounded neither by weather variability nor by other temporal and spatial scale factors that stream water quality monitoring is highly susceptible to — as documented by the INRS supplemental document "Stream Water Quality Monitoring Conducted in Support of the Iowa Nutrient Reduction Strategy" (Appendix 5).

In 2015, SF494 was enacted to provide funding support for a pilot project to develop the public-private system to enhance the state's ability to track its progress in reducing the transport of nutrients to water from nonpoint sources in Iowa. Below is the relevant language from section 18 of Senate File 494 passed by the Iowa General Assembly and signed by Governor Terry E. Branstad.

The three-year project shall be used to do all of the following:

a. *Enhance this state's ability to track its progress reducing the transport of nutrients to water from nonpoint sources within watersheds in accordance with the latest revision of the document entitled "Iowa Nutrient Reduction Strategy" initially presented in November 2012 by the department of agriculture and land stewardship, the department of natural resources, and Iowa state university of science and technology.*
b. *Develop a database of in-field agricultural practices and analyze the impact of those practices in the aggregate. An agricultural practice includes but is not limited to soil and water conservation*

practices, structures, technologies, and agricultural inputs and outputs. The college may also provide for the measurement of other impacts associated with agricultural production. The finding of the pilot project shall be used to develop a system to be implemented within a broader range of watersheds that measures existing agricultural practices and the impact of different nutrient management decisions.

The college shall enter into a private-public partnership with one or more persons responsible for receiving, collecting, or holding data described in subsection 2. The college shall provide for the terms and conditions of any legal or financial arrangement that it enters into with such person. Any information received, collected, or held by the person shall be confidential in the same manner as provided in section 466B.49, subsection 2. The college shall only enter into an arrangement with a person if the college is satisfied that the person will protect the confidentiality of the information.
Any information including aggregate data transmitted to the college by the person shall be available for public examination and copying under chapter 22, except for the same type of information described in section 466B.49, subsection 2, which shall remain confidential.

The college shall submit interim reports to the general assembly by March 1, 2016, and March 1, 2017, and a final report to the general assembly by March 1, 2018. The final report shall include its findings and recommendations.

This report, in two sections, serves as the final report and recommendations on the pilot project. The first section outlines efforts led by Iowa State University (ISU) College of Agriculture and Life Sciences that describe the logic model approach to measuring progress; improvements and efficiencies in compiling the annual INRS progress report; research on measuring farmer attitude and behavior toward in-field practice adoption; and measuring INRS practice adoption in three priority watersheds. The second section outlines the process for selecting a private-sector partner, Iowa Nutrient Research and Education Council (INREC), followed by the work led by INREC in this public-private partnership in collecting statistically sound in-field practice data to inform the nutrient load estimates.

Section 1: ISU College of Agriculture and Life Sciences-Led Efforts

Background: The Logic Model Approach to Measuring Progress

The 2015 annual progress report of the INRS introduced the "logic model" framework as the basis of considerations set forth by the WRCC Measures Subcommittee. The logic model is guided by measurable indicators of desirable change that can be quantified, and represents a progression towards goals for achieving a 45 percent reduction in nitrogen and phosphorus loads. This development of a measurement framework assists the annual reporting process, which was recommended by the 2011 EPA memo.

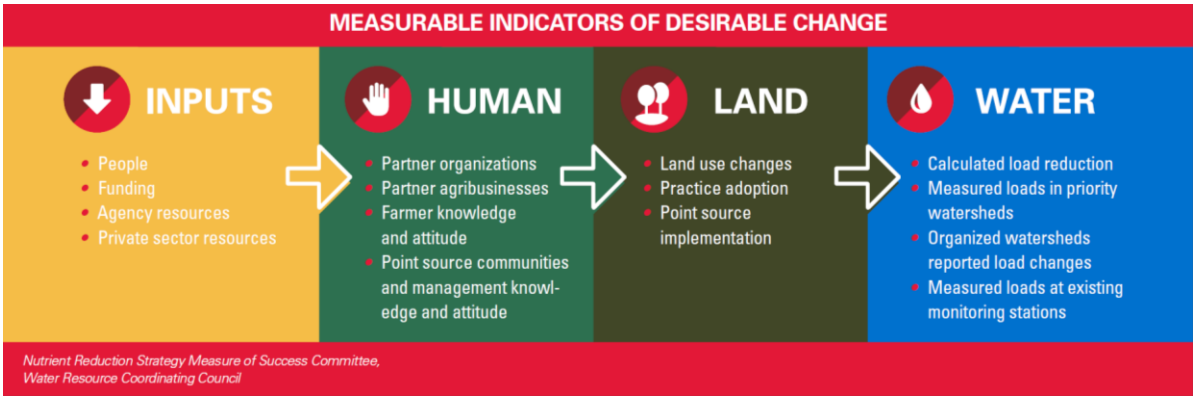


Figure 1 The Logic Model of the Iowa Nutrient Reduction Strategy, guided by measurable indicators of desirable change.

A significant reduction in nutrient loads is the ultimate goal of the INRS, and is represented by the right-most category of Figure 1. In order to affect change in water quality, there is a need for increased inputs defined as funding, staff and resources. Inputs affect change in outreach efforts and human behavior. This shift toward more conservation-conscious attitudes in the agricultural community is a desired change in the human dimension of water quality efforts. With changes in human attitudes and behavior, changes on the land may occur, measured as conservation practice adoption and wastewater treatment facility upgrades. Finally, these physical changes on the land may affect Iowa's surface water nutrient load, which ultimately can be measured through both empirical water quality monitoring and through modeled estimates of nutrient loads in Iowa surface water. The measurable indicators that correspond to each category, as outlined in Figure 1, provide quantified parameters in which to track year-to-year changes and continual trends to develop a standardized protocol for evaluating INRS progress.

In measuring progress of the INRS, the logic model serves as a comprehensive reporting tool to inform data collection, indicator development and assessment of the successes and challenges associated with reducing nutrient loads from point and nonpoint sources. The logic model guides the assessment of not only a progression of changes, but also can inform improvements in each of the four primary categories. With continually refined measurement of each category, potential adjustments may be made to the inputs and efforts that partner organizations devote to the INRS in order to impact change over time.

As part of the INRS Measurement Pilot Project, ISU College of Agriculture and Life Sciences hired a full-time INRS Measurement Coordinator. The coordinator's primary responsibility is to work with Iowa Department of Agriculture and Land Stewardship (IDALS) and Iowa Department of Natural Resources (IDNR) to prepare the INRS annual report. The annual progress report employs the logic model approach (Figure 1) to track progress of the INRS and to highlight efforts conducted across Iowa to reach the INRS goals of 45 percent reduction of annual nitrogen and phosphorus loads.

Since late 2015, the Measurement Coordinator has worked to coordinate the continued improvement of the INRS annual report, with significant support from the principal authors of the INRS — ISU College of Agriculture and Life Sciences, IDALS and IDNR. First, there has been increased collaboration with other partners — public, private, and non-governmental organizations — to improve data-sharing for tracking conservation efforts in Iowa. Second, methods for managing data and streamlining processes for analysis have improved reduced the potential for error, decreased the time needed for repeated analysis and expanded record-keeping. These items are described in further detail as follows:

1. Partnerships for Data-Sharing
    - The Measurement Pilot Project has facilitated partnerships between public agencies, private entities, universities and nongovernmental organizations to collect annual standardized data. These data consist of information on funding, staff, outreach, practices installed and water monitoring dedicated to promoting the goals of the INRS. Results from these efforts are published in the 2016 and 2017 INRS annual progress reports. In 2017, 18 partner organizations submitted reports on their INRS-related efforts.
    - ISU College of Agriculture and Life Sciences and IDALS have worked closely with the USDA Natural Resources Conservation Service (NRCS) to share annual data on cost-share programs' implementation of conservation practices. This data-sharing partnership has been instrumental in evaluating and reporting the extent of conservation practice use in Iowa. Results from these efforts also are published in the 2016 and 2017 INRS annual reports.

2. Data Management
    - In early 2017, the Measurement Pilot Project adopted more reliable methods for managing data sets that report funding, outreach efforts, and cost-share practices. As a result, the data

analysis for measuring INRS progress is replicable and efficient, which helps with repeated analysis of similar data sets each year for the INRS annual progress report. In addition, these methods reduce the potential for human error in processing and analyzing data sets.

- ISU College of Agriculture and Life Sciences collaborated with IDALS to develop an online reporting tool for watershed projects, funded by the Iowa Water Quality Initiative (WQI). As a result, WQI's quarterly project reports display standardized information on projects' efforts in education and outreach. Results from these efforts contributed to estimates of statewide INRS outreach, published in the 2017 INRS annual report. Future studies will examine the local impacts of these efforts on conservation practice adoption. In addition, this online reporting tool will be extended to watershed projects funded by programs other than WQI.

The INRS Measurement Coordinator's responsibilities extend beyond preparation of the INRS annual progress report. These projects are described in detail as follows:

1. Continued Development of Models for Calculating Nutrient Load Reductions
   - In 2013, the INRS Science Team developed methods for estimating the nutrient-load reductions affected by conservation practice adoption in Iowa. The INRS Measurement Coordinator, with support from researchers at ISU, University of Iowa and IDNR, has facilitated the continued improvement of these models by creating software tools for running calculations more efficiently and for adjusting input variables as new nutrient research is conducted.
   - A public-friendly tool has been developed for field- and watershed-scale nitrogen reduction calculations. Work is underway to develop a public-friendly tool for phosphorus reduction calculations. These tools will contribute to farmer and landowner outreach conducted by ISU Extension and Outreach and by watershed coordinators.

2. Analysis of the ongoing, five-year INRS Farmer Survey to assess knowledge, attitude and behavior toward the INRS as a measure in the Human indicator in the Logic Model.
   - The INRS Measurement Coordinator works with ISU sociology and statistics researchers to analyze responses collected for a five-year farmer survey.
   - The survey aims to understand farmers' knowledge of and attitudes toward the INRS, as well as farmers' use of conservation practices. The sampling design allows for analysis of change over time in watersheds where INRS priority areas have been identified; i.e., the INRS priority HUC8 watersheds and their surrounding watersheds.

3. Case studies to assess progress in small watershed projects of WQI
   - The INRS Measurement Coordinator is conducting analysis of WQI watershed project areas to measure progress toward INRS goals in these relatively small geographic areas. This project contrasts with the statewide approach to measuring INRS progress in the INRS annual progress report. In the first five years of INRS implementation, it is likely that progress is occurring in local areas of the state, but these cases of progress may be diluted in the statewide measures of progress.
   - This project has focused on three WQI project areas: Boone River watershed, Miller Creek watershed and West Fork Crooked Creek watershed. Preliminary results suggest that, with increased funding and a dedicated watershed coordinator to conduct community outreach, cover crop use is significantly higher within the project areas than in surrounding areas. Cover crop use in these project areas also is higher than the statewide rate, when calculated as a percentage of row-crop acres. This study will continue to examine additional practices. Also, this study aims to identify successes and

challenges in these projects, so that other watershed projects may employ the lessons learned from these early WQI project areas.

Public Reports and Publications (available at www.nutrientstrategy.iastate.edu/documents)

The following publications and reports have been published as a result of, or with support from, ISU College of Agriculture and Life Sciences' role in the INRS Measurement Pilot Project:

- 2017 INRS annual report and accompanying 2-page summary infographic.
- 2016 INRS annual report.
- Report: "Stream Water-Quality Monitoring Conducted in Support of the Iowa Nutrient Reduction Strategy" (coordinated by IDNR), and accompanying 2-page summary (coordinated by INRS Measurement Coordinator).
- Report: "Iowa Farmers and the Iowa Nutrient Reduction Strategy: 2015 Survey Results."
- Submitted for peer-review: A research article on causal mediation analysis of INRS Farmer Survey results; the paper explores factors that drive cover crop use among Iowa farmers.

Section 2: Iowa Nutrient Research and Education Council (INREC)-Led Efforts

In the summer and fall of 2015, a request for proposals was issued by ISU College of Agriculture and Life Sciences for the private partner with the capacity required as specified in SF494. After a proposal review and interview process, the Iowa Nutrient Research and Education Council (INREC) was selected as the private partner, and a contract finalized and signed between INREC and ISU.

INREC is a private nonprofit organization affiliated with the Agribusiness Association of Iowa, and as such has strong collaboration with the association's network of over 1,100 members, which includes over 130 agricultural retailers and over 5,000 associated crop advisers. In addition to these networks, the INREC Board of Directors is strategically structured to represent major farm and commodity organizations together with major fertilizer and crop production companies, agricultural retailers and crop advisers. INREC offers unique consolidated access to networks of agricultural professionals and farmer members to promote and assist with the organization's efforts.

Through this pilot project, INREC took a practice-based measurement approach to develop a tracking system that allows better assessment of year-to-year changes by collecting a statistically designed representative sample of the practices being used by farmers across the state. Then those aggregate results are used to calculate the resulting load reductions for N and P, based on the best available science in the INRS. The science summarizes the water quality performance of practices based on numerous years of scientific research conducted across variable climatic and environmental conditions, and as such provides an accurate assessment of the impacts that practices have on reducing nutrient loads across a wide range of conditions.

Executive Summary of Pilot Project Accomplishments:

- This effort has resulted in developing and establishing a first-of-its-kind statistically-based, scientifically credible measurement of farmer progress to adopt nutrient management and conservation practices. Paired with the INRS science, this system provides Iowa with the ability to quantitatively determine nutrient mass load reductions to Iowa waters on an annual basis. Iowa is the leading state in the nation to achieve this level of progress assessment, which also fulfills enactment of the public-private partnership called for by the INRS, using agricultural retailer and crop adviser records for progress measurement.

- The pilot project achieved methods to accumulate the data as needed for determinations of nutrient-load reductions to Iowa waters by the ISU Nutrient Science Team. This system fulfills the need for practice-based progress measurement rather than downstream ambient water quality monitoring, to provide comprehensive near-term measurement of outcomes not compromised by weather variability and other spatial and temporal factors. The data collection questions (Appendix 2) were coordinated with the ISU Nutrient Science team and designed to focus on collecting information about practices from the INRS science assessment, thereby providing the ability to calculate water quality performance.

- The effort achieved utilization of agricultural retailer and crop adviser records for tracking practice adoption with the advantages of:
    a. High accuracy resulting from customer transaction-based records
    b. Detailed historical records of purchased crop inputs/services available
    c. Better understanding at the crop adviser level of practices such as phosphorus applications
    d. Numerous locations statewide to draw a random, representative sample (Appendix 1)

- The pilot project achieved a workable solution to the challenge presented by the fact that Iowa's agricultural retailers and crop advisers use dissimilar record-keeping systems and software. Rather than complex software and data transitions, the solution achieved is a simple web-based fill-in form approach, which has worked extremely well given the variability in source data formats.

- The effort achieved exceptional data security. Both the physical security and cybersecurity of the private server provide military-grade security for housing information collected through the system. Protocols provide additional security features by software design and databases that separate the data source from actual farmer data.

- The project developed and implemented statistical randomization design by the ISU Department of Statistics (Appendix 3), to ensure science credibility of the randomized survey outcomes to credibly correspond to the actual progress by farmers across Iowa.

- The project achieved engagement of agricultural retailers and crop advisers to accomplish the surveys, including:
    a. Establishing four part-time regional liaisons to aid retailers and crop advisers in completing the surveys and necessary farmer consent.
    b. Determining timing of the surveys necessary under the extreme crop-seasonal workloads of retailers, crop advisers, and their farmer customers.
    c. Developing farmer consent procedures for use of their data in the aggregate, achieving widespread farmer consent (Appendix 4).

<u>INREC Pilot Project Accomplishments and Status by Phase:</u>
Phase 1 Pilot Accomplishments (2015-2016):

- Completed procurement of secure web server and data security consultant.
- Worked with ISU statisticians to validate sampling techniques and survey instrument.
- Completed design and development of online data collection system.
- Developed and completed the survey data collection questions, which were coordinated with input from ISU Nutrient Science Team

- Completed beta test survey with small set of crop input providers and farmers.
- Phase 1 testing provided proof of concept for the survey questions and demonstrated the web-based survey system works, is easy to use and that much of the desired data is available.
- Following the beta test of electronically surveying farmers practices from ag retailer records, the INREC project team held several in-person meetings with ag retailers from the test group to discuss the progress tracking system. All retailers expressed a strong willingness to support the work, but recognized that they could benefit from having a more dedicated point of contact assigned to working with their companies.
- Results of the feedback from agricultural retailer meetings were that the web-based collection system works well, and retailers have informational records available. Those who completed the survey with their customers noted no issues with obtaining farmer consent.

Phase 2 Pilot Accomplishments (2016-2017):

- In the fall of 2016, discussions were initiated with the ISU Science Team about generating a test results data set for the survey that could be used in the interim until actual survey data was collected to assist the science team in testing the ability to make load reduction calculations based on the type of information that the survey generates.
- Phase 2 expanded the number of responses to provide a more comprehensive test of scalability and how the process will work at the retailer level. This varies from business to business, but with a larger sample size and a larger number of retailers involved, it was determined what processes work well on the ground, and how retailers are best able to accomplish the task. This provided feedback to retailers to help them be as efficient as possible in completing the surveys. Efficiency and scalability are critical aspects of success.
- It was apparent from the first phase of the pilot project that acquiring the necessary data points and completing the surveys require more direct personal interactions and support to retailers. To provide adequate support to retailers to acquire the necessary survey data, three part-time regional liaison positions were developed to work from their home locations and assigned one of three regions of the state. These positions function as independent contractors working on a part-time basis whose primary roles are to establish relationships with all agricultural retail companies and provide the support necessary to complete the progress tracking surveys. The liaisons provide INREC (which operates with only 1.25 FTE staff) with the capability to reach retailers across the state and provide them with in-person assistance and support to completing the surveys in a timely manner. Future need for continuing this support will be determined based upon the experience in completing the surveys and feedback received from the retailers in Phase 2.
- Six regional liaison candidates were interviewed in January 2017 and three were hired in February 2017. The selected liaisons cover the northeast, northwest and southern portions of the state, focusing outreach efforts to agricultural retailers in their respective areas.
- A three-day training session for the newly hired liaisons on the progress tracking system was held in late February 2017 to provide background needed and ensure consistency across the state in their roles to provide support and assistance to all agricultural retailers in completing surveys.
- Following training, the Phase 2 survey was initiated in February 2017 and the regional liaisons were tasked with making contacts to as many retailer companies as possible prior to planting season.
- The regional liaisons met with the general managers and chief executive officers of the companies to get buy-in on the project and assistance from company leadership in working with the agronomy leads and crop advisers to complete the survey. Initial contacts with all retail

companies were made by the end of March 2017. The liaisons reported positive reception by retailers and agronomy leads to complete surveys.

- An updated proposed plan of work for statistical services from the ISU Department of Statistics was developed by INREC in June 2017, and in-person coordination efforts were initiated to develop a working agreement and statistical protocols.
- Phase 2 of the survey was concluded in July 2017 and results were analyzed for input relating to the next phase of the survey. Average time to complete the survey by retailers was under 15 minutes. Overall, a high response rate was received in this phase of the survey, which collected 159 total responses.
- INREC liaisons provided final feedback on phase 2 of the survey testing, identifying areas of improvement in communications and instruction materials.

Phase 3 Pilot Accomplishments and Status Update (2017-2018):

- Completed working agreement with ISU Department of Statistics for statistical services related to sampling design protocols for the fully randomized selection processes in September 2017.
- INREC and ISU developed and finalized the randomized survey sampling protocol, which includes random selection protocols for agricultural retail locations to be surveyed, random selection of farmers and random selection of farm fields to be surveyed.
- Additional retail companies were added to provide a large enough set of locations to randomly select a representative sample from.
- Based on results from phases 1 and 2, the phase 3 survey questions were modified to more accurately focus the survey to data points that agricultural retailers have in their records. Questions relating to structural conservation practices were removed, since most retailers do not have information on them in their records. Cover crop usage, however, is often reflected in retailer records and was retained as a survey question. Additional updates were made to the survey to improve functionality.
- The ISU random sampling protocol was utilized to identify a representative sample of agricultural retail locations across Iowa. ISU provided random sampling parameters for retailers to select data points, and the survey materials and instructions were provided to INREC liaisons for dissemination to their assigned retailers.
- Phase 3 survey was initiated in September 2017. To date, the majority of responses has been collected in January and February of 2018, which was expected due to the timing of the survey during heavy seasonal workloads for both agricultural retailers and farmers (e.g., 2017 crop harvest and post-harvest fertility applications and 2018 preseason crop management planning). Despite the heavy workloads, in-person contacts with the majority of retailers were completed by December 2017, providing them with survey instructions and prepping them for completing the survey work in early 2018.
- An additional INREC regional liaison was hired in December 2017 to provide additional capacity needed in the northwest region of Iowa.
- In December 2017, final edits to the test data set were completed for ISU nutrient scientists to develop science procedures to predict nutrient load reductions to Iowa waters based on survey results. This provided an aggregate data set for ISU to test the processes for calculating nutrient load reductions. In-person coordination between ISU and INREC to review the test data set occurred in February 2018. The ISU science team leads are now using the test data set to identify processes for calculating nutrient load reductions using aggregate data.
- Following the plan of work, Phase 3 data collection is scheduled to conclude by summer 2018. Following this, INREC will provide final aggregated statewide data from the survey to the ISU science team for making nutrient load reduction calculations and will continue coordination with ISU on statistical processes for sampling and post-survey processing of responses.

- Information on nutrient load reductions generated from the final aggregate data set will be disseminated in the fall of 2018. ISU and INREC will develop plans for ongoing implementation of the data collection system to measure farmer adoption of practices in successive crop years.

Additional INREC Progress Measurement Activities (Not Funded Through State Appropriations or ISU Grant):

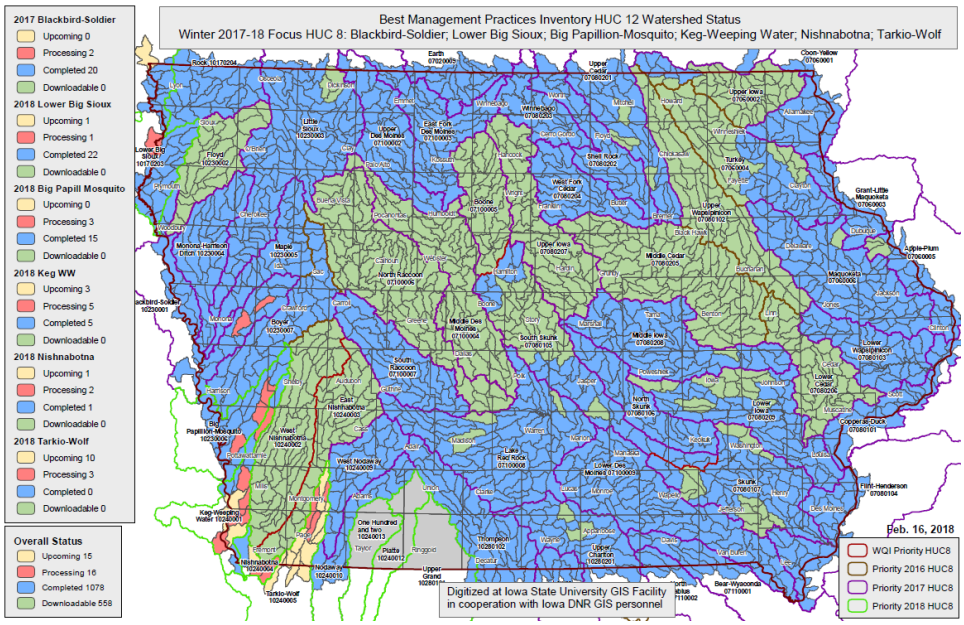
1. Geographic Information Systems Mapping of Structural Conservation Practices

This project uses Geographic Information Systems (GIS) technology and high-accuracy digital elevation data along with aerial imagery to provide an accurate inventory of six best management practices (terraces, grassed waterways, ponds, water and sediment control basins, contour buffer strips and strip-cropping) across the state of Iowa.

This project will provide valuable information on existing conditions of these practices and the ability to track changes in practice use over time. Benefits provided by GIS mapping of practices include:

- Ability to paint the whole picture of what practices exist, regardless of private or public funding source
- Establishment of a current baseline to compare against past and future
- Ability to estimate nutrient-load reductions from level of practices based on INRS science
- Ability to estimate level of conservation infrastructure investment
- Provides a way to visibly demonstrate the level of practices in watersheds
- Provides a uniform, consistent database to work from through a state-vetted process

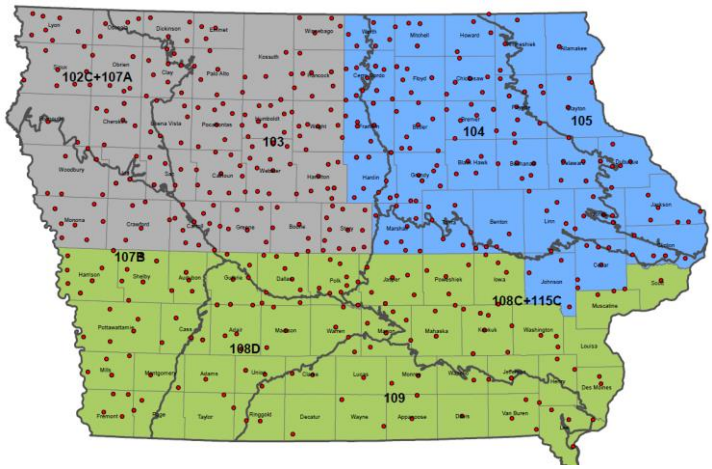
Beginning in Fiscal Year 2017, INREC has been providing the only private funding to assist with this project to complete the mapping for all HUC12 watersheds in Iowa. INREC also is providing private funding to assist with assessing the historic and current presence of practices in mapped watersheds to determine changes in practice levels over time. The historical and current status analyses will be done on a random sampling of 25 percent of the HUC12 watersheds in each HUC8 watershed in Iowa as the base mapping is completed. To date, 98 percent of the base mapping of practices for the state has been completed, as illustrated by the map below. Twenty-six percent of the historical assessment has been completed to date. Additional project information can be found at this ISU website, http://bit.ly/2FfTmjq.



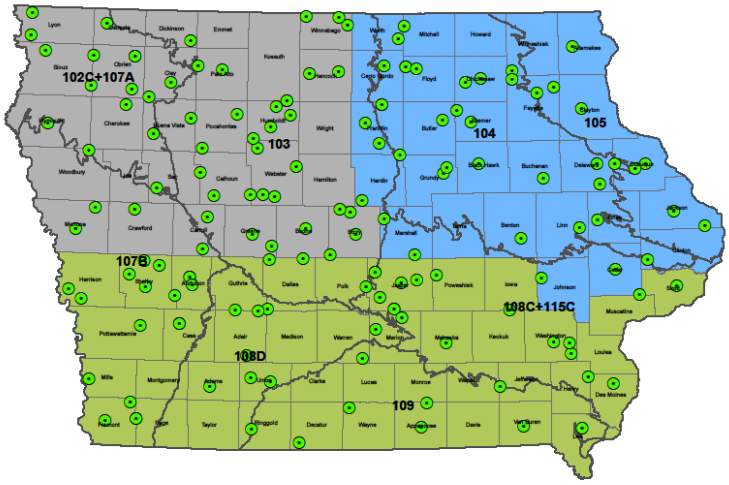
2. Estimate of Historic N and P Nutrient Loads for Nonpoint Sources

INREC provided financial assistance to ISU to assess historic nutrient load exports of N and P from Iowa. This assessment was conducted by the same team of scientists that produced an estimate of recent nutrient load exports at the time the INRS was developed (2007 to 2010). The ISU team assessed existing historical data sets and replicated the same procedures used for estimating current nutrient load exports from Iowa. This was accomplished to estimate the nutrient export levels during the 1980 to 1996 period, which matches the reference period used by the Gulf of Mexico Hypoxia Task Force and the baseline period for measuring progress of the INRS, which was recently established in accordance with SF512. The final report shows how nutrient loads for N and P have changed over time, and is available on the INRS website, http://bit.ly/2ETn3Ji. The executive summary is available in Appendix 6.

Appendix 1: Phase 3 INREC statewide sampling information.



Map 1: INREC liaison regions and all retail locations (red dots) utilized for random sampling.



Map 2: INREC liaison regions and randomly selected retail locations (green dots) utilized for sampling in Phase 3.

MLRA	2016 Corn/Soy Acres	% of State Acres	Target Responses out of 500	Samples Requested by MLRA	Samples Requested per Retail Location	Total # Retailer Locations in MLRA	Number of Retailers Randomly Selected in MLRA	% of Locations Selected by MLRA
102C+107A	2,346,474	10.0%	50	150	10	47	15	32%
103	6,122,471	26.2%	131	393	10	172	39	23%
104	4,276,674	18.3%	91	273	10	131	27	21%
105	1,228,670	5.3%	26	78	10	24	8	33%
107B	3,558,958	15.2%	76	228	10	76	23	30%
108C+115C	3,246,384	13.9%	69	207	10	69	21	30%
108D	1,419,828	6.1%	30	90	10	34	9	26%
109	1,197,373	5.1%	26	78	10	27	8	30%
All MLRAs	23,396,832	100%	500	1500	10	580	150	26%

Table 1: Summary of retail locations by major land resource area (MLRA).

Appendix 2: INREC Survey Questions

Farmer and Field Information Survey:

1. Please enter the customer name for this field.
2. Please indicate the size of the field being surveyed (acres).
3. Is this field owned or rented by the farmer?
4. Select the County that the field is located in.
5. Select the Township Number that the field is located in.
6. Select the Range Number that the field is located in.
7. Select the Section Number that the field is located in.
8. Select the Quarter Section the field is located in.
9. Please enter total acres that customer farms across their entire operation including all owned and rented land.

Field Practices Survey:

1. Please enter your contact information (ag retailer).

2. Approximately how many farmer customers do you provide agronomy services for from your location?

3. Please indicate the size of the field being surveyed (acres).

4. Please indicate the predominant land use for the field for the 2017 crop year.
    - Corn
    - Soybean
    - CRP/Land Retirement
    - Hay/Grazed Pasture
    - Energy Crop
    - Other

5. Please select the current crop rotation for this field.
    - Corn/Soybean
    - Continuous Corn
    - Extended Corn/Soybean Rotation w/Alfalfa at least 2 years out of a 4 or 5 year rotation
    - Permanent Pasture/Hay/CRP
    - Other

6. Were cover crops planted on this field for the 2017 crop year?

7. What type of cover crop was planted?

8. Please indicate if any of the following tillage types are utilized prior to corn planting for this field.
    - Conservation Tillage
    - No-Till
    - Don't Know
    - Other

9. Please indicate if any of the following tillage types are utilized prior to soybean planting for this field.
    - Conservation Tillage
    - No-Till
    - Don't Know
    - Other

10. Was anhydrous ammonia fertilizer applied in the fall before the most recent corn year of the rotation?

11. Was a nitrapyrin based nitrification inhibitor (such as N- Serve) utilized with fall applied anhydrous ammonia?

12. Please indicate if any of the following nitrogen application methods were utilized for the most recent corn year of this field's rotation. Please note that all the options are based on no fall application of anhydrous ammonia occurring.
    - Spring Pre-Plant N ApplicationSpring Pre-Plant N & In-Season Sidedress N (e.g. 40/60 split between pre-plant and sidedress)
    - In-Season Sidedress N Only
    - None of the above/other

13. Taking into account all commercial N fertilizer sources, what was the overall N rate (lbs/acre) applied to the most recent corn year for this field? Please include all commercial sources including MAP, DAP, starter, etc. and the combined rate of all sources across timing of all applications in fall, spring and in-season.

14. Please indicate if any of the following manure fertilizer sources were utilized for this field.
    - Liquid swine manure
    - Beef manure
    - Poultry manure
    - Dairy manure
    - Manure is not used
    - Don't know about manure usage for this field

15. Please indicate which of the following liquid swine manure uses apply to this field for the most recent corn year of the rotation.
    - Liquid swine manure applied in the fall before corn
    - Liquid swine manure applied in the spring before corn
    - Liquid swine manure applied in both the fall and spring before corn
    - Don't know about liquid swine manure usage for this field

16. Do you know from your records what the approximate N rate (lbs/acre) was for the manure application?

17. What N rate (lbs/acre) was manure applied at for this field? (Please indicate the total N rate applied in manure without applying any factors for the plant available amount).

18. Please indicate if any of the following practices were used for P application in this field.
    - Commercial (inorganic) P applied and incorporated into soil with planter
    - Liquid P (commercial fertilizer or manure) injected into soil
    - Commercial (inorganic) P applied in knifed bands
    - Commercial (inorganic) P surface applied and incorporated into soil within 1 week of application
    - None of the above/other
    - Don't know

19. Is soil sampling done to determine soil P levels for this field?

20. Does P application for this field only occur when soil test P levels are at or below optimum levels?

Appendix 3: ISU random sampling protocol

Sample Selection Procedure for INREC

Z. Zhu, 9/3/2017

In the attached file SampleSelection.csv, there are five columns. The first column is the id number from 1 to 600, corresponding to up to 600 locations in the sample. The second column is the first letter of the last name of the farmer for identifying the starting point. The third column gives the section number (high/low). The forth column is the direction in which the field is being sampled (N/E/S/W), and the fifth column is the second direction to break a tie.

If the total number of farms in a location is less than 50, sample every 5th farm after the starting point.

If the total number of farms in a location is between 50-99, sample every 10th farm after the starting point.

If the total number of farms in a location is between 100-199, sample every 20th farm after the starting point.

If the total number of farms in a location is 200 or above, sample every 30th farm after the starting point.

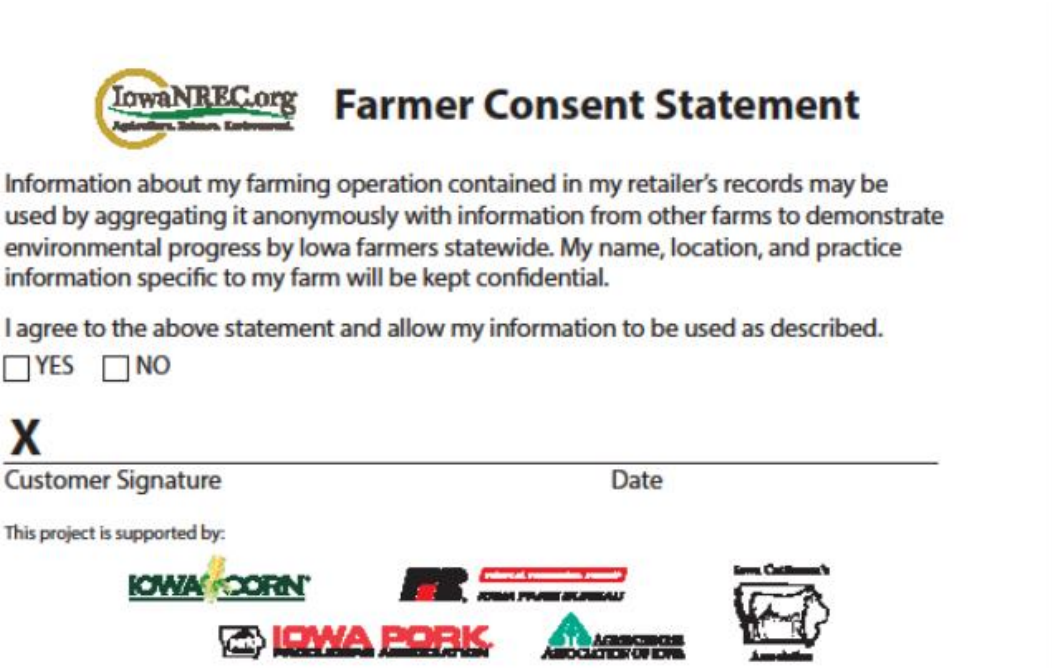
Example: suppose location 1 serves 150 farms.

1. The first row and the second column is M. So we find the first farm with the last name starting with M, which becomes the starting record. If there is no farm with last name starting with M, we find the next farm with the last name starting after M as the starting record.
2. 150 farms are between 100 and 199, so we count from the starting record to the 20th record, which becomes the first sample. Count to the 40th record for the second sample, and continue until enough sample is selected at this location. If there is a non-response, record the basic information for the non-response, and count from the last sample to the next 20th record as a new sample.
3. The first row third column is High. For all the selected farms from the first location, select the section with the highest section number.
4. The first row forth column is West. We select the west most field in the section from (3) to survey.
5. The first row fifth column is South. If there are more than one fields which can be considered west most, select the most southern one to survey.

Appendix 4: Sampling instructions and farmer consent form.

Survey Checklist & Instructions

- Select 10 customer records and farm fields using the sample selection instructions.
  - Obtain customer signature on provided consent form.
  - For each customer that grants consent, identify one of their farm fields to report on for the surveys following the sampling instructions.
  - The field size should be at least 40 acres or larger.
- Assign a unique token from the ones you were provided to each customer record.
  - You've been provided with 10 unique "tokens" that grant access to the surveys. For each customer you will complete both surveys using the same token.
- Use the survey links to access and complete the surveys.
  - Two separate surveys need to be completed for each selected customer. One is a very short survey to collect field location and customer info, the other is a survey that will collect information about the conservation practices being used in that field.



IowaNREC.org

Farmer Consent Statement

Information about my farming operation contained in my retailer's records may be used by aggregating it anonymously with information from other farms to demonstrate environmental progress by Iowa farmers statewide. My name, location, and practice information specific to my farm will be kept confidential.

I agree to the above statement and allow my information to be used as described.

☐ YES ☐ NO

X _____

Customer Signature Date

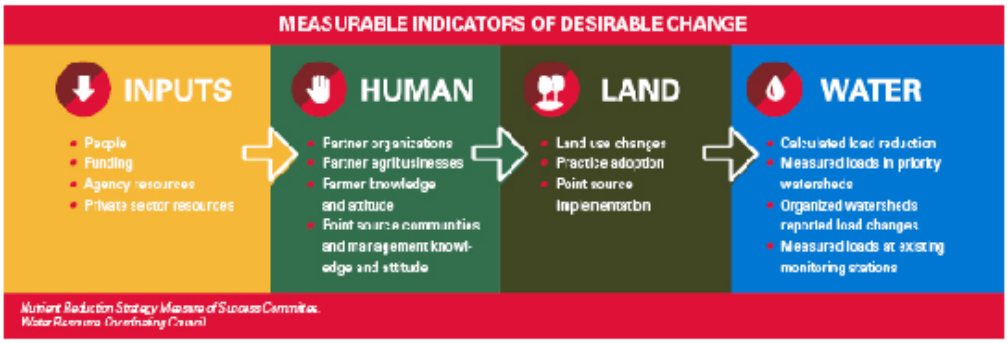
This project is supported by:

Appendix 5: "Stream Water-Quality Monitoring Conducted in Support of the Iowa Nutrient Reduction Strategy" report summary.

Iowa Nutrient Reduction Strategy
Stream Water Quality Monitoring in Iowa

Measuring Progress

The Iowa Nutrient Reduction Strategy (NRS) is a research- and technology-based approach to assess and reduce nutrients—nitrogen and phosphorus—delivered to Iowa waterways and the Gulf of Mexico by 45 percent. To measure progress, researchers track many different factors, from inputs (e.g. funding) and the human domain (e.g. farmer perspectives) to land management (e.g. on-farm practices) and water quality. Monitoring Iowa streams provides valuable insight into measuring water quality progress and the reduction of surface water nutrient loss. The Iowa Nutrient Reduction Strategy (NRS) aims to reduce the load, or total amount (e.g. tons), of nutrients lost annually. Researchers calculate the load from water monitoring results, which measure concentration combined with stream flow.



This handout serves as a summary of the collaborative report, titled "Stream Water Quality Monitoring Conducted in Support of the Iowa Nutrient Reduction Strategy", which can be accessed at http://nutrientstrategy.iastate.edu/documents.

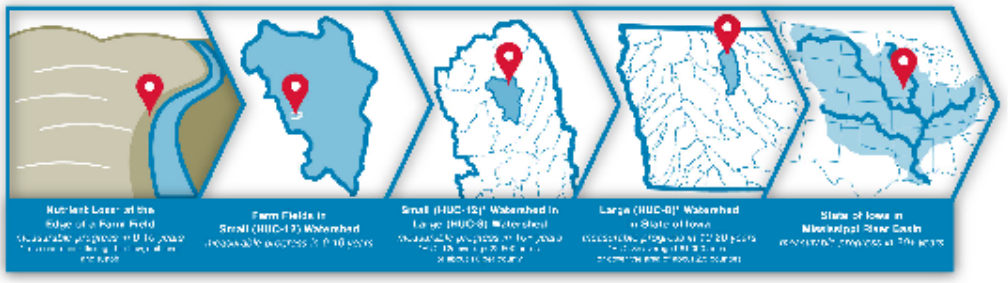
What are the Challenges in Tracking Progress Using Stream Water-Quality Monitoring Data?

While a wide array of monitoring projects are conducted in Iowa, there are a variety of key challenges that make it difficult to track progress in water quality over time. These challenges are continually evaluated and explored through research and continued monitoring.

- **Legacy Nutrients**: While nutrients are lost from land use and management, nitrogen and phosphorus that are already present in soil and groundwater can exit the system through surface water.
- **Lag Time**: After conservation practices are used in a watershed, it can take a significant amount of time, typically years, before the benefit is measured in the water depending on watershed size.
- **Limitations of Conservation Practice Data**: The use of conservation practices in a watershed must be well documented in order to attribute water quality changes to those practices.
- **Extreme Weather Events**: Heavy rains and severe droughts add complexity to measured changes in water quality, or make it difficult to effectively monitor. Climate change will increase the frequency of these events.
- **Locations of Monitoring Sites**: Selecting the appropriate location within a watershed area of a monitoring site is crucial to detecting changes that occur upstream.
- **Importance of Long-Term Data Collection**: Long-term records are often necessary to attribute water quality changes to conservation efforts (see framework on reverse side of handout).
- **Variable Precipitation and Stream Flow**: Precipitation is a factor that is highly variable, impossible to control, and significantly impacts nutrient loss; accounting for this variability in monitoring design and data analysis is a major challenge.

What kinds of surface water monitoring projects are happening in Iowa?

Many water monitoring projects are conducted across Iowa to gather data on the status of streams and rivers. Iowa may experience improved water quality at the outlets of small watersheds much sooner than at the outlets of large watersheds. To measure this change, current monitoring efforts target a variety of scales. Examples include, but are not limited to:



Large Watersheds

Hydrologic Unit Code (HUC) 8 or larger (about 961,000 acres, or about 2.5 counties in area)

- Iowa Department of Natural Resource's fixed-station network includes 60 monitoring sites throughout the state as of 2015. The data collection by these sites support a variety of projects, including the annual report of Iowa's water quality submitted to the U.S. Environmental Protection Agency and to the public.
- University of Iowa's IIHR—Hydroscience and Engineering manages 45 real-time monitoring stations that measure nitrate every 15 seconds.

Small Watersheds

HUC 12 size (about 22,500 acres, or about 16 per county)

- The Iowa Water Quality Initiative supports 23 demonstration projects, helping prioritize areas and identify practices that reduce nutrient loss. Eighteen projects focus on targeted small-scale watershed areas for implementing agricultural conservation practices. These small watersheds aim to implement conservation practices and monitor their effectiveness.

Paired Watersheds

- Two ongoing projects in Iowa examine paired small watersheds. In each project, one watershed receives targeted conservation practice implementation, while the other recieves no targeted practices and remains relatively the same. Water monitoring at the outlet of each watershed is conducted with the goal of eventually detecting the collective impact of conservation practices.

Edge-of-Field Monitoring

- Multiple organizations, including the Iowa Soybean Association and Iowa State University, are conducting monitoring at the edge of farm fields through farmer collaboration and on research sites. Efforts are underway to inventory and report on these efforts in detail by August 2017.

This summary and its accompanying report were developed collaboratively by:
Iowa Department of Natural Resources
Iowa Department of Agriculture and Land Stewardship
IIHR—Hydroscience and Engineering
Iowa State University College of Agriculture and Life Sciences

Appendix 6: Executive summary of "Assessment of the Estimated Non-Point Source Nitrogen and Phosphorus Loading from Agricultural Sources from Iowa During the 1980-96 Hypoxia Task Force Baseline Period"

The Iowa Nutrient Reduction Strategy (2013) is a science and technology-based framework to assess and reduce nitrogen and phosphorus flux to Iowa waters and the Gulf of Mexico. It is designed to direct efforts to reduce nutrients in surface water from both point and nonpoint sources. Its development was prompted by the 2008 Gulf Hypoxia Action Plan that calls for Iowa and other states within the Mississippi River watershed to reduce nutrient loadings to the Gulf of Mexico

To develop the strategy, the Iowa Department of Agriculture and Land Stewardship and the College of Agriculture and Life Sciences at Iowa State University partnered in October 2010 to conduct the Iowa Nutrient Reduction Strategy Nonpoint Source Science Assessment (INRS-NSSA). The assessment involved estimating nutrient loads over the 2006-2010 time period, reviewing scientific literature to assess potential performance of practices, estimating potential load reductions of implementing various scenarios involving nutrient reduction practices, and estimating implementation costs.

The initial INRS-NSSA estimated nitrate-N and phosphorus loads using land use and land information from the 2006-2010 time period. This period was used due to the availability of data. However, the 2008 Gulf of Mexico Action Plan states load reductions be "..measured against the average load over the 1980-1996 time period…". Efforts described herein provide estimates of nitrate-N and phosphorus loads from Iowa over this period. As possible, methods consistent with the original INRS-NSSA were employed. Lack of available data over this historic period provided a significant challenge and necessitated interpolation and other estimation for missing years. Assumptions made are detailed within each section. The effort relied heavily on data from the Census of Agriculture in 1982, 1987, 1992, and 1997.

The average nitrate-N load for the 1980-96 time period was estimated to be 292,022 tons, compared to 307,449 tons reported in the INRS-NSSA (Table ES-1). This represents an estimated 5% increase in nitrate-N load from the baseline period specified within the 2008 Gulf Hypoxia Action Plan until the start of the INRS-NSSA. Nitrate-N loads ranged from 273,909 tons in 1992 to 319,714 tons in 1997. Increased nitrate-N loads over this period were due primarily to the steady-to-slightly-increasing corn/soybean and continuous corn acreage and N application rate since the 1980-96 time period.

The average phosphorus load for the 1980-96 time period was estimated to be 21,436 tons, compared to 16,800 tons reported in the INRS-NSSA. This represents an estimated 22% reduction in phosphorus load from the baseline period specified within the 2008 Gulf Hypoxia Action Plan until the start of the INRS-NSSA. Phosphorus loads ranged from a high of 24,797 tons in 1982 to 16,800 tons for the period reported within the INRS-NSSA. Reduced phosphorus loads were primarily due to fewer acres under intensive tillage, and a significant increase in no-till acreage from the 1980-96 time period.

Limitations resulting from data availability and additional research needs are identified within appropriate report sections and summarized within a *Limitations and Future Needs* section. Issues identified include incorporating additional information on the impact of changes in precipitation on water yield and nutrient loads; structural conservation practices; stream bed and bank contribution to phosphorus loads; variable rate nutrient application; and changes in nitrogen content in grain. Load estimates in this assessment account only for changes to loading due to agricultural land management practices and did not consider any point source loading changes.