Testimony of Kent Rodelius

Agricultural Drainage Water Management Coalition

House Agriculture Committee

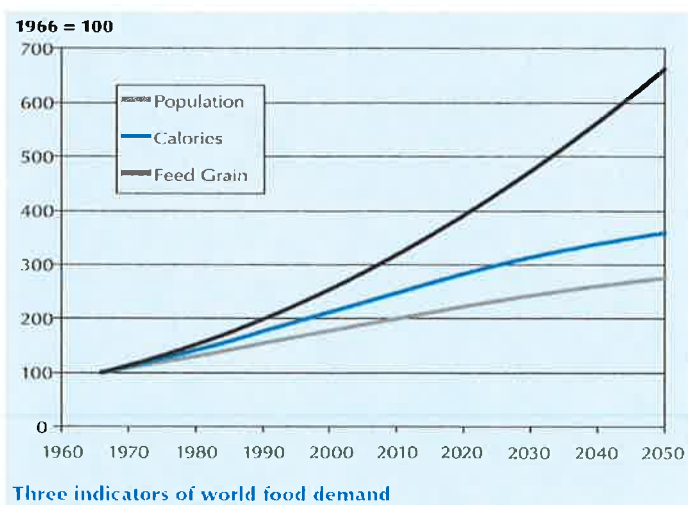
Subcommittee on Conservation and Forestry

March 1, 2016

Mr. Chairman, Ranking Member, and Members of the Subcommittee, thank you for the opportunity to testify before you today. I am Kent Rodelius, Vice President of the Agricultural Drainage Water Management Coalition[1] and am here today representing that group. I am also the Agricultural Sales Manager at Prinsco and Chair of the Associates for the National Land Improvement Contractors of America. The purpose of the ADMC is to promote public and private partnerships committed to improving water quality, wildlife habitat, and agronomics through water management, research and education.

I have personally worked in the drainage industry traveling the Midwest for the past 30 years.

It is estimated that we will soon have 9 billion people in the world to feed. And demand will grow well beyond just population growth.



Source: Iowa State, Bruce Babcock

We have the land resources, technology and seed varieties to feed the world but without managing our water we will not be able to meet this challenge.

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[1] The ADMC is a collaboration of agricultural producers, agricultural industry corporations, conservation groups and others to advance water quality and agricultural productivity. http://admcoalition.com/

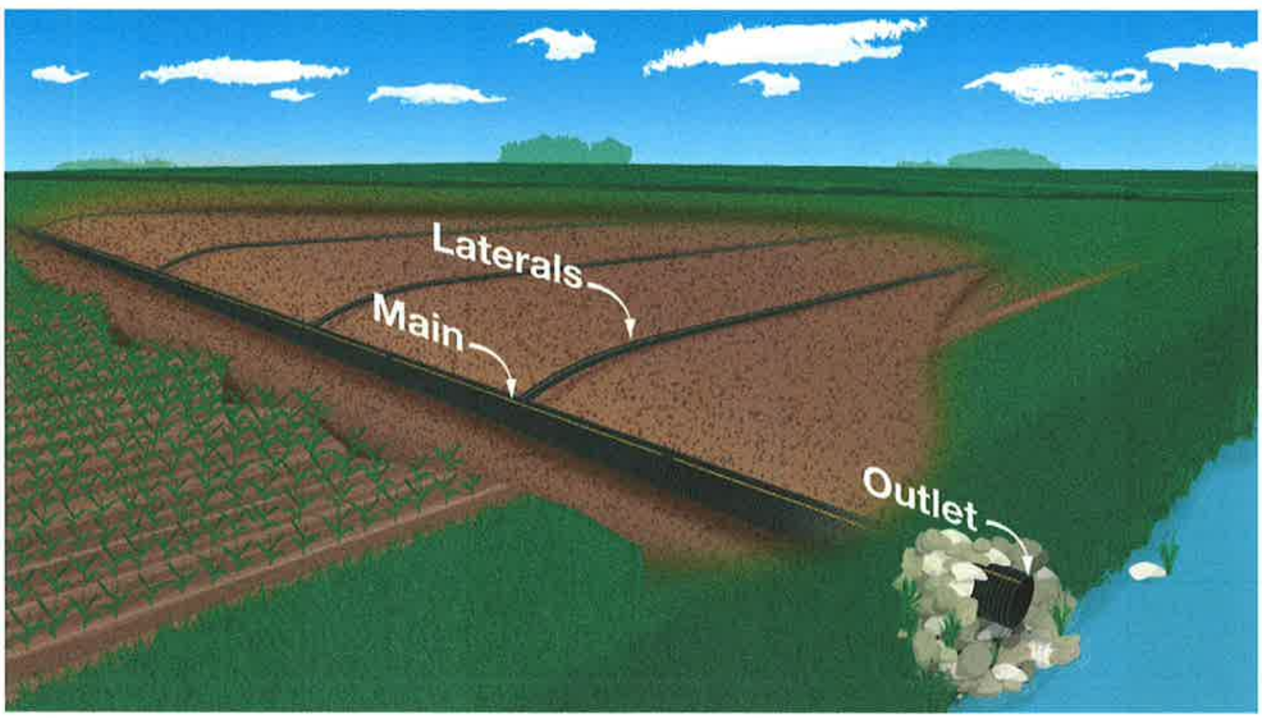
The key question of our time is how to address this need while maintaining a productive environment. Can we manage the tension this creates, such as hypoxia zones and harmful algal blooms that are occurring in areas like the Gulf of Mexico, Western Lake Erie Basin, Chesapeake Bay and other, with challenges like that exemplified by the Des Moines Water Works Clean Water Act lawsuit and other environmental questions.

Managing Agricultural Drainage Systems

Today I would like to share with you some history and information on the current status of water table management in the U.S.

It is critical that we all have a basic understanding of water table management or sub surface drainage systems.

Agricultural drainage systems are designed to manage the water table below the ground surface. Commonly plastic pipe (generally called tile) is installed beneath the surface of agricultural lands to collect water. Those lines then run into a main that conveys the water out of the field. These mains eventually have and outlet; usually a ditch.



The Egyptians and Romans are credited with some of the earliest drainage. Later on, the Northern Europeans developed extensive systems for drainage, and, as Northern Europeans immigrated to the Unites States they brought the practice of tiling with them.

One of most significant development in drainage came as a result of the great dust bowl that occurred during the 1920's and 30's. As a result of the vast amount of soil erosion caused by the dust bowl the Soil Conservation Services came into being. This was the genesis of the incredible conservation infrastructure we have today.

From the 1940's through the 1970's, USDA had a program called the Agricultural Conservation Program (ACP). It was administered by the Agricultural Stabilization and Conservation Service (now the Farm Service Agency) with technical assistance provided by the Soil Conservation Service (now the Natural Resources Conservation Service). During this time period USDA promoted drainage of farm land as a best practice to conserve soil and improve farm viability.

This program provided cost share that helped farmers pay the cost of wetland drainage. It was estimated that during this time period there were over 57 million acres drained. Much of this happened in the Midwest and great tracts of land came into production.

So the question can be asked why all this drainage?

The simple answer is economics and crop production.

Here is a brief list of why people drain or manage the water table on their land:

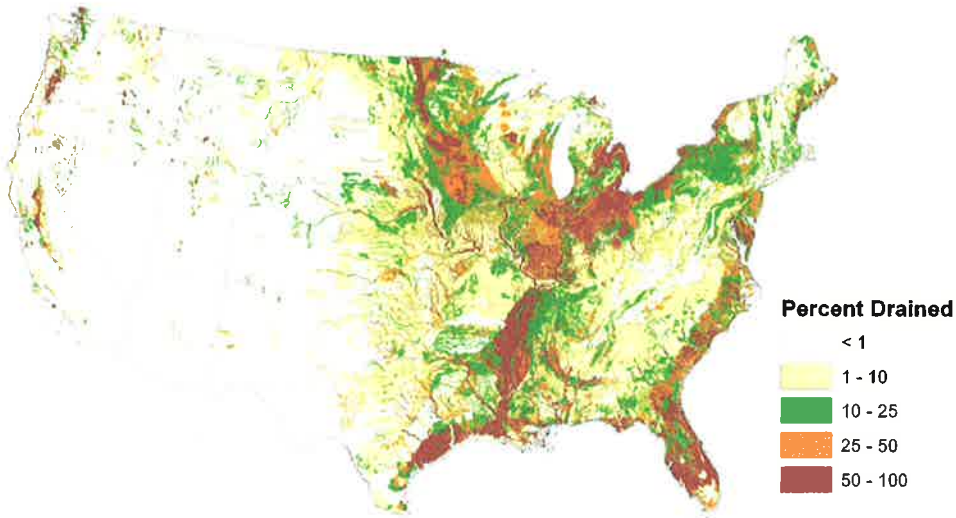
1. Increase yields- 15 to 20% increases;
2. Reduce soil erosion – keeps topsoil on the land;
3. Reduce phosphorous loss;
4. Store water in the soil profile – soil acts like a sponge – reduces flooding;
5. Allow timely planting and harvest; and
6. Reduce salinity (salt levels) of soils.

However, the landscape changed dramatically with the implementation of the 1985 farm bill. This introduced the "Swampbuster" provision and Conservation Compliance.

The new Swampbuster provision effectively ended federal incentives to drain wetlands and made USDA program benefits contingent on farmers NOT draining or manipulating wetlands.

It is important to understand that today new drainage on farmland in the U.S. has virtually stopped and farmers know to ask NRCS for a wetland determination to make sure they don't inadvertently run afoul of Swampbuster.

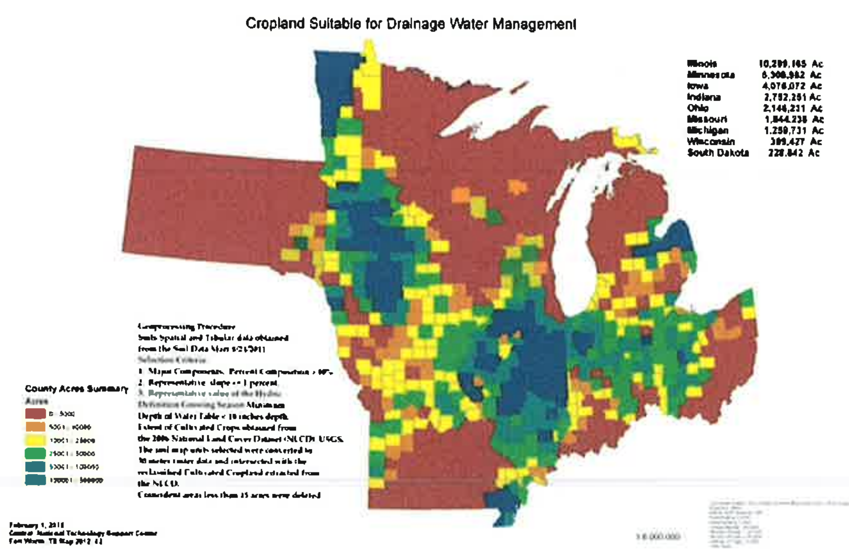
With drainage water management, we are not talking about draining wetlands but rather MANAGING the water on land that is already drained and upon which it is appropriate to install modern drainage.



The graphic above shows the percentage of drained land in the U.S. and some groups are challenging farming practices and seeking solutions to water quality issues. Farm groups are looking for answers as well.

And finding answers is the reason the ADMC was formed in 2003. Our goal is to find solutions and practices that help maintain and improve agronomic production while at the same time providing environmental benefits.

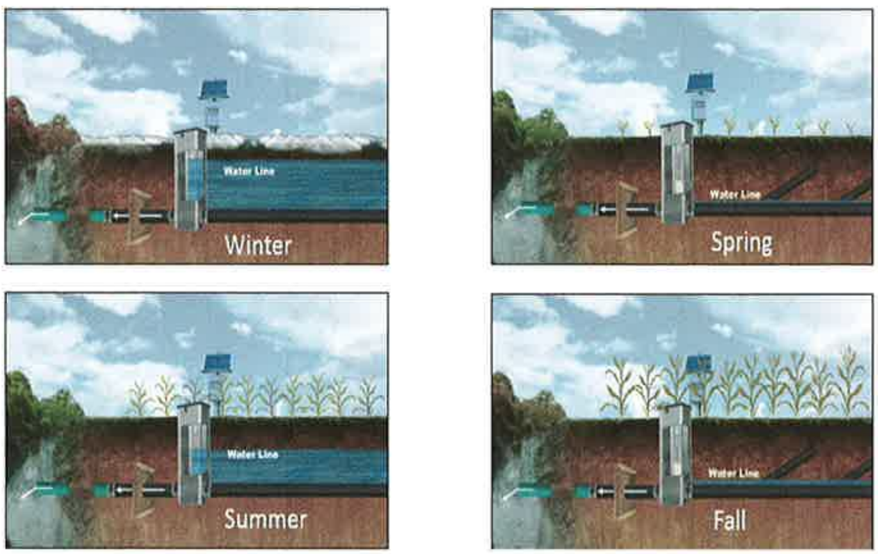
Of the 300 million acres of row crop lands in the continental US, approximately 100 million acres has tile drainage. As the chart below illustrates, in just nine states in the Upper Midwest, the NRCS estimates that approximately 30 million acres would benefit from DWM with existing technology today.



Managing drainage systems encompasses a set of conservation practices that can be implemented on a large scale that will produce equally large scale beneficial results such as improvements in water quality, flood reduction, wildlife habitat, and, for many practices, increases in farm economic viability and energy efficiency.

Highlights of projects the ADMC has been working on:

In 2006 we received a large Conservation Innovation Grant (CIG) from NRCS to demonstrate and assess the benefits of Drainage Water Management. This practice holds water back in the soil profile with a control structure on the outlet. The graphics below illustrates how water can be managed year round to maximize both crop production and environmental benefits.



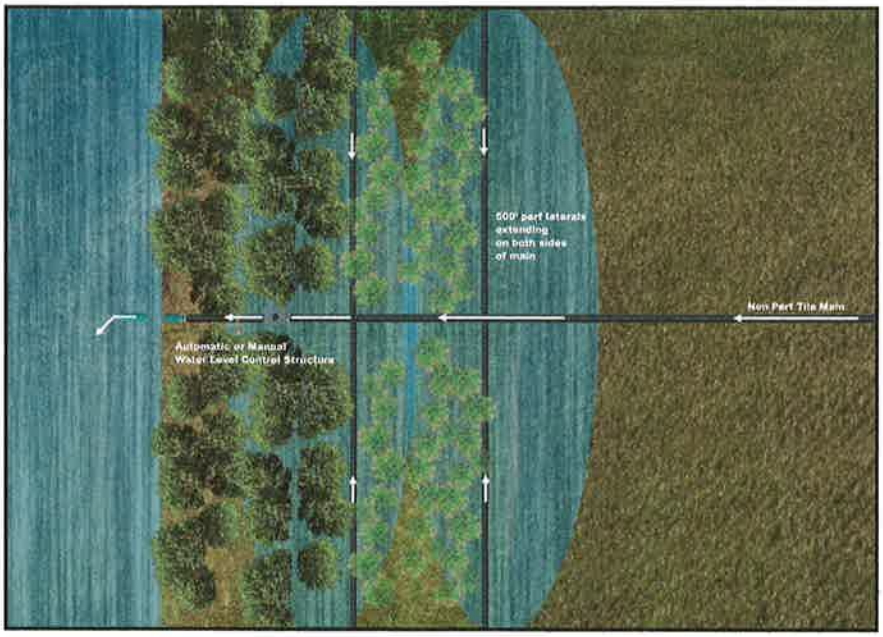
We have been able to significantly reduce the nitrates in the water coming off these fields. Often we see a reduction of nitrates of 45% or more.

We received another CIG grant in 2011 to demonstrate and quantify the benefits of saturated buffers to denitrify water in buffers along ditches and stream banks. As the Committee knows, across much of America we have built thousands of miles of buffers around agricultural fields to improve environmental outcomes. But typically only surface runoff runs through the buffer, most of the water circumvents the buffer by running through tile lines.

Saturated buffers, a new practice developed by the Agricultural Research Service, directs water into the buffer where habitat is enhanced and water quality vastly improved.[2] Saturated buffers will not work everywhere but they are one of the most cost effective tools available for

[2] Data generated from this project indicates that properly designed saturated buffers can reduce nitrate concentrations in discharge waters below the limits of detection with modern analytical techniques! That is amazing performance at low cost. The cost of installing a saturated buffer is simply to install a control structure and seep lines to distribute water into the buffer. These findings are fully reported in "Demonstrate and Evaluate Saturated Buffers at Field Scale to Reduce Nitrates and Phosphorus from Subsurface Field Drainage Systems" December 15, 2015.

improving water quality. I note, however, there is no on-farm benefit, so incentives will have to come from off the farm to support widespread adoption of this practice. NRCS is currently developing a conservation practice standard for financial assistance. Additional incentives could come from payments for ecosystem services and other market mechanisms. The graphic below provides an overview of how a saturated buffer functions.



In 2011 the ADMC signed a Memorandum of Understanding with the NRCS to train and certify Technical Service Providers to help with implementation of approved practice.

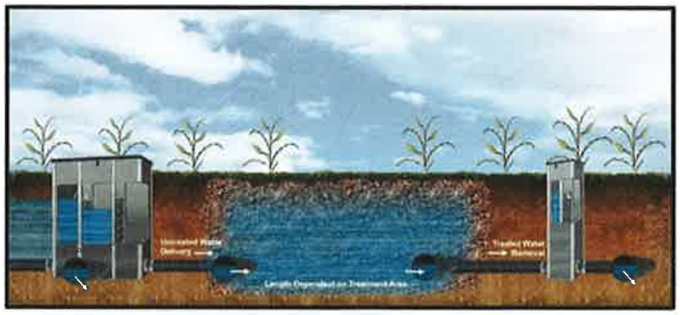
In addition, we are studying and implementing practices such as Bio Reactors and sub-irrigation.

Bioreactors provide the habitat for bacteria that can "digest" nitrates and strip them out of the water. They perform much like wetlands in this regard. They have the advantage of not taking land out of production.

An operator can farm right over top of a bio reactor. Again the environmental return on investment is high,[3] but, again, there are no on-farm benefits so outside incentives are required if this practice is to be widely adopted.

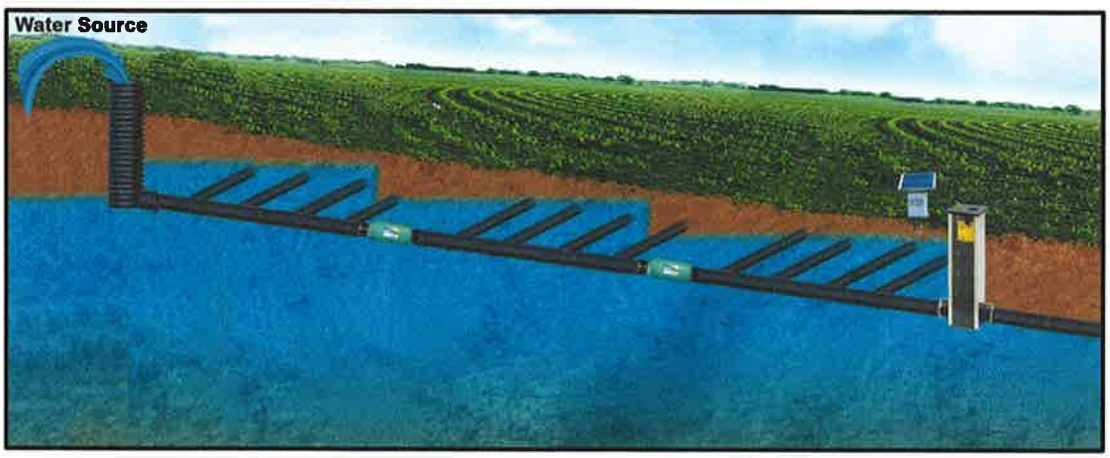
[3] http://web.extension.illinois.edu/bioreactors/design.cfm

Schematic of Bioreactor



Subirrigation uses the same tile lines that take water out of the fields in times of excess and provide back into the growing zone during times of drought. With minor modification in the design and installation, the same system can move water out of or into the field. This eliminates the need for two systems to provide irrigation or drainage – a substantial capital saving. But the savings go well beyond that. Subirrigation uses less than half the amount of water of conventional irrigation. In addition, Subirrigation allows the capture of tail water and enables the reuse of that water (and any nutrients it may contain) to support crop production. Reusing the water further strips nutrients that previously were lost from the system; improving both water quality and crop production at a substantial savings to the producer.[4]

SubIrrigation



The NRCS has been an amazing partner on these projects. Currently they are writing practice standards so much of this research can be adapted. We are grateful for our relationship with the NRCS.

[4] Economics of Controlled Drainage and Subirrigation in Selected Missouri Soils
M. Nussbaum, J. Hester, J. Henggeler, ASABE Online Technical Library, June 10, 2013

I would briefly like to comment on a couple of additional key benefits of managing these systems: flood reduction and risk reduction.

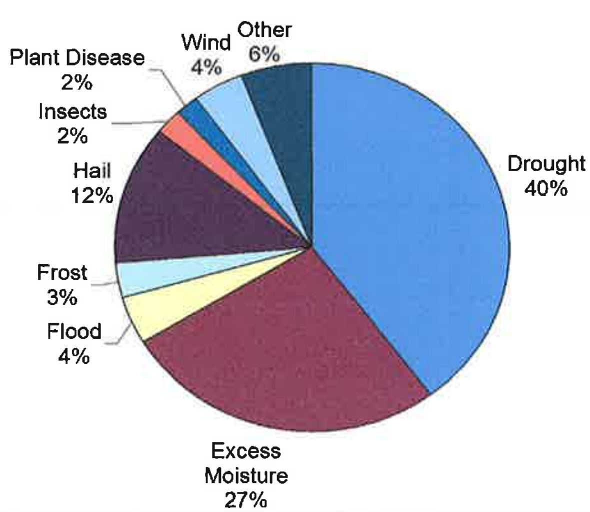
To foster flood reduction, we can manage tile lines to hold water and thereby store water in the soil profile. Not only can we close one valve to hold water in one field, but we can link these systems together. We can operate them remotely – and they can be operated as single systems or as a group. In fact, we can link not only fields, but whole farms and even a watershed to hold water in the soil. So if, for example, a large low pressure is moving across the Midwest and threatens flooding – say in the Red River – we can actually hold water in the soil profile on hundreds – even thousands of acres. The water held in the soil would decrease any flooding and it can be done tomorrow; we don't have to wait decades for permits.

But holding the water back in the field could cause crop damage and farmers would need to be compensated for any losses – perhaps through a downstream flood reduction fund. But it is unquestionably less expensive to hold the water in a field than to pump out a town and pay for restoration, or to build a large impoundment area that takes land out of production and away from agricultural producers and requires ongoing public management expense. With this approach, a farmer has a new "commodity" to sell and a new market.

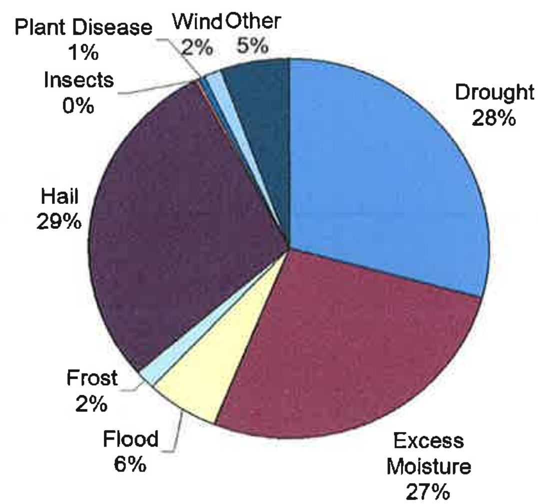
Finally, I call the Committee's attention to reducing risk associated with agricultural production. We are already embroiled in a conversation about the crop insurance system. But let me point out a bright light where there will not be controversy – and where there is need for action. A very substantial portion of crop loss is caused by either too much water or not enough. We can take huge bites out of these risk variables through practices such as managing tile lines and sub irrigation.

Reducing Risk

Corn Loss Iowa Post WWII



Soybean Loss Iowa Post 1950



Charts courtesy of Chad Hart, Managing Risk in Agriculture, Iowa State University, June 2013

As you can see from these charts, over two-thirds of corn loss has come from too much or too little water. Likewise these variables have accounted for over half of soybean loss in the past sixty years in Iowa. We can foster boarder adoption of these beneficial practices, and reduce the burden on taxpayers and costs to producers if we adjust the premiums to farmers who adopt and use these practices.

As I stated earlier- we must manage the tension to feed the growing world population and also provide water quality solutions.

In these uncertain times when farm prices are unstable and manufacturing and skilled jobs are at risk, this again is an opportunity. This is American technology, developed and made right here in the USA. Expanded utilization of these practices will not only improve agricultural profitability and the environment but create thousands of good paying jobs that stay at home. Our export position will be strengthened and recovery in the Heartland expanded.

Just a few reminders in closing:

1. The world's population continues to grow and must be fed
2. Managing water is an essential factor in all crop production
3. We have the luxury of excess water on much of our cropland
4. Water quality matters to everyone
5. The suite of practices know as Drainage Water Management are some of the most cost efficient and effective ways to improve water quality and many of them contribute to other goals like expanded production, wildlife habitat and flood reduction
6. Water Table Management is still the "Best Management Practice"

Thank you for your kind attention.

Committee on Agriculture
U.S. House of Representatives
Required Witness Disclosure Form

House Rules* require nongovernmental witnesses to disclose the amount and source of Federal grants received since January 1, 2013.

Name: Kent Rodelius

Organization you represent (if any): Agricultural Drainage Management Coalition

1. **Please list any federal grants or contracts (including subgrants and subcontracts) you have received since January 1, 2013, as well as the source and the amount of each grant or contract. House Rules do NOT require disclosure of federal payments to individuals, such as Social Security or Medicare benefits, farm program payments, or assistance to agricultural producers:**

Source: ______ **Amount:** ______

Source: ______ **Amount:** ______

2. **If you are appearing on behalf of an organization, please list any federal grants or contracts (including subgrants and subcontracts) the organization has received since January 1, 2013, as well as the source and the amount of each grant or contract:**

Source: USDA **Amount:** $67,721.81

Source: FSA **Amount:** $38,298.59

3. **Please list any payment or contract originating with a foreign government (including subcontracts) you have received since January 1. 2013, as well as the country of origin and amount of each payment or contract.**

Country of Origin: ______ **Amount:** ______

Country of Origin: ______ **Amount:** ______

4. **Please list any payment or contract originating with a foreign government (including subcontracts) the organization has received since January 1. 2013, as well as the country of origin and amount of each payment or contract.**

Country of Origin: ______ **Amount:** ______

Country of Origin: ______ **Amount:** ______

Please check here if this form is NOT applicable to you: ______

Signature: Kent Rodelius

* Rule XI, clause 2(g)(5) of the U.S. House of Representatives provides:

(A) Each committee shall, to the greatest extent practicable, require witnesses who appear before it to submit in advance written statements of proposed testimony and to limit their initial presentations to the committee to brief summaries thereof.

(B) In the case of a witness appearing in a nongovernmental capacity, a written statement of proposed testimony shall include a curriculum vitae and a disclosure of any Federal grants or contracts, or contracts or payments originating with a foreign government, received during the current calendar year or either of the two previous calendar years by the witness or by an entity represented by the witness and related to the subject matter of the hearing.

(C) The disclosure referred to in subdivision (B) shall include--(i) the amount and source of each Federal grant (or subgrant thereof) or contract (or subcontract thereof) related to the subject matter of the hearing; and (ii) the amount and country of origin of any payment or contract related to the subject matter of the hearing originating with a foreign government.

(D) Such statements, with appropriate redactions to protect the privacy or security of the witness, shall be made publicly available in electronic form not later than one day after the witness appears.

PLEASE ATTACH DISCLOSURE FORM TO EACH COPY OF TESTIMONY.

Committee on Agriculture
U.S. House of Representatives
Information Required From Nongovernmental Witnesses

House rules require nongovernmental witnesses to provide their resume or biographical sketch prior to testifying. If you do not have a resume or biographical sketch available, please complete this form.

1. **Name:** Kent Rodelius

2. **Organization you represent:**
   Agricultural Drainage Management Coalition

3. **Please list any occupational, employment, or work-related experience you have which add to your qualification to provide testimony before the Committee:** ____
   Agricultural Sales Manager for Prinsco, Inc.
   Chair of the associates for the Land Improvement Contractors of America

4. **Please list any special training, education, or professional experience you have which add to your qualifications to provide testimony before the Committee:** ____
   Vice president of the Agricultural Drainage Management Coalition

5. **If you are appearing on behalf of an organization, please list the capacity in which you are representing that organization, including any offices or elected positions you hold:**

PLEASE ATTACH THIS FORM OR YOUR BIOGRAPHY TO EACH COPY OF TESTIMONY.

Innovations in Water Management
to Improve Crop Productivity and Water Quality

Several key innovations are coming on line to dramatically improve both agricultural productivity and water quality by management of water flowing through tile lines. The first of these is Drainage Water Management where water is held in the field during the dry periods of the growing season and during fallow periods to improve productivity, and water quality. The second is Sub-Irrigation, which uses the same subsurface tile lines used for drainage to irrigate crops. These two systems can dramatically improve farm economic viability and cost-effectively reduce nutrient loss to waterways.

With the exceptional growth in demand for agricultural production to meet growing populations, higher expectations on diet, and provide fiber and fuel for the 21st Century we will see a massive intensification of agricultural lands. To achieve these objectives of protecting environmental quality and raising agricultural productivity we have to revolutionize our agricultural production systems. We simply have to be more efficient in our use of land and water.

Automated instrumented DWM site - note how little land is taken out of production.

Drainage Water Management Overview

Of the 300 million acres of row crops in the Continental US, approximately 100 million acres have artificial drainage. This is not drainage of wetlands, but systems to reduce the amount of water in the field, particularly during early season for planting and initial plant growth, and harvest. Drainage removes water that could impede germination and allows the soil to warm earlier, improves field trafficability during wet periods and significantly increases yield. While there may be some environmental benefits like reduced rill erosion and resulting soil and phosphorous loss, these systems can foster increased loss of nitrogen from fields and reduce the water holding capacity of a watershed.

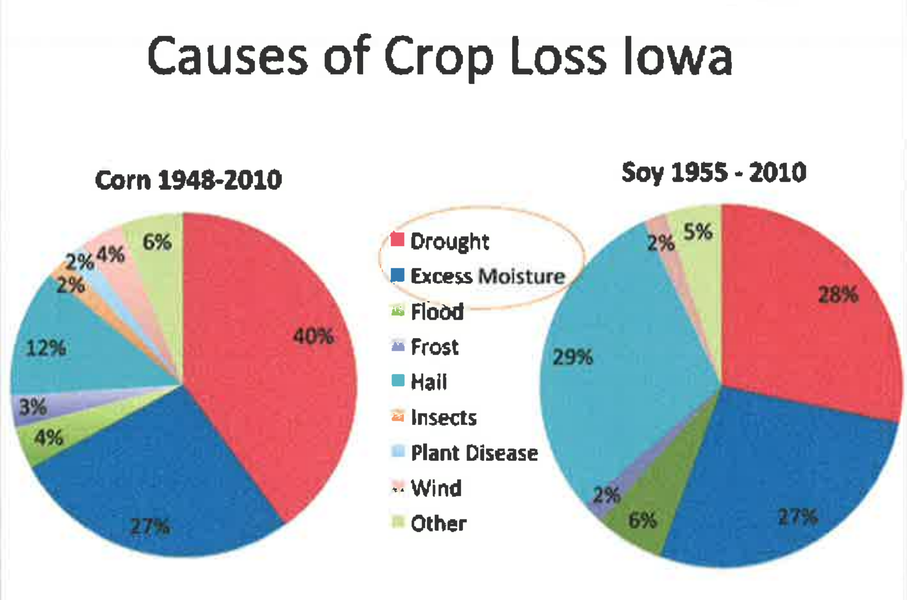
The Natural Resources Conservation Service (NRCS) has identified that with existing technology, over 30 million acres in ten Midwestern states alone would benefit from Drainage Water Management. (DWM) DWM has been shown to be one of the most cost effective techniques to reduce nutrient loss from agricultural lands.[1] This practice also has the advantage of increasing yields, particularly in drought years.

DWM refers to controlling the flow of water discharged from tile lines to improve environmental performance and agricultural production. Without controls, tile lines drain water and associated materials from fields around the clock year round. However, drainage typically is only needed during part of the year, and closing off drainage during most of the year will significantly reduce nutrient loss and improve yields.

The golden rule of drainage management is "Drain only what is necessary to ensure trafficability and crop production – and not a drop more." That means during the fallow season, tile lines should be shut off. This allows water to stay in the field, nitrogen uptake to occur by any cover crop or residual in the field and denitrification to occur by bacteria in the soil. In addition, after the crop has become established, it is prudent to reduce water (and nutrient loss) by selectively managing tile outflow to hold water in the field just below the root zone of the crop. This increases agricultural productivity and reduces nutrient loss.

By managing tile lines typical nutrient loss can be reduced by about half. Less nutrient application is required as the nutrients are held in the field instead of lost through water drainage. Production is increased, particularly during dry years when crops are stressed by lack of water and nutrient availability. It's a "win win" for both the producer and the environment. Input cost can be reduced, yield increased and water quality protected. Secondary ecosystem service benefits like flood reduction, wildlife habitat improvements and greenhouse gas emission reductions can also be achieved.

DWM does not require land to be taken out of production. An automated system can be monitored and managed remotely. The capital investment to install DWM has a life cycle of fifty to one hundred years making it one of the best production and environmental management investments available. Design and installation of controlled drainage is eligible for financial assistance from the NRCS. This practice can be implemented on over 30 million acres with existing technology – as identified by NRCS.

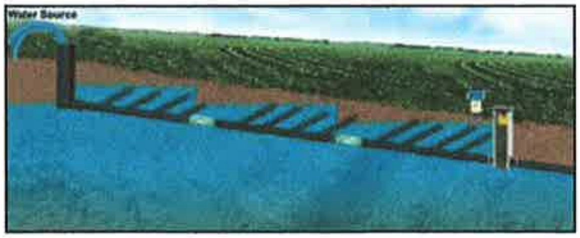


Charts courtesy of Chad Hart, Managing Risk in Agriculture, Iowa State University, June 2013

Sub-Irrigation

A new emerging practice is to use the same tile lines to also provide irrigation. The same infrastructure that removes water during times of excess can be used to put water into fields during periods of drought. Sub-Irrigation requires only modest changes from DWM: 1) a slightly upgraded tile system that allows for more close management of flow, and 2) a pump to raise water to the highest point in the filed where it can be introduced into the tile system.

Sub-Irrigation has several advantages over conventional irrigation. First, it uses about half the water. There is no evaporation as the water is sprayed on the crop because water is put proximate to the root zone where it is needed instead of on the surface. Second, Sub-Irrigation uses less than half the energy. Less water is moved to meet plant requirements so less water is pumped. In addition, the only energy required is to deliver water to the highest point in the field for introduction into the tile system. With Sub-Irrigation gravity rather than an "energized" system distributes water through the field. Control structures within the field (I.E. float operated valves that require no separate management or energy inputs) provide for even water distribution. Third, the same infrastructure system that removes excess water is used to provide irrigation removing the need for two water management systems.



Schematic of sub-irrigation distribution of water into cropped field. Graphic courtesy of AgriDrain.

Sub-Irrigation can be economically implemented with existing technology on up to six million acres today. If water drained from fields during wet periods can be stored on site, the economics and environmental outcomes of this practice can be further improved. Nutrient rich drainage waters can be treated in wetlands or ponds and can be reused for irrigation.

On Farm Benefits

In addition to reducing environmental impact, these practices have significant economic benefit for producers. DWM and Sub-Irrigation can contribute to substantial yield increases. They can reduce input costs from savings in nutrient, energy and water. These practices can also take a huge bight out of the risks farmers face every time they plant a crop.

By utilizing these water management systems, tremendous risk can be taken out of crop production. For example, 65% of corn loss in Iowa since the Second World War has been from either not enough water or so much that the crop is flooded out. 55% of crop loss since 1950 for soybeans is from the same causes.

Another on farm benefit is to deliver enhanced ecosystem services. Ecosystem services are the goods and services provided by nature like clean water, abundant wildlife and other valuable "products" that make life possible or increase our enjoyment of it. There is growing acceptance that people are willing to pay for these services and some markets are emerging. Hunters are commonly willing to pay for the right to hunt on a farm and greenhouse gas markets are operating around the world. There are many ecosystem services delivered by DWM and Sub-Irrigation like flood reduction, water quality, greenhouse gas reduction and wildlife habitat improvements that are highly quantifiable and readily can enter into ecosystem service markets. As markets develop and are more broadly operated, ecosystem service products may offer a new class of assets that farmers can produce and derive income from.

Conclusion

There are significant on farm benefits from installing DWM and Sub-Irrigation

There are significant on farm benefits from installing DWM and Sub-Irrigation including but not limited to increased agronomic production, reduced input costs and reduced risk. There are also significant off site benefits including reducing nutrient loss to waterways, reduced flooding and other ecosystem services.

including but not limited to increased agronomic production, reduced input costs and reduced risk. There are also significant off site benefits including reducing nutrient loss to waterways, reduced flooding and other ecosystem services. If ecosystem service markets develop it may be possible to for commerce in those activities to add to the economic viability of farm operations. Likewise, early voluntary action that reduces environmental impact can help reduce pressure for regulation and reflect positively on agricultural producers. **L&W**

by Dave White & Alex Echols

Dave White, President, Ecosystem Services Exchange

Dave was Chief of the Natural Resources Conservation Service from January 2009 to December 2012, where he led, directed, and managed the nation's largest private lands natural resource conservation organization. In addition to his work with NRCS, White was detailed to Iowa Senator Tom Harkin's office in Washington, D.C., where he helped craft the conservation title of the 2008 Farm Bill and to Indiana Senator Richard Lugar and helped develop the conservation title of the 2002 Farm Bill.

Alex Echols, Executive Vice President, Ecosystem Services Exchange

Alex started his career working for the Senate for 12 years, writing key conservation programs like the Conservation Title of the Farm Bill and an extensive rewrite of bilateral and multilateral foreign aid programs. He spent six years at the National Fish and Wildlife Foundation as Deputy and then Acting Executive Director. In 2001, he set up a consulting firm to help industry, landowners, the conservation community and government deliver more conservation for dollars invested.

[1] Kieser et al noted just the environmental benefits (not including agronomic benefits) to be substantial. "Assuming a 30-percent nitrogen load reduction, the costs for a retrofit would be $0.66/lb to $0.93/lb and the costs for a new installation would be $2.86/lb to $4.17/lb.xii Jaynes et al.xiii estimated at of $1.23/lb when the costs were applied over a 20-year lifetime at a 4% interest rate, and found this price to be cost-competitive with other nitrogen removal practices. For example, constructed wetlands cost $1.48/lb, fall cover crops cost $5.02/lb, and bioreactors cost $1.08/lb to $6.88/lb.xivAdvances in technology are likely to reduce the cost of DWM implementation."

Drainage Water Management Implementation Costs
Abstract

Joanna E. Allerhand
James A. Klang, P.E.
Mark S. Kieser

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Build-up of the current agricultural drainage network began during the 1870s as part of a national land reclamation policy. Since then, drainage has been both criticized and praised. Overall, agricultural drainage enabled previously marginal land to become highly productive and profitable farmland.[i] However, intense drainage also contributed to negative environmental impacts, including substantial losses of wetlands and wildlife habitat.[ii]

Subsurface drainage lines act as conduits of nitrate – the mobile form of nitrogen – to surface waters. Under natural conditions, nitrate-laden water would filter through the soil profile and be removed, at least partially, through denitrification. In fields with subsurface drainage, tile lines intercept the water before denitrification can occur. As a result, subsurface drainage effluent typically contains high concentrations of nitrate.[iii] Figure 1 illustrates the estimated extent of subsurface drainage.[iv]

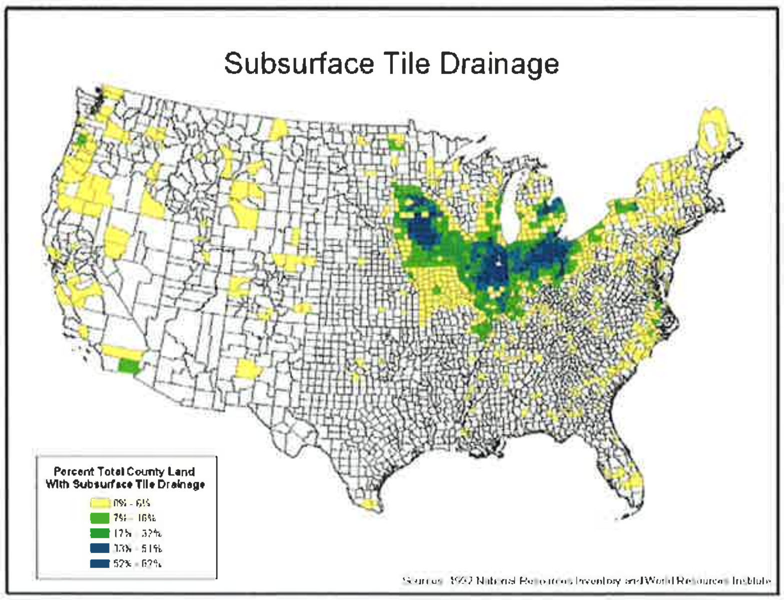

Figure 1. Extent and location of subsurface drainage, as estimated by Sugg, 2007.

Nitrate exports through tile lines can be reduced by implementing drainage water management (DWM). One such practice involves installing a device that controls the volume of water leaving a field. These controlled drainage devices can be adjusted based on the season and drainage needs. Outlet levels can be lowered prior to planting to allow the water table to drop and the fields to become sufficiently dry for equipment access. Subject to producer desires and time constraints, the level of the outlet can be adjusted throughout the growing season. Then after harvest, the outlet level is raised to minimize drainage during the non-cropping season.

DWM reduces nitrate exports by reducing the drainage volume from tile drain outlets as opposed to reducing the concentration of nitrate in the effluent. In humid temperate regions, approximately 88 to 95-percent of nitrate loss through conventional tile drainage occurs during the fallow period. Most of the nitrate reductions from DWM systems occur when drain flow is reduced during the non-cropping season.

DWM implementation has been shown to substantially reduce nitrate losses from farm fields, thereby contributing to water quality improvements. From 2001-2005, an average of 813,000 metric tonnes of nitrate-N (1.8 billion pounds) per year were transported to the Gulf.[v] Based on this loading estimate, DWM could reduce the transport of nitrate to the Gulf from the Upper Mississippi and Tennessee/Ohio watersheds by 7.6%.

Costs of implementing DWM vary based on site characteristics, drainage system design, and the type of control structure installed. One study estimated costs could range from $65/acre for a new installation on a 6-inch main to $88/acre for a retrofit on a 12-inch main.[vi] Annualizing these costs based on a 15-year lifetime and a 19.8-acre treatment area, estimated costs ranged from $6.73/year on a 6-inch main and $9.08/year on a 12-inch main.[vii] Cooke *et al.*[viii] estimated $20/acre to $40/acre for a retrofit installation and $89/acre for a new system in complex topography. Assuming a 30-percent nitrogen load reduction, the costs for a retrofit would be $0.66/lb to $0.93/lb and the costs for a new installation would be $2.86/lb to $4.17/lb.[ix] Jaynes *et al.*[x] estimated a cost of $1.23/lb and found this price to be cost-competitive with other nitrogen removal practices. For example, constructed wetlands cost $1.48/lb, fall cover crops cost $5.02/lb, and bioreactors cost $1.08/lb to $6.88/lb.[xi] Advances in technology are likely to reduce the cost of DWM implementation.

A simple analysis was completed here to estimate the cost of DWM under various scenarios and assumptions. Provisional implementation costs were calculated based on the assumptions used by Jaynes *et al.*,[xii] with a few modifications. Jaynes assumed that DWM implementation would be comprised of 20-percent retrofits and 80-percent new installations. A retrofit was assumed to drain 11.86 acres while a new installation would drain 19.77 acres. Both the new and retrofit practices had a unit cost of $1,100, and new installations included an additional cost of $80.36 [xiii]. Applying these assumptions, a basic analysis indicates the following costs associated with DWM implementation:

- The total cost of implementing DWM on all suitable cornland in the Upper Mississippi and Tennessee/Ohio watersheds would be $638 million
- The cost of retrofit installations would be $93/acre
- The cost of new installations would be $88/acre
- The cost of nitrate reductions achieved by implementing DWM on all suitable cornland in the Upper Mississippi and Tennessee Ohio watersheds would be $5.57/lb nitrate

DWM implementation costs potentially could be offset by a yield increase or covered through a water quality trading (WQT) program. Any potential yield increase would depend on the specific application of controlled management. A yield increase of 1.68 bushels/acre for a 6-inch main and 2.27 bushels/acre for a 12-inch main would offset the control structure expense,

Managing Agricultural Drainage
Flood Mitigation and Associated Ecosystem Benefits

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What it is and why you should care

Agricultural drainage water management (DWM) entails managing the flow of subsurface water on agricultural land. By reducing the volume of water that drains from land, temporarily storing runoff, and slowing or altering the timing of the flow of runoff, DWM mitigates the risk of downstream flooding. Retaining or retarding subsurface-flow water in soils at critical times of the year when soils rebuild also reduces the movement and discharge of nutrients that otherwise would pollute rivers and streams.

Conversion of wetland or poorly drained soils to agricultural use or enhancement of the agricultural productivity of marginal, heavy "wet" soils has generally involved installing subsurface tile drainage lines. These lines, as they have conventionally been constructed, lower the water table and drain water quickly from the fields to local ditches, streams and rivers, reducing the waterlogging of soils. Depending upon the porosity of the soil and the level of the watertable, they can also reduce the volume of surface runoff. By directing and retarding water flow through soils, they can change the timing of peak water flows. Depending upon the nature of storm events, the contour of the land, and the characteristics of the watershed, such changes in the timing and volume of water flows can reduce or contribute to downstream flood impacts.

To farmers the advantage of subsurface drainage has been earlier cropping, reduced risk of root damage, and greater crop yield. Improving the productivity of the land for agricultural use comes at a societal cost when uncontrolled drainage inadvertently contributes to downstream water flows and leads to on-farm loss of nutrients, such as nitrates and phosphorus, that degrade downstream water quality. By regulating water flows through control of the timing and volume of its release and thereby retaining water from extreme events on the land, DWM contributes to public safety from flooding and protects water quality.

Studies in the Red River Basin and elsewhere find that tile drainage can both mitigate or contribute to the severity of flooding. Whether or not tile drainage is a boon or a cost depends upon the ability to manage the drains. Regardless of whether or not tile drainage contribute marginally to downstream flow and flooding, DWM can, by allowing for controlled reduction or management of flow, provide a means for significantly reducing downstream water volume and increased water levels associated with flooding. Modeling and actual field trials suggest that properly time in-field retention of stormwater can reduce peak flows. In conjunction with surface berms and outlet gates such as ditch risers, tile drainage controls enhance the amount of water that can be stored per acre, in some circumstances up to 3 acre-feet (Manale, JSWCS 2000, 2006). Through the inclusion of structures, such as roads and culverts, in an overall system of water management, DWM can holdmultiple acre-feet of floodwater for timed release of runoff when it is less likely to contribute to high flood stages.

Drain Water Management techniques can mimic natural systems, such as wetlands, for slowing the flow and storing of water. Just as a wetland provides a suite of ecosystem services, DWM, by allowing for management of soil functions in agricultural systems to build soil, enhances the delivery of their environmental benefits, such as carbon and nitrogen sequestration, and ground water infiltration. Over longer periods of time more water is retained in the upland areas of watersheds and less water isavailable to contribute to rising downstream flood levels.

Farmers themselves benefit from DWM from healthier, more drought resilient soils and retention of more nutrients in the soils. Healthier soils require fewer fertilizer inputs. Healthy, productive soils and less outlay for fertilizers mean more income for farmers.

Yet Despite the advantages to farmers, market conditions and government policy alter the calculus for installing DWM. High commodity prices encourage farmers to expand production to marginal lands. Federally subsidized crop insurance shields the farmer from the risk of producing on marginal land. And improvements in soil quality, and hence economic return, accrue over many years, whereas the additional cost of DWM is today.

There are a number of policy options to encourage the greater use of DWM. A traditional approach is to subsidize the installation of DWM where new tile drains are being installed or to pay for modification of existing tile drainage systems. Just paying to have the control devices installed does not however guarantee that the devices are maintained and used, particularly when controlled drainage and water retention on the land is most needed in time of flooding or high flood risks. Easements and land purchase can be expensive, such as what has been the policy in New York State to protect the city of New York's water supply. Newer approaches involve advanced options contracting and paying for ecosystem services. In the former, called options contracts for contingent takings, flood control authorities contract with farmers to manage floodwaters on their land in the likelihood of extreme weather (RFF, 2008). They are insured against loss of revenue should doing so lead to reduced yield or increased costs. In the latter, farmers are paid for storing floodwater on their lands as an ecosystem service. The more water they store, the more they earn.

New federal policy developments will lead to increased interest in DWM and temporary storage of floodwaters on agricultural lands. Under the Federal Water Resources Development Act of 2007, the White House has issued new requirements, the Principles and Requirements, that lay out broad principles guiding how federal agencies develop and implement water investments, including the maintenance of existing projects (White House 2013). The new requirements specifically call for non-structural and watershed approaches that examine how the larger landscape can be managed to achieve public safety and other desired public outcomes. DWM and temporary water retention on agricultural lands are consistent with these new principles for flood mitigation.

Manale, A,.Flood and water quality management through targeted, temporary restoration of landscape functions. Journal of the Soil and Water Conservation Society, 2000.

Manale, A.. Waffles are not just for breakfast anymore. Journal of the Soil and Water Conservation Society, 2006.

Resources for the Future. Options Contracts for Contingent Takings. 2008.
Benefits to farmers

White House, Council on Environmental Quality. Principles and Reqruirements for Federal Investments in Water Resources. March 2013.