

## **Minutes of NCERA217: Drainage Design and Management Practices to Improve Water Quality Annual Meeting and NCERA217 Station Reports**

Annual Meeting: April 14-15, 2015 at the Hilton Garden Inn, Ames, IA.

**Members Present:** Jane Frankenberger (IN), Eileen Kladviko (IN), Tim Harrigan, (MI), Gary Feyereisen (MN), Gary Sands (MN), Jeff Strock (MN), Matt Helmers (IA), Christopher Hay (SD), Xinhua Jia (ND), Dan Jaynes (IA), Kelly Nelson (MO), Richard Cooke (IL), Mohamed Youssef (NC), Jeppe Kjaersgaard (SD) and Ramesh Kanwar (Administrative advisor).

Guests present: There were an additional 55 guests present during the meeting.

### **Meeting Overview**

#### *Pre-meeting field tour*

A pre-meeting field tour was organized by Matt Helmers from Iowa State University on April 14 8:00-12:00 noon with the following stops:

- Iowa State University new ABE building
- USDA-ARS drainage water quality research facility
- Iowa CREP wetland – discussion of wetland performance by Dr. Bill Crumpton
- Saturated buffer in Story county, IA with discussion of performance by Dr. Dan Jaynes

### **NCERA217 Meeting Presentations**

The NCERA217 meeting began at 1:00 pm on April 14 with presentations by NCERA217 committee members and other drainage professionals. The afternoon session ran from 1:05 – 4:45 pm and was moderated by Jeppe Kjaersgaard. Chair Mohamed Youssef welcomed all attendees and presented results from an ongoing controlled drainage study where he observed substantial subsurface lateral flow, and reported on work on setting up DRAINMOD for agency personnel to use. Eileen Kladviko reported on 29 years of drainage research in Indiana, including impacts of tile spacing and the use of cover crops on effluent nitrate-nitrogen concentrations. Chris Hay reported on nitrate-nitrogen reduction results from four bioreactors installed in South Dakota, a recently started phosphorus adsorption study, and yield benefits from a field plot study in SE SD. Matt Helmers reported on nitrate-nitrogen concentrations in the effluent from a comparison study between native prairie, continuous corn and continuous corn with cover crops, and discussed a yield comparison from fields with and without subsurface drainage. Jeff Frey from the USGS discussed nitrate-nitrogen concentrations in Midwest streams following the dry year 2012. Dan Jaynes discussed results from multiple saturated buffers installed in Iowa. The following presentations focused primarily on phosphorus losses and pathways. William Crumpton from Iowa State discussed phosphorus export at the network scale, including concentrations, loads and pathways. Merrin Macrae

from Agri-Food Canada presented on phosphorus studies and loss through the subsurface drainage. TQ Zhang from Agri-Food Canada discussed phosphorus loss pathways related to inorganic fertilize and cattle manure application. Gary Fayereisen presented on the effect of alternative inlet designs on sediment and phosphorus losses through subsurface drainage systems. The meeting was adjourned at 4:45.

The NCERA217 meeting continued on April 15 with a mini-symposium on drainage water retention from 9:00 am – 12:00 noon with the speakers below:

- Managing Water for Increased Resiliency of Drained Agricultural Landscapes , Jane Frankenberger, Purdue
- Drainage water retention in Manitoba, Merrin Macrae, University of Waterloo
- Wetland reservoir subirrigation systems in Ohio: What was learned, Barry Allred, USDA-ARS
- Drainage capture and use in the Red River Valley, Xinhua Jia, NDSU
- Integrated water management systems in Missouri, Kelly Nelson, U. Missouri
- Drainage capture and use in Ontario, Canada, Chin Tan, Agriculture and Agri-Food Canada
- Coupling landscape water storage and supplemental irrigation, John Baker, USDA ARS

Starting at 1:00 pm, Paul Sweeney presented an NRCS report on the current status of drainage water management and the Ag Water Management Team. Members of the Agricultural Drainage Management Coalition Board introduced themselves and spoke of the importance they see for managing drainage. Nathan Utt gave an update on saturated buffers that are being monitored around the region by ADMC, funded by a Conservation Innovation Grant. Rob Sampson, NRCS National Water Management Engineer, led a discussion on the interim Saturated Buffers standard. Beth Clarizia (NRCS Indiana) discussed efforts to provide NRCS funding for ponds, which has been infrequent in recent years. Jeff Frey of USGS demonstrated several on-line tools being made available by USGS. A brief discussion of the Des Moines Water Works lawsuit was provided by Dan Jaynes and John Torbert of the Iowa Drainage District Association. Katie Flahive of USEPA discussed recent EPA studies related incorporating to drainage water management into watershed planning. Chris Hay stated that the recorded presentations on drainage water management developed by extension agricultural engineers in several states are available for everyone at <http://www.conservationwebinars.net/webinars/dwm-module-2-1>. This group is also developing a webinar series and possibly other educational material, and information will be sent to the ADMS mailing list (this activity is further discussed in the station report from South

Dakota). Gary Sands presented an overview of the plans for the 2016 International Drainage Symposium, and invited everyone to the planning meeting to be held in the evening.

The meeting adjourned at 4:45 pm, and all were invited to the kick-off meeting to the new eight-state project *Managing Water for Increased Resiliency of Drained Agricultural Landscapes* and to see the new Agricultural and Biosystems Engineering Building at Iowa State University.

### **NCERA217 Business meeting**

The NCERA217 business meeting was called to order on April 14, 2015 at 5:00 pm by Chair Mohamed Youssef.

- 1) Administrative Advisor Ramesh Kanwar welcomed the NCERA217 members to Ames, IA. Dr. Kanwar congratulated project partners from NCERA217 on the recent award from the USDA NIFA Water for Agriculture program.

He indicated the NCERA217 group is a very well organized group with very well attended meetings and suggested the group should be awarded the Experiment Station Director's Award of Excellence. Ramesh will provide more information about this award. Matt Helmers, Dan Jaynes and Gary Sands volunteered to coordinate with Ramesh.

NCERA217's USDA NIFA liaison Mary Ann Rozum has retired and it is unclear who will be the new liaison. Dr. Kanwar will follow up with the USDA to clarify.

NCERA217 has been renewed through October 2019. Members are not automatically transferred from the NCERA217\_old to the new one, so all members should check to make should they are registered correctly. The NIMSS system is under revision which should make the revision easier.

- 2) Update on drainage-related session at the Agronomy/Soil Science/Crop Science Societies Annual Meeting in Minneapolis, MN November 15-18 2015. Jeppe Kjaersgaard provided an update on the drainage sessions:
  - a. Oral symposium: Reducing Nitrogen Loss Through Subsurface Drainage: Practices, Efficiencies and Impacts.
  - b. Poster session: Case studies in Managing Denitrification in Agronomic Systems
- 3) Jane Frankenberger gave an update on the multi-state and multi-institutional USDA NIFA award for the *Managing Water for Increased Resiliency of Drained Agricultural Landscapes* Project. The project is about to hire a project manager. The project has a 15-

member project team, 9 project collaborators and has already established a 10-member project advisory board. The project kick-off meeting is scheduled to be held on April 16.

- 4) Jane Frankenberger provided an update on the International Drainage Symposium scheduled for September 2016 in Minneapolis. The Soil and Water Conservation Society will likely be the sponsoring organization. A conference flyer will be developed for the symposium and distributed among NCERA217 members to distribute. Several individuals volunteered to help with organizing the conference and a kickoff meeting was scheduled for April 15, 2015.
- 5) Election of new secretary: Chair Mohamed Youssef asked for nominations. Gary Feyereisen was nominated. Since no other nominations were made, Mohamed Youssef closed the nomination and opened the election. Gary Feyereisen was elected.

The business meeting was adjourned at 5:55 pm by Chair Mohamed Youssef. The business meeting reconvened on April 15, 2015 at 8:00 am.

- 6) Suggestions for location and time for next year's meeting. North Carolina, Purdue and Arkansas were suggested. One concern was whether industry representatives would consider NC too far outside their area, but those present said it would not be a problem, so should be considered for future meetings. The decision was to hold it in March 2016 at Purdue. Next year's meeting will likely include three activities: i) NCERA217/ADMS, ii) International Drainage Symposium Discussions, and iii) Managing Water for Increased Resiliency of Drained Agricultural Landscapes Project meeting.

The business meeting was adjourned on April 15, 2015 at 8:15 am. Minutes respectfully submitted by Jeppe Kjaersgaard.

### **Accomplishments - Station Reports**

*Iowa – Matt Helmers, Iowa State University:* Research and extension efforts at Iowa State University relative to drainage design and management practices to improve water quality continue to center on nutrient export from tile drainage systems and nutrient management practices to minimize this export of nutrients, specifically nitrate-nitrogen. Work is also continuing that is evaluating drainage water management and cropping practice impacts on drainage volume and drainage water quality. Water quality and water quantity are being monitoring from seven drainage water quality research sites.

Work continued in 2014 examining the impacts of manure (poultry and liquid swine) on drainage water quality. This work is continuing to examine nutrient loss but has been expanded to include bacteria and antibiotic resistant bacteria assessments.

Extension work has focused on disseminating information relative to drainage water quality and economic design of drainage systems. This has included statewide, regional, and local programming events. In collaboration with colleagues at the University of Minnesota and South Dakota State University, the 15th IA-MN-SD Drainage Research Forum was held in November 2014 and was attended by approximately 85 stakeholders. In August 2014, an Iowa Drainage School was held near Nashua, IA that focused on hands-on design of drainage systems. Approximately 45 individuals participated in this event.

An outcome from the IA-MN-SD Drainage Research Forum is that we are providing research-based information on drainage water quality to stakeholders including state agency personnel in Iowa and the Midwest with a goal of improving the knowledge of drainage water quality issues and practices that can be used to minimize drainage water quality impacts. Feedback from the IA-MN-SD Drainage Research Forum continues to indicate attendees valued the research based presentations, the cooperation of Iowa State University, University of Minnesota, and South Dakota State University on drainage issues, and the mix of basic and applied studies that were presented at the meeting.

*Iowa – Dan Jaynes, USDA-ARS:* In this project we are investigating the efficacy of reconnecting tile drainage to shallow ground water flow through riparian buffers for removing nitrate. By diverting a fraction of the tile discharge through a distributary tile installed along the top of the buffer, we are diverting a fraction of the tile water into shallow ground water flow through the buffer. We hypothesis that both denitrification and sequestration processes known to be active in buffers will remove nitrate before it can enter the adjacent stream, Figure 1.

We have monitored performance of saturated buffers installed at Bear Creek and the Maass farm over the past year. These results, plus results from Bear Creek in previous years are shown above. Currently, none of the nitrate being diverted into the buffers appears to be reaching the streams. We assume the nitrate loss is due to denitrification and are testing this assumption at several sites. Annual flow diversion into the buffers has ranged from 35 to 64% of the total tile-outlet discharge. Annual nitrate removal in the buffers has ranged from 55 to 290 kg-N. We will continue to monitor these sites plus new sites installed as part of the Iowa Water Quality Initiative.

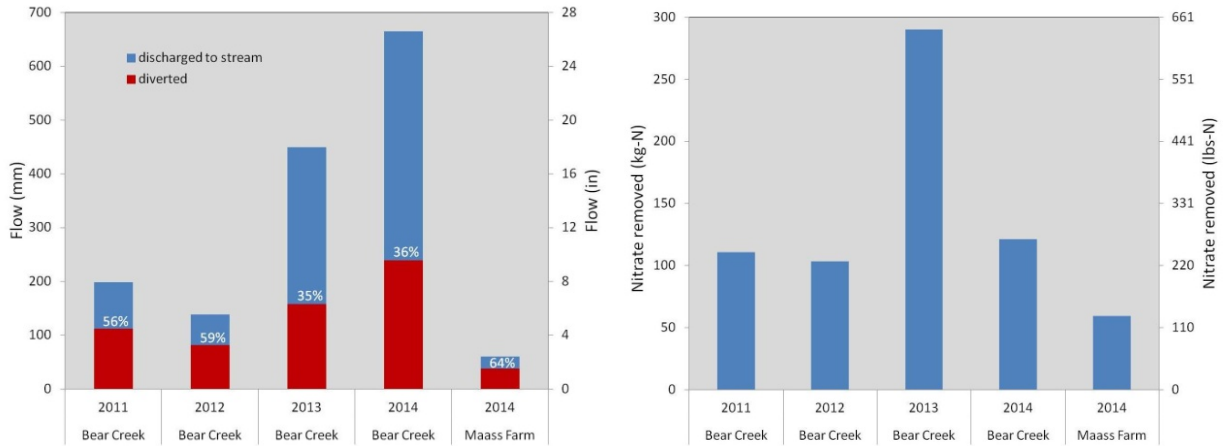


Figure 1. Flow into and nitrate removed at Bear Creek and Maass farm buffer from 2011 – 2014.

*North Dakota – Xinhua Jia, North Dakota State University: Project 1: Effect of optimal water management for sustainable and profitable crop production and improvement of water quality in Red River Valley by Xinhua Jia, Thomas F. Scherer, Dean D. Steele, and Thomas M. DeSutter.* Despite unusual weather, the research and education programs progressed well in 2014. Due to an extended cooler than normal spring, the growing season was delayed until mid to late May. There were frequent rainfall events in June followed by cooler than normal temperatures in July. Unfortunately, the period for optimizing water management using the controlled drainage system could only be done from July 22 to September 4. For research purposes, water could only be added to the subirrigation field for two weeks in late July and August. The crop yields varied from the Clay County average by -20.8%, 48.9%, 38.2%, and 53.6% for the undrained, free drained, control drained, and control drained plus subirrigated fields, respectively. The low yield in the undrained field was due to excessive waterlogging stress in June when the water table was less than 60 cm from the soil surface for 37 days. Water quality monitoring indicated that higher nitrate-N concentrations and electrical conductivity (EC) were found in drainage outflow than that from the surface drainage. A distinct difference in water quality between the subsurface water and surface water was observed from the four fields. Control drainage implies less water and less nitrate-N in the surface water, but an annual water balance for the controlled drainage and subirrigation field showed a 54.2 mm deficiency between inflow and outflow, which implies an adequate water supply for crop use. In addition, the field was used as an outside classroom for an NRCS workshop where the research team was the main presenters.

Project 2: Subirrigation with high sodium adsorption ratio groundwater and its effect on soil and water quality by Xinhua Jia, Thomas F. Scherer, and Dean D. Steele. A subirrigated field in Fairmount ND was planted with corn on May 20. The corn germinated on May 26, and was

harvested on October 23, 2014. Water balance, water level, water quality, soil quality, soil salinity map, and crop yield were measured or monitored during the growing season. The water balance analysis showed that water added to the field through rainfall and subirrigation was roughly equivalent to the outflow via crop water requirement and drainage. Rainfall mainly occurred in June while subirrigation was applied in July and August when the crop needed more water. Water flowed from the tile until late spring and also in the fall in response to rain events. The highest crop water requirement occurred in late July when irrigation was added. The water level changes in the outlet structures and in the field clearly showed how water was managed during drainage and subirrigation periods. Water quality monitoring results showed that nitrate was highest in the spring from the tile outlets, upstream and downstream of the field in the surface drain on the north side of the field. Corn yield at the research site was 6.5% higher than that in a corn field at the surrounding area but with soybean as the previous crop, and 19.5% higher than the county average corn yield. Subirrigation water use efficiency was high, greater than 100%, indicating all water applied was used by the crop or soil moisture was depleted. Soil chemical analysis at different distances from the drain tile indicated that there was no build-up of sodium around the drain due to higher sodium adsorption ratio in subirrigation water source. This implied that it was safe to subirrigate using the groundwater at this stage.

*Michigan – Tim Harrigan, Michigan State University: The symposium - A Matter of Balance-- Feeding our Crops, Protecting our Water in a Changing Climate Symposium organized and presented jointly with the MI Chapter of the Soil and Water Conservation Society and Michigan State University Extension. March 6, 2015, Kellogg Center, Michigan State University - was largely an extension of new work and educational programming presented at the 2014 NCERA 217 meeting in Findlay, OH. Dr. Dave Baker, guest speaker at the NCERA 217 meeting kicked off the symposia with a presentation titled Long-Term Trends in Agricultural Runoff to Lake Erie: Causes, Consequences and Remedies. Larry Geohring, NCERA 217 member made two presentations, Water and Contaminant Movement Through Soils: Facts and Fallacies and Using Controlled Drainage and Bioreactors to Reduce Water Quality Impacts from Tile Drain Discharges. The symposium was well attended with 78 paid attendees. On a scale of 1-5 with five being best, the respondents overall impression averaged 4.4 and all reported that the information gained would help their professional development. The most common comment regarding how they benefited was in a greater understanding of soluble phosphorus and how it moves in the soil.*

*North Carolina – Mohamed Youssef, North Carolina State University: DRAINMOD-based tools for quantifying reductions in annual drainage flow and nitrate losses resulting from drainage water management on croplands in North Carolina and the U.S. Midwest. A new generation of drainage water control structures have been designed to minimize the time and cost of drainage water management. These structures can be adjusted to automatically open and close*

according to a preset schedule. A smart water management system has been designed to manage the outlets of the drainage systems depending on the soil water conditions in the field. The new structures are being demonstrated in two demonstration sites. Continued to experimentally investigate the effects of drainage water management on crop yield and N export to surface waters. We collect and analyze hydrologic, water quality and yield data for two artificially drained agricultural sites in eastern North Carolina; Experimental research is underway to assess the effectiveness of controlled drainage and bioreactor systems in reducing N export to surface waters from land application of liquid animal waste to subsurface drained fields. The DRAINMOD-DSSAT model has been developed and field tested. DRAINMOD-DSSAT is a field scale, process based model that simulates the hydrology, soil carbon and nitrogen dynamics, and crop growth for agricultural lands. A new version of DRAINMOD is currently being developed to simulate the fate of phosphorus in drained agricultural land. The results of our research have shown that both controlled drainage and bio-reactor systems have the potential to be used as BMPs for reducing nutrient export from drained spray fields. Our research could lead to the adoption of these two practices by the state of North Carolina to reduce nitrogen losses to surface waters from land application of animal waste to drained fields.

*Missouri – Kelly Nelson, University of Missouri:* Field research was initiated on claypan and silty clay (river bottom) soils to evaluate the impacts of managed drainage systems on crop production and water quality from 2009 to 2013. In addition, demonstration sites on drainage water management in Northwest Missouri near Oregon and Albany are ongoing (2013-present). Long-term crop production research is still evaluating integrated water management systems (2001-present) as well as corn response to drainage water management on claypan (2010-present) and river bottom (2010-present) soils. Managed drainage research evaluating nitrate-N loss in a poorly drained, river bottom soil as well as yield response, nitrate-N loss, and ortho-P loss in a claypan soil was completed.

Poorly-drained, river bottom soils (Wabash) can be high corn (*Zea mays* L.) yielding environments, but saturated soil conditions often reduce corn yields. This research evaluated whether the use of managed subsurface drainage (MD) in combination with a controlled release N fertilizer could reduce the annual amount of nitrate-N loss through tile drainage water compared to free subsurface drainage (FD) with a non-coated urea application. Nitrogen fertilizer source did not affect nitrate-N loss through tile drainage water flow, which was likely due to limited corn uptake over the three-year study due to adverse weather conditions. Averaged over three years, MD reduced tile water drained 52% and nitrate-N loss 29% compared to FD.



Poorly-drained claypan soils in the midwestern United States commonly have wet soil conditions in the spring and dry soil conditions in the summer. Management practices that can improve or mitigate the effects of excessive wet and dry soil conditions are essential to obtain maximum corn yield potential and may reduce N and P loss. Averaged over 2010 to 2013, the presence of drainage (FD or MD) increased corn yield (15–21%) compared to ND when non-coated urea was applied. Managed drainage systems in claypan soils from 2010 to 2013 increased corn yields 4% compared to free drainage. Flow-weighted ortho-P concentration in the tile water was significantly lower with MD (0.09 mg L<sup>-1</sup>) compared with that of FD (0.15 mg L<sup>-1</sup>). Ortho-P loss in the tile water of this study was reduced with MD (36 g ha<sup>-1</sup>) by 80% compared with FD (180 g ha<sup>-1</sup>). Due to dry conditions over the summer and fall months, MD reduced the annual amount of water drained by at least 73% compared with FD in two of the four crop years. Low N loss and reduced corn N uptake possibly resulted in carry-over N and high soil N concentrations throughout the study, which may have limited the effect of N fertilizer source on annual nitrate-N loss in the tile drainage water. Use of MD reduced annual nitrate-N loss in the tile drainage water by 78 to 85% in two of the four years. High nitrate-N loss reduction with MD compared with FD was largely due to dry growing season conditions in combination with wet conditions over the noncropping period.

*Indiana – Jane Frankenberger and Eileen Kladviko, Purdue University:* Purdue University research is assessing the impact of tile drains of nitrate export at the field and watershed levels, and the impact of drainage water management on hydrologic parameters including flow, soil moisture, and water table, as well as nitrate. Field research conducted at the Southeast Purdue Agriculture Center has provided data for advancing the new DRAINMOD-DSSAT drainage and water quality models (Ngem et al., 2014). To facilitate sharing field data among researchers, including across institutions, detailed research protocols were developed to standardize the types of measurements taken and the specific details such as depth, time, method, numbers of samples, and minimum data set required from each site (Kladviko et al., 2014).

Subsurface tile drainage is an important contributor to the high nitrate load in Midwestern watersheds, but the magnitude of its influence at the watershed scale is not well-known. We quantified the relationship between flow-weighted mean concentration (FWMC) of nitrate-N and the subsurface tile-drained area of the watershed, using long-term flow and nitrate data from 25 watersheds (Jiang et al., 2014). This relationship may further the understanding of the impact of agricultural drainage practice on water quality and provide a tool for estimating the potential effectiveness of management strategies that reduce field-scale nitrate-N loss to reduce nitrate-N loss at the watershed scale.

We have educated people about drainage strategies to improve water quality at numerous local, statewide, and regional presentations and workshops. We have collaborated with USDA-

NRCS through participating as an advisor on their internal Ag Water Management Team, working together on the Agricultural Drainage Management Systems Task Force, and providing regional training for staff.

*South Dakota – Chris Hay, South Dakota State University:* South Dakota State University has a continuing project to evaluate the performance and utility of denitrifying bioreactors in removing nitrate from tile drain water and assess the production of nitrous oxide, an intermediate product of the denitrification process and a greenhouse gas. Four bioreactors have been installed and are being monitored: one near Baltic, SD (installed in July 2012), one near Montrose, SD (December 2012), one near Arlington, SD (July 2013), and one near Hartford, SD (November 2014).

The bioreactor project has been expanded to evaluate potential materials for phosphorous adsorption that could be added in series to the bioreactor for phosphorous reduction. The products have been evaluated at the lab scale. Products evaluated include minerals (limestone, zeolite, and calcite) and industrial by-products (steel chips, steel turnings, steel slag, and iron filings). The industrial by-products showed the most promise at the lab scale. A phosphorous adsorption bed is being designed using the by-products for installation and field testing later in 2015.

Work continued on plot-scale research at the SDSU Southeast Research Farm near Beresford, SD. The study is set up in a split-plot design with drainage as the whole-plot treatment and nitrogen as the split-plot treatment. The tile plot area was in corn in 2014.

There were no statistically significant yield differences among the drainage treatments in 2014. However, the yield variability was much greater for the undrained plots. There was also no significant differences in shallow groundwater nitrate concentration among the treatments. There were differences in soil penetration resistance among the plots, with the drained plots having greater resistance.

A project investigating the impact of subsurface drainage on evapotranspiration (ET) using a remote sensing approach. The METRIC (Mapping Evapotranspiration at high Resolution with Internalized Calibration) model was used with Landsat imagery to estimate ET from three locations with fields in the same crop with similar management and soils but where one field (or area) was drained and the other was not. In three out of the four site years, there was no significant difference in ET from the drained and undrained fields. ET was nearly identical for corn regardless of drainage, but differences were greater for soybean. Differences were usually greatest in the spring with more ET from the undrained fields. In the one instance where there were statistically significant differences, the results were confounded by insect damage that

impacted yield in the drainage field and may have explained more of the difference in ET than the drainage.

*Extension drainage programming.* Extension activities were focused on educating producers and the public on drainage and the impacts of drainage on hydrology and water quality. These activities have included a number of local and regional presentations and events. A series of three drainage design workshops were held during the winter in the region in collaboration with University of Minnesota and North Dakota State University Extension. These workshops were targeted at producers, contractors, and others interested in drainage design. The workshops served a total of approximately 120 attendees. The IA-MN-SD Drainage Research Forum was held in November 2014 in Ames, Iowa. The forum presented basic and applied drainage-related research results to stakeholders and updates on drainage policy issues and had a keynote address on the history and future of drainage research in celebration of the 15th anniversary of the event. A series of web-based drainage calculators were developed to assist with common drainage calculations. The calculators feature a responsive web design which enables them to adapt to the platform on which they are being used (desktop, laptop, tablet, or smartphone).

### **Impact Statements**

- 1) *All NCERA217 members:* The NCERA group has published 27 peer reviewed publications in the past year in addition to well over 60 presentation, non-peer reviewed publications and extension materials.
- 2) *Iowa – Matt Helmers, Iowa State University:* The research information generated on drainage water quality was utilized heavily in developing the Iowa Nutrient Reduction Strategy Non-point Source Science Assessment. This information has been essential for educational activities with stakeholders in Iowa. Being able to report on results from Iowa is important for gaining confidence of these stakeholders. We continue to assist with subsurface drainage bioreactor design without Iowa and the broader cornbelt region.
- 3) *Iowa – Matt Helmers, Iowa State University:* With Greg Brenneman and Kapil Arora the 8th Iowa Drainage School was organized. Participants rate this program as good to excellent and nearly all participants indicate that the program will help them design more effective drainage systems that will improve their bottom line.
- 4) *Iowa – Dan Jaynes, USDA-ARS:* The research has quantified the potential nitrate removal capacity and water quality benefits from reconnecting a portion of field tile flow to riparian buffers. The research has led to a CIG grant from NRCS, an AFRI grant from NIFA, and an NRCS Interim Conservation Standard # 739 “Vegetated Subsurface Drain Outlet” for the practice.

- 5) *North Dakota – Xinhua Jia, North Dakota State University:* Our project site 1 was included as a field tour for two day long drainage water management (DWM) training sessions for Natural Resource Conservation Service (NRCS) personnel. Over 50 NRCS employees visited the site and heard presentations by the project leader, Xinhua Jia, as well as the land owner, Mr. Jerry Zimmerman. The project site installation and yield results have been and will continue to be used in Drainage Design Workshop presentations by Extension engineers as an example of one method of subirrigation. The landowner, Mr. Zimmerman, was a guest presenter at Drainage Design Workshop held in Grand Forks. He provided the farmer/tile installer perspective to the workshop attendees.
- 6) *North Carolina – Mohamed Youssef, North Carolina State University:* The development of the smart agricultural water management system including the automated drainage water control structure will lead to the revitalization of controlled drainage in eastern NC where large areas of agricultural lands are artificially drained. This will result in a potential increase in crop production, reduction in production cost, conservation of water, and substantial improvement in surface water quality.
- 7) *North Carolina – Mohamed Youssef, North Carolina State University:* The continued advancements in the DRAINMOD suite of models will enhance the field of agricultural drainage research since these models are widely used by the drainage research community.
- 8) *Indiana – Jane Frankenberger and Eileen Kladviko, Purdue University:* NCERA-217 participants developed a coordinated agricultural project proposal which was funded by USDA NIFA in the Water for Agriculture program. This new project, which includes 15 NCERA-217 participants either as Co-PIs or collaborators, will advance three drainage management practices: drainage water management, saturated buffers, and drainage water recycling. These practices retain drainage water in different parts of the landscape, in order to two challenges that are expected to be exacerbated by climate change: crop loss due to increased seasonality of precipitation, and water quality degradation from drained land. The project will bring together field research that has been conducted across the region, and add drainage water recycling field sites to provide data needed for future decision making. It will extend estimates of benefits and costs through modeling, both temporally to account for future climate change, and spatially across the region. It will develop strategies and tools to apply the research findings in decision-making on the farm, in watersheds, and in state and national policy.
- 9) *South Dakota – Chris Hay, South Dakota State University and other NCERA217 members:* Participants in the drainage design workshops rated the programs as very useful or useful. Participants indicated that they gained knowledge on drainage system layout, drainage calculations, and drainage design considerations. They also indicated that this

knowledge would give them more confidence in designing drainage systems and help them avoid mistakes. The drainage calculators received over 1,400 page views in the first month, with an average session duration of over 5 minutes, indicating that users were using the site and not just moving on.

**10) South Dakota – Chris Hay, South Dakota State University:** the Baltic bioreactor is installed adjacent to the area used for the annual field day organized by the private company, Ag PhD. This field day primarily attracts producers. The bioreactor installation was on display at the field day along with some of the preliminary results. The field day attracted approximately 5000 attendees.

### **Publications published by NCERA217 members**

#### *Peer reviewed*

- Qi., Z., R. Singh, M.J. Helmers, and X. Zhou. 2015. Evaluating the performance of DRAINMOD using soil hydraulic parameters derived by various methods. *Agricultural Water Management* 155: 48-52.
- Wang, Z., Z. Qi, L. Xue, M. Bukovsky, and M. Helmers. 2015. Modeling the impacts of climate change on nitrogen losses and crop yield in a subsurface drained field. *Climatic Change* 129(1-2): 323-335.
- Kladivko. E.J., M.J. Helmers, L.J. Abendroth, D. Herzmann, R. Lal, M. Castellano, D.S. Mueller, J.E. Sawyer, R.P. Anex, R.W. Arritt, B. Basso, J.V. Bonta, L. Bowling, R.M. Cruse, N.R. Fausey, J. Frankenberger, P. Gassman, A.J. Gassmann, C.L. Kling, A. Kravchenko, J.G. Lauer, F.E. Miguez, E.D. Nafziger, N. Nkongolo, M. O'Neal, L.B. Owens, P. Owens, P. Scharf, M.J. Shipitalo, J.S. Strock, and M.B. Villamil. 2014. Standardized research protocols and database development for transdisciplinary understanding of corn systems and climate. *Journal of Soil and Water Conservation* 69(6): 532-542.
- Daigh, A.L., M.J. Helmers, E. Kladivko, X. Zhou\*, R. Goeken, J. Cavadini, D. Barker, and J. Sawyer. 2014. Soil water during the drought of 2012 as affected by rye cover crop in fields in Iowa and Indiana. *Journal of Soil and Water Conservation* 69(6): 564-573.
- Daigh, A.L., X. Zhou, M.J. Helmers, C.H. Pederson, R. Horton, and R. Ewing. 2014. Subsurface drainage flow and soil water dynamics of reconstructed prairies and corn rotations for biofuel production. *Vadose Zone Journal* doi:10.2136/vzj2013.10.0177.
- Garder J.L., Moorman T.B., Soupir M.L. 2014. Transport and Persistence of Tylosin-Resistant Enterococci, erm Genes, and Tylosin in Soil and Drainage Water from Fields Receiving Swine Manure. *Journal of Environmental Quality* 43:1484-1493. DOI: 10.2134/jeq2013.09.0379.
- Ikenberry C.D., Soupir M.L., Schilling K.E., Jones C.S., Seeman A. 2014. Nitrate-Nitrogen Export: Magnitude and Patterns from Drainage Districts to Downstream River Basins. *Journal of Environmental Quality* 43:2024-2033. DOI: 10.2134/jeq2014.05.0242.
- Moorman, T.B., Tomer, M.D., Smith, D.R., and Jaynes, D.B. Evaluating the potential role of denitrifying bioreactors in reducing watershed-scale nitrate loads: A case study comparing three CEAP watersheds. *Ecol. Engin.* 75:441-448. 2015.

- Kladivko E.J., Kaspar T.C., Jaynes, D.B., Malone, R.W., Singer, J., Morin X., K. and Searchinger, T. Case study analysis of the potential reduction of nitrate leaching losses through the expanded use of cover crops in the upper Midwest. *Journal of Soil and Water Conservation*, 69(4):279-291. 2014
- Malone R.W., Jaynes D.B., Kaspar T.C. Thorp, K.R., Ma, L., James, D.E., Kladivko E.J., Singer, J.W. Morin X.K., Searchinger, T.D. Simulated potential water quality impact of fall-planted cover crops across the Midwestern USA. *Journal of Soil and Water Conservation*, 69(4):292-305. 2014.
- Jia, X., T. F. Scherer, D. Lin, X. Zhang, and I. Rijal. 2014. Comparison of reference evapotranspiration calculations for southeastern North Dakota. *Irrigation & Drainage Systems Engineering* 2:112. doi:10.4172/2168-9768.1000112.
- Rahman, M. M., Z. Lin, X. Jia, D. D. Steele, and T. M. DeSutter. 2014. Impact of subsurface drainage on streamflows in the Red River of the North basin. *Journal of Hydrology* 511: 474-483.
- Amira, O., Kumar, A., Harrigan, T., Angelakis, A. and Xagorarakis, I. 2014. Effects of Biosolids and Manure Application on Microbial Water Quality in Rural Areas in the U.S. *Water* 2014, 6(12), 3701-3723; doi:10.3390/w6123701
- Hamaamin, Y.A., Adhikari, U., Nejadhashemi, A.P., Harrigan, T., Reinhold, D.M. 2014. Modeling *Escherichia coli* removal in constructed wetlands under pulse loading. *Water Res.* 2014 Mar 1;50:441-54. doi: 10.1016/j.watres.2013.10.052
- Adhikari, U., T. Harrigan and D. Reinhold. 2014. Use of duckweed-based constructed wetlands for nutrient recovery and pollutant reduction from dairy wastewater. *Ecol. Eng.* (2014) <http://dx.doi.org/10.1016/j.ecoleng.2014.05.024>
- Tilak, A.S., M.R. Burchell II, M.A. Youssef, R.R. Lowrance, and R.G. Williams. 2014. Field testing the Riparian Ecosystem Management Model on a riparian buffer in the North Carolina upper coastal plain. *Journal of American Water Resources Association* 50 (3): 665-682.
- Negm, L.M., M.A. Youssef, R.W. Skaggs, G.M. Chescheir, J. Jones. 2014. DRAINMOD-DSSAT model for simulating hydrology, soil carbon and nitrogen dynamics, and crop growth for drained agricultural land. *Agricultural Water Management* 137: 30-45.
- Negm, L.M., M.A. Youssef, R.W. Skaggs, G.M. Chescheir, E.J. Kladivko. 2014. DRAINMOD-DSSAT simulation of the hydrology, nitrogen dynamics and plant growth of a drained corn field in Indian. *Journal of Irrigation and Drainage Engineering* 140 (8): 04014026.
- Nash, P., K. Nelson, and P. Motavalli. 2014. Reducing nitrogen loss in subsurface tile drainage water with managed drainage and polymer-coated urea in a river bottom soil. *J. Water Resource and Protection* 6:988-997.
- Nash, P.R., K.A. Nelson, P.P. Motavalli, and S.H. Anderson. 2015. Corn yield response to managed drainage and polymer-coated urea. *Agron. J.* 107:435-441. doi:10.2134/agronj14.0273.
- Nash, P.R., K.A. Nelson, P.P. Motavalli, M. Nathan, and C. Dudenhoefter. 2015. Reducing phosphorus loss in tile water with managed drainage in a claypan soil. *J. Environ. Qual.* 44:585-593 doi:10.2134/jeq2014.04.0146.

- Nash, P., K. Nelson, and P. Motavalli. 2015. Reducing nitrogen loss with managed drainage and polymer-coated urea. *J. Environ. Qual.* 44:256-264. doi:10.2134/jeq2014.05.0238.
- Jiang Y., Y. Sui, J. Frankenberger and L. C. Bowling, 2014. Estimation of Nonpoint Source Nitrate Concentrations in Indiana Rivers Based on Agricultural Drainage in the Watershed, *J. American Water Resource Association*, 50.6 (2014): 1501-1514. doi: 10.1111/jawr.12216
- King, K. W., Williams, M. R., Macrae, M. L., Fausey, N. R., Frankenberger, J.R., Smith, D. R., Kleinman, P.J., & Brown, L. C., 2014. Phosphorus transport in agricultural subsurface drainage: A review. *Journal of Environmental Quality*. doi: 10.2134/jeq2014.04.0163.
- Kladvik, E.J., M.J. Helmers, L.J. Abendroth, D. Herzmann, R. Lal, M.J. Castellano, D.S. Mueller, J.E. Sawyer, R.P. Anex, R.W. Arritt, B. Basso, J.V. Bonta, L.C. Bowling, R.M. Cruse, N.R. Fausey, J.R. Frankenberger, P.W. Gassman, A.J. Gassmann, C.L. Kling, A. Kravchenko, J.G. Lauer, F.E. Miguez, E.D. Nafziger, N. Nkongolo, M. O'Neal, L.B. Owens, P.R. Owens, P. Scharf, M.J. Shipitalo, J.S. Strock, M.B. Villamil. Standardized research protocols enable transdisciplinary research of climate variation impacts in corn production systems. *Journal of Soil and Water Conservation*, 69(6):532-542, doi:10.2489/jswc.69.6.532.
- Negm, L.M., M.A. Youssef, R.W. Skaggs, G.M. Chescheir, and E.J. Kladvik. 2014. DRAINMOD-DSSAT simulation of the hydrology, nitrogen dynamics, and plant growth of a drained corn field in Indiana. *J. Irrig. Drain Eng.* 140.8. doi: 10.1061/(ASCE)IR.1943-4774.0000738.)

#### *Non-peer reviewed publications*

- Kjaersgaard, J., K. Khand, C. Hay, and X. Jia. 2014. Estimating evapotranspiration from fields with and without tile drainage using remote sensing. ASCE World Environmental & Water Resources Congress (EWRI) Annual Meeting, June 1-5, 2014, Portland, Oregon.
- Nash, P.R., K.A. Nelson, and P.P. Motavalli. 2014. Ammonia and Nitrous Oxide Gas Loss with Subsurface Drainage and Polymer-Coated Urea Fertilizer in a Poorly-Drained Soil. Abstr. ASA-CSSA-SSSA. On-line.
- Nelson, K.A., P.R. Nash, and P.P. Motavalli. 2014. Corn Yield Response to Managed Drainage and Polymer-Coated Urea Fertilizer in a Poorly-Drained, Claypan Soil. Abstr. ASA-CSSA-SSSA. On-line.
- Nash, P.R., K.A. Nelson, and P.P. Motavalli. 2014. Reducing Phosphorus Loss in Tile Drainage Water with Managed Drainage in a Bottomland Soil. Abstr. ASA-CSSA-SSSA. On-line.
- Kaur, G., B. Zurweller, P. Motavalli, and K. Nelson 2014. Nitrogen fertilizer management of temporarily waterlogged soils to improve nitrogen availability and corn production. Abstr. ASA-CSSA-SSSA. On-line.
- Motavalli, P., K.A. Nelson, and P.R. Nash. 2014. Crop and soil management practices for adaption to temporarily waterlogged soils caused by climate change in the Midwestern United States. Abstr. ASA-CSSA-SSSA. On-line.

- Zurweller, B., P. Motavalli, K. Nelson, and R. Udawatta. 2014. Nitrogen fertilizer management of temporarily flooded soils to improve corn production and reduce environmental N loss. Greenley Memorial Research Center Field Day Report. pp. 4-16.
- Kaur, G., P. Motavalli, K. Nelson, and F. Fritschi. 2014. Use of nitrogen fertilizer sources to enhance tolerance and recovery of new corn hybrids to excessive soil moisture. Greenley Memorial Research Center Field Day Report. pp. 17-27.
- Nash, P., and K. Nelson. 2014. Maximizing forage production in a poorly-drained, blackoar soil with subsurface drainage systems. Greenley Memorial Research Center Field Day Report. pp. 61-68.
- Nash, P., K. Nelson, P. Motavalli, M. Nathan, and C. Dudenhoeffer. 2014. Reducing phosphorus loss in tile water with managed drainage in claypan soil. Greenley Memorial Research Center Field Day Report. p. 69.
- Nash, P., K. Nelson, and P. Motavalli. 2014. Reducing nitrogen loss in subsurface tile drainage water with managed drainage and polymer-coated urea in a river bottom soil. Greenley Memorial Research Center Field Day Report. p. 70.
- Nelson, K., and C. Dudenhoeffer. 2015. MU Drainage and Subirrigation (MUDS) research update for claypan soils. Greenley Memorial Research Center Field Day Report. pp. 71-81.
- Karki, G., C. Hay, J. Kjaersgaard, and T. Trooien. 2014. Design drainage intensity for eastern South Dakota. ASABE Paper No. 141914059. St. Joseph, Mich.: ASABE.
- Karki, G., C. Hay, T. Trooien, and J. Kjaersgaard. 2014. Calibration of DRAINMOD in South Dakota for Houdek soil series (state soil of South Dakota). ASABE Paper No. SD14-065. St. Joseph, Mich.: ASABE.
- Khand, K., J. Kjaersgaard, C. Hay, and X. Jia. 2014. Estimating evapotranspiration from drained and undrained agricultural fields using remote sensing. ASABE Paper No. 1829687. St. Joseph, Mich.: ASABE.
- Partheeban, C., J. Kjaersgaard, C. Hay, and T. Trooien. 2014. Demonstrating the nitrogen-removal effectiveness of denitrifying bioreactors for improved drainage water management in South Dakota. ASABE Paper No. 141911325. St. Joseph, Mich.: ASABE.

#### *Extension presentations and publications*

##### *Matt Helmers – Iowa State University*

- January 28, 2015 – Presentation on “Field to stream nitrate reduction: Nutrient management, cover crops, bioreactors, and wetlands” at the Crop Advantage Series meeting in Iowa City, IA (45 attendees)
- January 22, 2015 – Presentation on “Field to stream nitrate reduction: Nutrient management, cover crops, bioreactors, and wetlands” at the Crop Advantage Series meeting in Waterloo, IA (65 attendees)
- January 15, 2015 – Presentation on “Use of prairie strips for reducing sediment and nutrient loss” at the Crop Advantage Series meeting in Moravia, IA (18 attendees)



- January 9, 2015 – Presentation on “Field to stream nitrate reduction: Nutrient management, cover crops, bioreactors, and wetlands” at the Crop Advantage Series meeting in Burlington, IA (25 attendees)
- January 7, 2015 – Presentation on “Iowa Nutrient Reduction Strategy: Opportunities for local watershed improvement” at the Crop Advantage Series meeting in Okoboji, IA (25 attendees)
- December 18, 2014 – Presentation on “Iowa Nutrient Reduction Strategy: One Farm Many Practices” as part of the United Suppliers Sustain Training (35 attendees)
- December 11, 2014 – Presentation on “Benefits of Drainage” at Drainage Workshop in Stanhope, IA (75 attendees)
- December 11, 2014 – Presentation on “Water quality impacts of drainage” at Drainage Workshop in Stanhope, IA (75 attendees)
- December 5, 2017 – Presentation on “Landuse Impacts on Drainage” at the Iowa Drainage District Association Annual Meeting in Fort Dodge, IA (85 attendees)
- December 4, 2014 – Presentation on “Cover Crops, Bioreactors, and Wetlands for Nitrate Reduction” at the Integrated Crop Management Conference in Ames, IA (405 attendees)
- November 20, 2014 – Presentation on “Iowa Nutrient Reduction Strategy: Cover Crops and Bioreactors” at the Iowa Learning Farms workshop near Washington, IA (45 attendees)
- November 6, 2014 – Presentation on “Practices to Reduce Nutrient Loss from Agricultural Lands” to Leadership Iowa group (45 attendees)
- November 5, 2014 – Presentation on “Practices to Reduce Nutrient Loss from Agricultural Lands” to Ames High School Environmental Science class (205 attendees)
- October 21, 2014 – Training for Ag Leader on Drainage Design (20 attendees)
- October 1, 2014 – Presentation on “Iowa Nutrient Reduction Strategy: One Farm Many Practices” as part of the United Suppliers Sustain Training (35 attendees)
- September 24, 2014 – Presentation on “Iowa Nutrient Reduction Strategy: One Farm Many Practices” as part of the United Suppliers Sustain Training (35 attendees)
- September 12, 2014 – Presentation on “Iowa Nutrient Reduction Strategy: Cover Crops and Prairie Strips” at the Iowa Learning Farms workshop near Williams, IA (55 attendees)
- September 3, 2014 – Presentation on “Iowa Nutrient Reduction Strategy: One Farm Many Practices” as part of the United Suppliers Sustain Training (35 attendees)
- June 23, 2014 – Presentation on “Iowa Nutrient Reduction Strategy” at the SERA-17 annual meeting in Des Moines, IA (75 attendees)
- June 26, 2014 – Presentation on “Drainage Water Management” at the Southeast Iowa Summer Field Day (95 attendees)
- June 26, 2014 – Presentation on “Iowa Nutrient Reduction Strategy: One Farm Many Practices” at the Southeast Iowa Summer Field Day (55 attendees)
- June 19, 2014 – Presentation on “Water Quality Benefits of Prairie Strips” at the Iowa Learning Farms field day in Elkadar, IA (15 attendees)

- June 11-12, 2014 – Presentation on “Soil Loss and Drainage” at the Water Rocks! Teacher Summit in Ames, IA (35 attendees)
- October 28, 2014 – Presentation “Design of Drainage Water Management Systems” as part of Regional Drainage Training for NRCS in South Dakota (35 attendees)
- October 2, 2014 – Presentation on “Water Quality Benefits of Prairie Strips” at the North Central Water Conference in Minneapolis, MN (35 attendees)
- August 6, 2014 – Presentation on “Drainage Water Management Systems” as part of Sustainable Corn annual meeting in Ames, IA (75 attendees)
- August 1, 2014 – Presentation “Design of Drainage Water Management Systems” as part of Regional Drainage Training for NRCS in Iowa (25 attendees)
- July 30, 2014 – Presentation “Design of Drainage Water Management Systems” as part of Regional Drainage Training for NRCS in Iowa (35 attendees)
- June 17, 2014 – Presentation “Design of Drainage Water Management Systems” as part of Regional Drainage Training for NRCS in Missouri (25 attendees)
- May 14, 2014 – Panel Participation on Nutrient Loss from Agricultural Lands at the Food and Agriculture Conference in Minneapolis, MN (125 attendees)

*Dan Jaynes – USDA-ARS*

- Gave presentation “The Iowa Nutrient Strategy”, at Iowa Water Environment Association Region 4 annual meeting, 4 Apr. 2013, Carson, IA, 200 IAWEA members.
- “Saturated stream buffer test: Farmers divert tile water into streamside grass buffers to remove nitrates”, Corn and Soybean Digest, Jan 30, 2014 by Liz Morrison. <http://cornandsoybeandigest.com/conservation/saturated-stream-buffer-test>
- Gave invited presentation “ Nitrogen Use Efficiency Research in the United States Department of Agriculture” at the 2014 Tetrapartite meeting, 3-6 Jun, 2014, Vancouver, CA. Agriculture Directors from US, Canada, United Kingdom, and France.
- Gave invited presentation “Saturated Buffers”, to Iowa chapter of the Iowa Soil and Water Conservation Society, 26 Sep, 2014, Nevada, IA. 50 SWCS members.
- Gave invited presentation “Saturated Buffers”, at NE Iowa Project Coordinator Fall Meeting, 15 Oct, 2014, Elkader, IA. 20 Coordinators, NRCS, IDALS, IA DNR personnel.
- Toured David White, former NRCS Chief, Chris Adamo, Senate Ag Committee Majority Staff Director, Sean McMahon, Executive Director, Iowa Water Alliance and Jeff Moore, lobbyist for municipal wastewater treatment facilities to see saturated buffer, drainage water management, and bioreactor sites in Mid-Iowa. 27 Oct, 2014,
- Gave two presentations on saturated buffers at 2014 Minnesota Board of Water and Soil Resources Academy, Breezy Point, MN, 29 Oct, 2014. 150 MN government employees taking courses.
- Gave invited presentation “Saturating Riparian Buffers in Tile Drained Landscapes for Nitrate Removal” at 2015 Waseca County Farmer Forum, 11 March, 2015, Waseca, MN. 150 farmers and state agency personnel.
- Gave interview for article “Saturated buffer zone keeping pollutant out of Hamilton County stream” by Larry Kershner appearing in the 20 March 2015 issue of Farm News and in the 22 March 2015 Sunday edition of the Ft. Dodge Messenger.

- Interviewed by Donnelle Eller for article in the Des Moines Register on Saturated Buffers to appear in April 2015.

*Xinhua Jia – North Dakota State University*

- Jia, X. 2015. Drainage capture and use in the Red River Valley. Mini-Symposium on Drainage Retention at NCERA 217 Annual Meeting. April 15, 2015. Ames, IA.
- Roy D., X. Jia, and D.D. Steele. 2015. Infiltration. Written for presentation at the North Central American Society of Agricultural and Biological Engineers Conference, 10-11 April 2015, Fargo, North Dakota. Presentation No. RRV15-031.
- Wamono A.W., D.D. Steele, Z. Lin, T. DeSutter, and X. Jia. 2015. Effects of calcium amendments on infiltration rates of subsurface drained sodic soils. Written for presentation at the North Central American Society of Agricultural and Biological Engineers Conference, 10-11 April 2015, Fargo, North Dakota. Presentation No. RRV15-031.
- Steele, D.D., A.W. Wamono, T. DeSutter, Z. Lin, and X. Jia. 2015. Measuring Chisel Plow Draft on a Sodium-Affected Soil. Written for presentation at the North Central American Society of Agricultural and Biological Engineers Conference, 10-11 April 2015, Fargo, North Dakota. Presentation No. RRV15-046.
- Jia, X., D. Steele, T. Scherer, K. Kolars, and K. Horntvedt. 2014. Measuring subirrigation efficiency and uniformity on two subirrigation fields in the Red River Valley. 2014 Eastern South Dakota Water Conference. October 29, 2014. Brookings, SD.

*Tim Harrigan – Michigan State University*

- Harrigan, T.M. 2014. Potential Links between Tile Drainage and the Re-eutrophication of Lake Erie. Presentation for the Nutrient Utilization sub-committee of the Generally Accepted Agricultural and Management Practices (GAAMPS). April 29, MSU PSMS Field Lab.
- Harrigan, T.M. 2015. On the re-eutrophication of Lake Erie Michigan State University Extension News. March 25, 2015.