**PROJECT ACTIVITY NUMBER:** **NCERA-217**

**DURATION:** October 1, 2019 through September 30, 2024

**TITLE:** Drainage design and management practices to improve water quality

**STATEMENT OF ISSUE AND JUSTIFICATION:**

Nitrogen (N) and phosphorus (P) pollution of surface water from nonpoint sources is a serious problem nationwide, particularly in the Midwest USA. Much of this region is characterized by land use dominated by row crop agriculture (i.e., corn, soybean, small grains), and by the extensive use of subsurface drainage systems (a.k.a., tile drainage) and maintained ditches to manage soil water conditions. Hypoxia in the Gulf of Mexico has been a serious problem since the mid 1980’s, and this is largely attributed to nutrient enrichment of marine waters by N and P entering the Gulf from the Mississippi River (Alexander et al., 2008). A federal task force recommended a 45% reduction in N and P loads entering the Gulf of Mexico from the Mississippi River to reduce the long-term average area of the Gulf hypoxic zone to 5,000 km2 or less (Greene et al., 2009). States including Illinois, Iowa and Minnesota have responded to the need to meet nutrient reduction targets within their states and beyond state borders by developing nutrient reduction strategies based on scientific and economic assessment of practices with potential to achieve nutrient reduction goals (IDALS, IDNR, & ISU, 2013; MPCA, 2014; IEPA, & IDOA, 2015).

These serious environmental water quality issues are exacerbated by the prevalence of artificially improved drainage in the Midwest and across other regions of the country (e.g., Carolina coastal plain, Delmarva Peninsula). Agricultural producers install artificial drainage (tiles and ditches) on their land to improve trafficability while reducing compaction, allow for timely planting during wet spring periods and increase crop yields. Approximately 57 million acres of artificially drained agricultural land exists in the United States, with 41 million acres of drained cropland present in the Midwest alone, which corresponds to as much as 50% of all cropland in some states being subsurface drained. These lands are among the most productive in the world, but only if adequate drainage is provided. Achieving new and ongoing water quality goals while maintaining adequate drainage systems for these highly productive areas will be a necessary but a monumental task.

A renewal of this committee is needed because many critical issues and questions remain concerning drainage impacts on water quantity and quality, and particularly on the relationship among the various drainage management practices that may reduce contaminant loading. In addition to critical research needs, there is continued need for coordination of Extension products and activities to significantly advance towards crop production and water quality goals. Specifcally, there is a critical need to develop improved drainage designs and management strategies that maintain crop production benefits to meet the supply of a safe and abundant food supply while reducing nutrient loss to our nation’s waters. Several approaches have the potential to reduce the negative water quality impacts of crop production on subsurface drained lands. These approaches include the use of alternative crop rotations and cover crops, adjusting the timing and rate of fertilizer application to better match crop uptake, redesign and management of drainage systems to reduce drainage outflows and promote in-field denitrification, installation of drainage water treatment systems that work by enhancing denitrification (i.e., wetlands, bioreactors, saturated buffers, and two-stage ditch design) and drainage water capture and use for supplemental irrigation using on-farm reservoirs. Currently, researchers across the North Central Region are investigating these and other approaches for reducing nutrient and other contaminant losses from drained croplands. While research has shown promising results, there is continued need for coordination and interaction among the different state researchers as well as facilitation of Extension products and activities. Given the critically important function and the large regional nature of Gulf hypoxia and freshwater eutrophication across the Midwest and the nation, a multistate research and extension effort is required.

**ACCOMPLISHMENTS OF NCERA 217:**

The current project has developed a number of new and effective drainage design and management options, all of which reduce nutrient delivery to our nation’s waters, while maintaining strong crop productivity. For example, the committee studied the effectiveness of edge-of-field structures across the Midwest, NY, NC, and Canada and worked with USDA-NRCS to establish design standards for these practices (e.g., Conservation Practice Standard #554 “Drainage Water Management,” CPS #604 “Saturated Buffer,” and CPS #605 “Denitrifying Bioreactor”). The importance of these Practice Standards cannot be understated. Each standard details the official federal design specifications required for any cost-shared instance of the given practice. Impressively, this means that the committee’s work has informed every single instance of these practices across the country. The existence of these standards means farmers can apply for cost-sharing of these practices, dramatically increasing producer interest.

The committee’s applied research and outreach has importantly led to many of our recommendations being adopted by the Mississippi River/Gulf of Mexico Hypoxia Task Force and by many of the Mississippi basin states in developing individual state strategies for nutrient reduction as required by USEPA. Our committee efforts have led the USDA-NRCS to establish the National Ag Water Management (AGWAM) Team to increase the adoption of improved drainage practices with a focus on the Upper Mississippi River Basin, the Great Lakes Basin, and the Red River of the North. In these ways, our work has moved beyond the field to positively influence policy and the adoption of improved practices.

More overtly, in the past four years, we have generated at least: 122 peer-reviewed publications; 78 Extension and non-refereed publications; 262 presentations to farm, research, and state/federal agency audiences; and two national ASABE extension excellence awards for regional publications. Committee members led development and planning of the 10th International Drainage Symposium with 250 attendees representing the U.S., Denmark, Canada, Ireland, Finland, Norway, Sweden, Latvia, Lithuania, and the Netherlands (134 presentations/abstracts which resulted in publication of 14 papers in special issues of the Transactions of the ASABE and Applied Engineering in Agriculture). Collaborative efforts among committee members resulted in multi-institutional and cross-disciplinary projects totaling more than $30M including funding by the USDA-NRCS-CIG program, USDA-NIFA-AFRI, and the Foundation for Food and Agriculture Research. The committee was recently awarded the 2018 Experiment Station Section Award for Excellence in Multistate Research (to be officially awarded in November 2018 at the APLU meeting).

**OBJECTIVES AND PROCEDURES:**

*1. Evaluate alternative drainage design, drainage conservation practices, soil and crop management practices and drainage management to reduce nutrient loss from drained farmland.* Research in many of the North Central states is currently underway to develop and evaluate different drainage design (e.g., shallow drainage), drainage conservation practices (e.g., controlled drainage, denitrifying bioreactors, saturated buffers, constructed wetlands), and drainage management (e.g., controlled drainage, on-farm storage/drainage water recycling and ditch management). Research is also being conducted on subsurface drainage to evaluate different in-field management practices for reduction of nutrient losses into tiles, including the use of cover crops, fertilizer practices, tillage and crop rotation. While the committee continues to focus on N losses from drained lands, the committee will also investigate the impact of drainage on phosphorus fate and transport. This objective mainly addresses water quality issues related to drinking water and the Hypoxic zone in the northern Gulf of Mexico. There is a critical need for researchers from different states to meet regularly and exchange information about their research findings.

*2. Assess the role of drainage in emerging areas such as soil health, food, energy security, greenhouse gas emissions, pathogens, pharmaceuticals, and loss of agrochemicals in drainage water.* Although the main emphasis of the committee will be on crop yield impacts and nutrient leaching into subsurface drains, the committee will continue to investigate other emerging issues. Emerging areas include but not limited to soil health, greenhouse gas emissions, pathogens, pharmaceuticals,and transport of agrochemicals in drainage water (i.e., herbicides, pesticides, insecticides, fungicides). These emerging areas combined with drainage water quality/quantity and crop production have the potential to impact health, food, and energy security due to the importance of drained lands for agricultural production. As a result, there is a need for coordinated research efforts in these areas. The committee will facilitate the exchange of information on these emerging issues and help coordinate new research on these topics.

*3. Improve our understanding of the impact of climate change on drainage water quantity and quality.* Much of the North Central region is experiencing increased climate variability and with this comes increasing interest in and concern about the interaction of drainage and climate change. Specific areas of concern relate to the hydrologic impacts of drainage and how drainage system design might be influenced by climate variability. Although annual precipitation is roughly in balance with crop water use in the Midwest, rainfall does not always occur when it is needed by the crops. Excess water in the spring makes artificial drainage essential for allowing timely field work. Excess water can negatively impact soil aeration of the root zone in the early growing season, while water deficit during summer is another reason that crop yields fail to reach their potential. Since this need spans the Corn Belt, there is a need for coordination of research activities and sharing of information.

*4. Foster collaboration on Extension and outreach programming to maximize impact and to create and implement strategies to facilitate communication among scientists and policy makers.* This objective promotes partnership with stakeholders interested in drainage, soil and crop management, and environmental quality in agricultural landscapes. There is a need to collaborate regionally to enhance the impact of state-level Extension programs. The committee will include extension personnel and an NRCS representative to coordinate the development of educational materials for drainage design and management for improved water quality and quantity. The committee will work with the Agricultural Drainage Management Systems Task Force (ADMSTF) to assess needs for technical bulletins and other educational material. Many of the representatives of the North Central committee are also participating in meetings of the ADMSTF, which will facilitate communication and coordination between the groups. The ADMSTF is a collaborative effort of USDA-ARS, USDA-NRCS, and Land-Grant Universities primarily from Minnesota, Iowa, South Dakota, North Dakota, Missouri, Illinois, Indiana, Ohio, Michigan, New York and North Carolina. The group also includes members from USGS, USEPA, and Canadian scientists. This group also interacts closely with the Agricultural Drainage Management Coalition (ADMC), which is a coalition of the agricultural drainage industry that educates farmers, policy makers, and drainage and conservation groups about the latest technology in the drainage area.

**INTERNAL AND EXTERNAL LINKAGES:**

The team consists of 22 core members (agricultural engineering, agronomy, crop, plant and soil sciences) from 13 institutions (LGU and non-LGU), USDA-ARS and USDA-NRCS, and other collaborators (state and federal government agencies, industry, NGOs). Our annual meeting includes presentations from all these groups to provide a comprehensive update spanning research, outreach, policy, and industry issues. Moreover, we include a graduate student poster session to encourage younger scientists and continue our momentum into the future. NCERA-217 works closely with SERA-46 “Framework for Nutrient Reduction Strategy Collaboration: The Role for Land Grant Universities” on drainage issues within the Mississippi watershed. We are strongly integrated with the drainage industry; for example, industry members formed the ADMC (see above) to work with this committee in developing and promoting new technologies for reducing tile drainage nutrient losses.

**EXPECTED OUTCOMES AND IMPACTS:**

1. Coordination of research programs in drainage design and management for reduced contaminant losses in subsurface drains.
2. Exchange of information about research studies on nutrient and water recycling, soil health, greenhouse gases and climate change as they pertain to artificial agricultural drainage.
3. Identification of key research needed to improve water quality from drained lands in the North Central region and other critical drained areas of the US.
4. Publication of joint research articles on contaminant losses to subsurface drains in studies from several states.
5. New extension materials to support the implementation of improved drainage and cropping management practices on drained lands.
6. Improved water quality, resulting from implementation of improved management practices on drained lands.

**EDUCATION PLAN:** Extension materials and programs developed or coordinated by the committee will be available through standard channels, and in additional ways identified by the ADMSTF.

**GOVERNANCE:** Standard

**BUDGET:** Travel expenses for annual meetings only.

**AUTHORIZATION:**

**APPENDIX 1 – LITERATURE CITED**

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**APPENDIX 2 – DRAINED LANDS WITHIN THE TWELVE STATE NORTH CENTRAL REGION**

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