Drainage Design & Management Practices to Improve Water Quality

NCERA-217 (2009-2014)

Drainage Improves Agricultural Land, but Impacts Surrounding Environment

Tile drainage lines run under the surface of agricultural lands and channel water off the farm, sometimes causing erosion and depositing nutrients and chemicals at the end of the line. USGS photo.

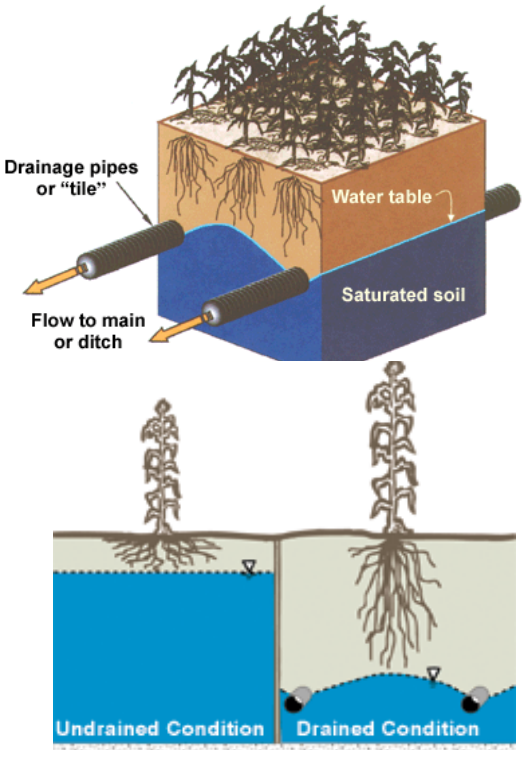
In the North Central US, farmers often need to improve drainage on their land. Drainage reduces soil compaction, makes it easier for farm machinery to work on the land, enhances field conditions for planting and harvesting operations, and decreases crop damage from excess moisture. In a subsurface—or "tile"—drainage system, a network of "tile lines" are installed below ground. These pipe-like lines channel excess water from the soil off the field. Despite the benefits of draining agricultural lands, subsurface drainage systems can lead to water quality issues. Nitrate, phosphorous, chemicals, and bacteria from fertilizers, pesticides, and manure that were applied to the land can make their way through the drainage system into lakes, streams, rivers, and groundwater. To simultaneously meet production goals and minimize negative environmental impacts, farmers need improved drainage systems. Cover crops, vegetated buffers, more efficient use of fertilizers, and other agronomic management practices may complement improved drainage system designs and minimize environmental impacts; however, more information is needed to use these practices effectively and economically.

Multistate Research Project Tests Drainage Systems & Water Quality

For the past five years, Multistate Research Project NCERA-217 coordinated research and extension to improve agricultural drainage design and management. Bringing together scientists with a range of technical expertise and cross-regional perspectives, NCERA-217's findings are nuanced and broadly applicable.

Early on, NCERA-217 developed new models to evaluate the impacts of various drainage systems on hydrology, nutrient loss, and crop yield. To identify effective drainage designs, researchers tested different drainage depths and intensities. Scientists also ran tests to quantify the water quality benefits of placing different structures—like bioreactors, saturated buffers, wetlands, and vegetated ditches—at the edge of fields to remove nitrates and phosphorus from drainage water. Based on study results, the group worked with USDA-NRCS to help establish design standards for some of these practices. NCERA-217 also quantified the amount of nitrate that various land covers, such as living mulch, winter cover crop, perennial grass, and native prairie, were able to prevent from entering into subsurface drainage systems.

Other studies indicated that phosphorous transport to subsurface drains is most likely to occur in soils with pores greater than one millimeter in diameter and in cracked soils where liquid manure or inorganic fertilizers have been applied to the surface. Building on these findings, NCERA-217 researchers identified practices that can help reduce phosphorus transport via the subsurface drainage system. These practices include tilling the soil above the tile lines before applying fertilizer to fields, avoiding applications on wet ground and less than one full day before a forecasted rainfall, and using lower application rates.



Subsurface drainage systems improve agricultural lands and promote healthier crops. Graphics by University of Minnesota Extension.

Improved Drainage Reduces Water Quality Problems, Sustains Productive Farms

NCERA-217 findings were used by state governments to develop drainage practice standards that improve water quality. For example, Iowa's response to the Gulf of Mexico Task Force Action Plan relied on research results from many group members. At the national level, the NRCS developed Interim Conservation Standards #739 "Vegetated Subsurface Drain Outlet" and #747 "Denitrifying Bioreactor" as well as Conservation Practice Standard #554 "Drainage Water Management" based on the group's work. These standards are a necessary first

step toward farmers adopting sustainable practices. For example, since a national conservation standard was put in place, farmers can apply for cost-share to install subsurface drainage bioreactors, dramatically increasing producer interest in this practice.

Because of NCERA-217's Extension efforts, farmers have adopted improved drainage water management techniques and cropping system management practices. University of Minnesota education programs increased adoption of controlled drainage practices that are decreasing drain outflow and nutrient losses. The development of an automated drainage water control structure and effective bioreactors is trailblazing the revitalization of controlled drainage in eastern North Carolina. Because of Cornell University outreach activities, producers, contractors, and confined animal feed operation advisors are paying more attention to vulnerable subsurface drainage outlets and adjusting their manure application methods, rates, and timing accordingly. Furthermore, the drain spacing calculator developed by NCERA-217 has been used in 44 countries and 36 states. The DRAINMOD models developed by NCERA-217 are being used by researchers worldwide. These models are essential tools for assessing climate change adaptation strategies for forests and agricultural systems on drained lands.

Implementing improved drainage water management has led to a significant reduction in nitrogen, phosphorus, and other contaminant losses from drained lands and a dramatic reduction of water quality problems associated with nutrient enrichment. Best management practices for the land application of manure and biosolids on drained land have reduced contamination of surface and groundwater and lowered health risks. Using these systems has allowed farmers to drain land and boost crop yields without degrading the surrounding environment. Improving drainage has also reduced variability in crop yields from year to year, which allows a more stable source of food for consumers and predictable profits for farmers.

Extension Improves Awareness & Boosts Adoption

Members of NCERA-217 acquired more than $27,000,000 in outside grants to extend research and education efforts on drainage-related issues. The group developed strategies to facilitate communication between scientists and policymakers and promoted partnerships with stakeholders. Several NCERA-217 members used funds to create publications, bulletins, web sites, and other educational materials about drainage design and management systems. NCERA-217 scientists also gave TV and radio interviews, and numerous popular press articles were written about the project. Members gave presentations at a wide variety of meetings and conferences for state and national level trade and regulatory organizations. The group also hosted drainage schools and DRAINMOD workshops. Participants at the Iowa Drainage School indicated that the program will help them design more effective drainage systems that will improve their bottom lines. Participants at NCERA-217 workshops reported gaining useful knowledge that gave them more confidence in designing drainage systems and avoiding mistakes. Thousands of stakeholders attended field days organized by NCERA-217 members. Face-to-face discussions and hands-on learning at these events increased participants' awareness of the value of protecting soil and water quality and increased their knowledge of new techniques and tools for managing drainage.

USDA-ARS ecologist Matt Moore and soil scientist Martin Locke assess the biomass of plants growing in a vegetated drainage ditch and test to see how well the ditch reduces agricultural pesticide and nutrient runoff. USDA photo by Peggy Greb.

Want to know more?

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Impact Statement compiled by Sara Delheimer.