A Presentation of the 2013 Drainage Research Forum

November 14, 2013
SDSU Extension Regional Center
Sioux Falls, SD

IOWA STATE UNIVERSITY
University Extension

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Extension

Integrated Drainage and Wetland Landscape Systems

Challenges & Opportunities

Shawn Richmond – Iowa CREP Coordinator
Iowa Department of Agriculture & Land Stewardship

November 14, 2013
Drainage Research Forum

Situation

- To reduce the size of the Gulf of Mexico Hypoxic Zone - at least 45% reductions in both riverine total nitrogen flux and riverine total phosphorus flux are called for
- To achieve these reductions as well as local water quality goals will require a combination of practices implemented at the watershed scale
- Nitrate removal wetlands are a watershed scale practice that have been shown to be effective in removing nitrate
- Optimal drainage capacity has the potential to reduce surface runoff, phosphorus & other SRO contaminants
- Market driven, public/private partnerships will be essential to achieve these nutrient reductions at full landscape scale

Current Conditions

- Deteriorating drainage infrastructure that will need replacement largely over the next 10-30 years
- Farmed wetlands provide lowered crop production and little wetland function compared to original state
- Most farmed wetlands have drainage installed, but the drainage system capacity is too low to provide adequate drainage for good crop growth
- Farmed wetlands result in high losses of nitrogen fertilizer as result of denitrification
- “Worst of both worlds”- Poor crop production- poor wetland function

Future Vision

- “Engineer” the watershed for better drainage and wetland function
- Set aside areas where wetlands can be established at the discharge end of the watershed for better wetland function as well as water quality renovation
- Allow these wetlands to be used for mitigation of farmed wetlands in the watershed
- Allow higher capacity outlet systems to be installed to provide better crop production
- “Best of both worlds”- a win-win situation

Research/Science Basis

- Water Quality & Drainage Studies – Since 1988, Fees on Sale of Ag Chemicals
  - Gilmore City Research Station & Outlying Farms
  - Ames Research Farm
  - Pekin Farm
- EPA Grant $1 million – “Integrated Drainage-Wetland Systems for Reducing Nitrate Loads from Des Moines Lobe Watersheds”

Development Team

Dr. James Baker, ISU (emeritus) & IDALS

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Dean Lemke, IDALS

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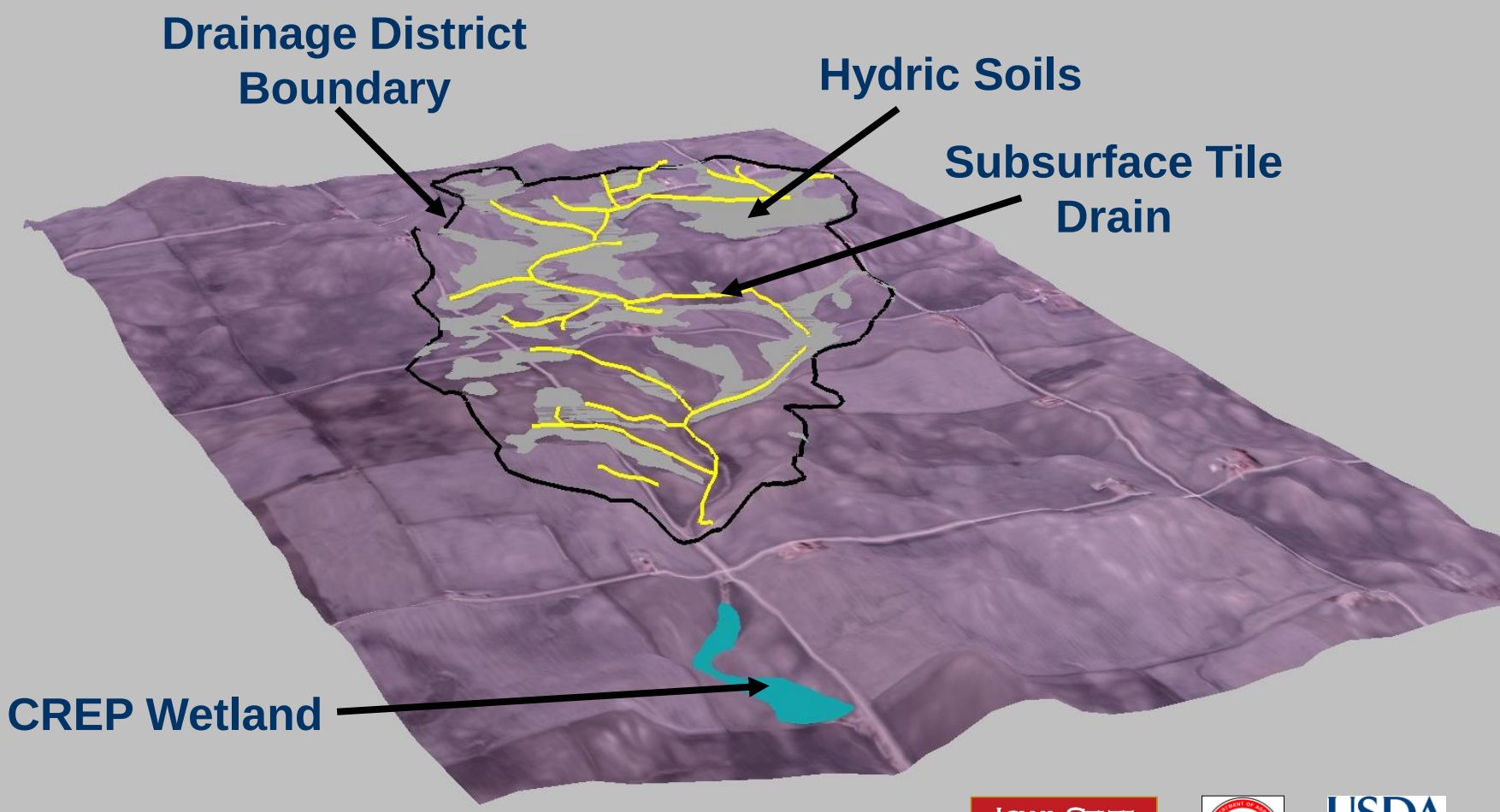
John Torbert, IA Drainage District Assn

Nitrate Removal by Targeted Wetland Restorations in Agricultural Watersheds

Iowa Conservation Reserve Enhancement Program



Iowa State University

USDA

EASEMENT BOUNDARY
IOWA
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Reserve
Enhancement
Program
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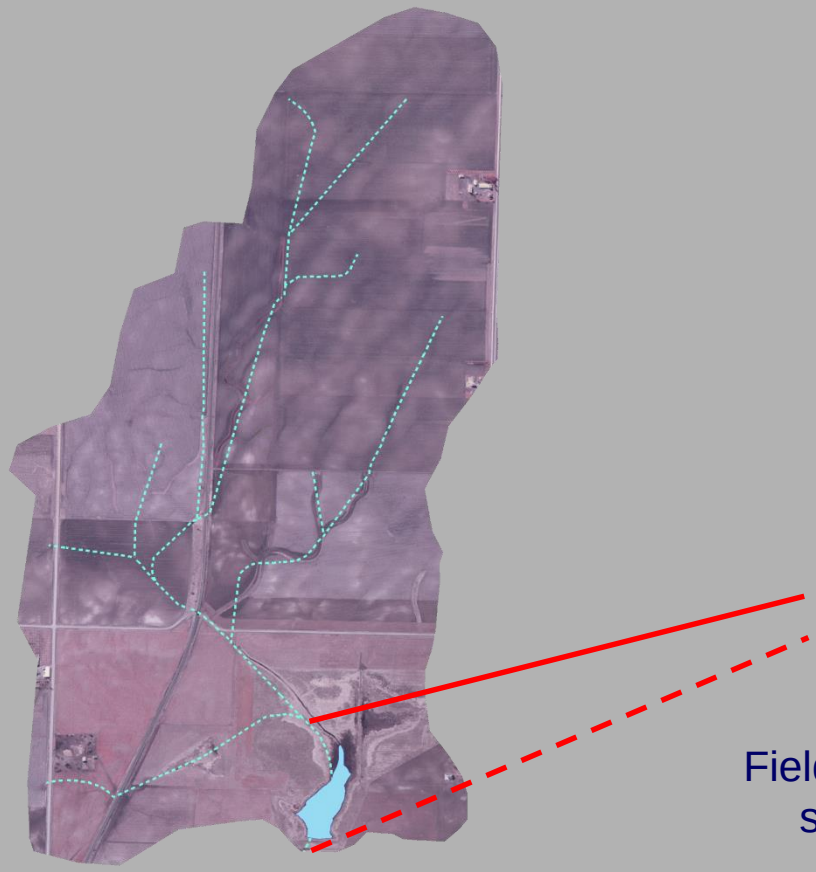
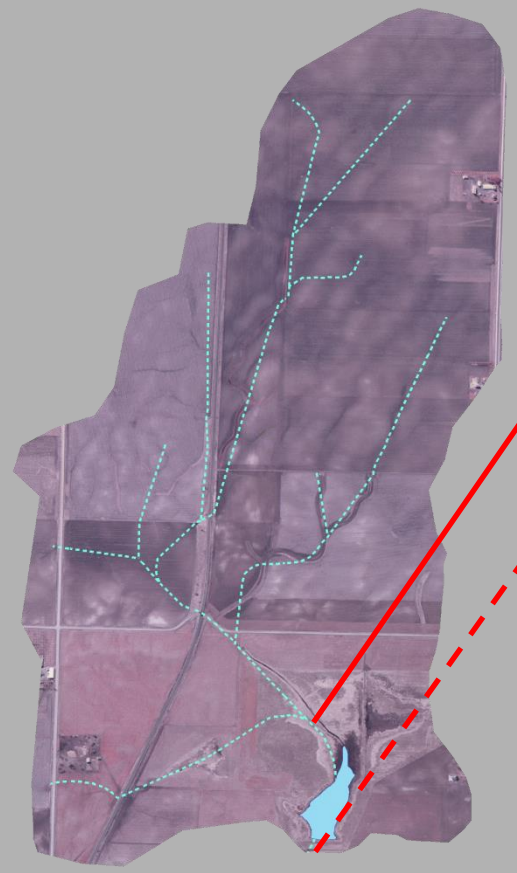
Monitoring wetland performance



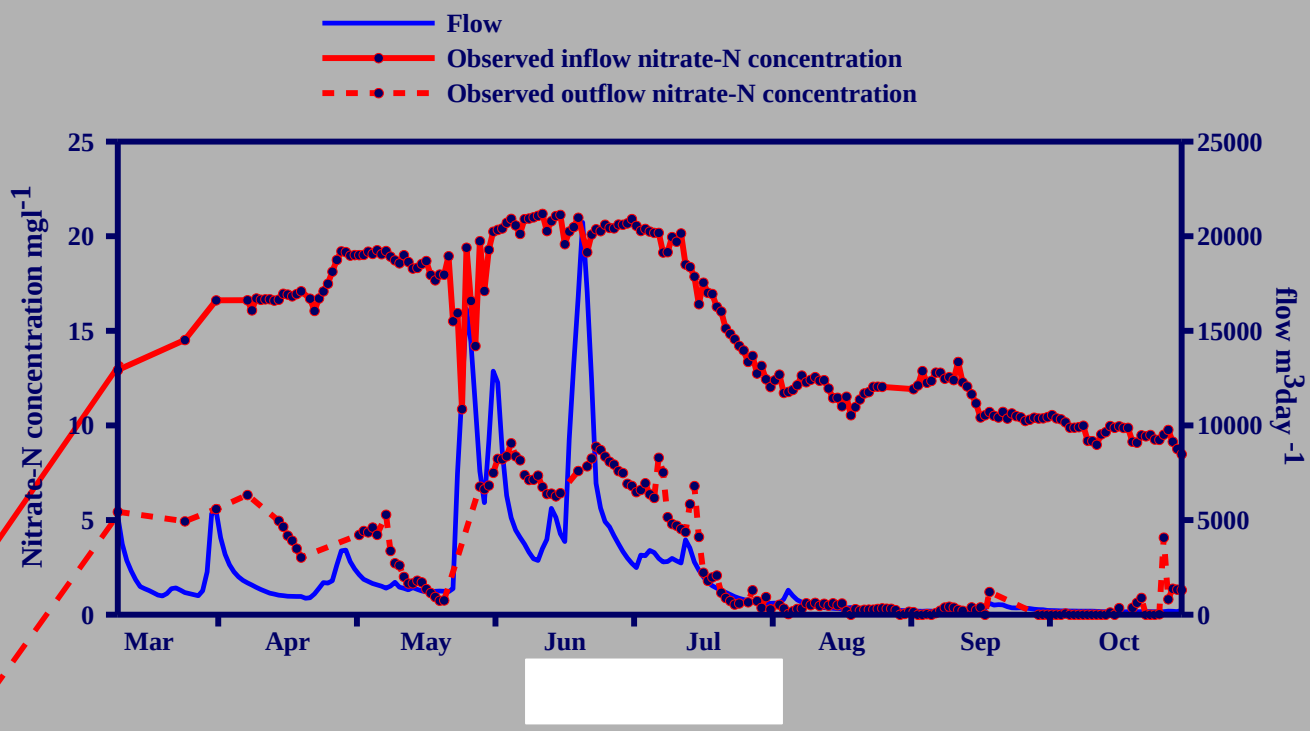
VH Wetland

Field sites instrumented for automated sampling and flow measurement

Monitoring wetland performance



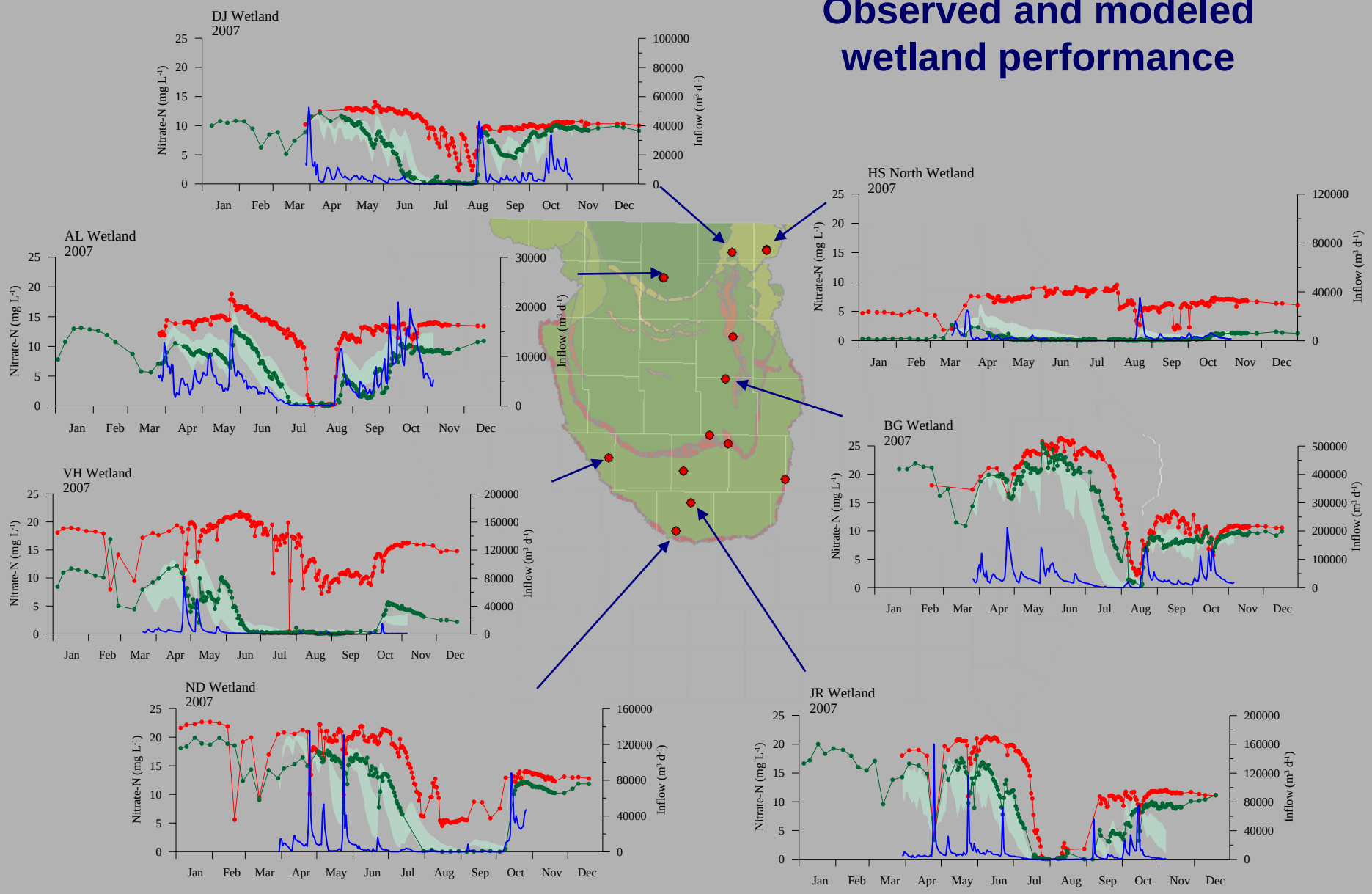
VH Wetland



Observed Nitrate concentrations and flow rates for VH Wetland in 2004

W.G. Crumpton, Iowa State University

Observed and modeled wetland performance



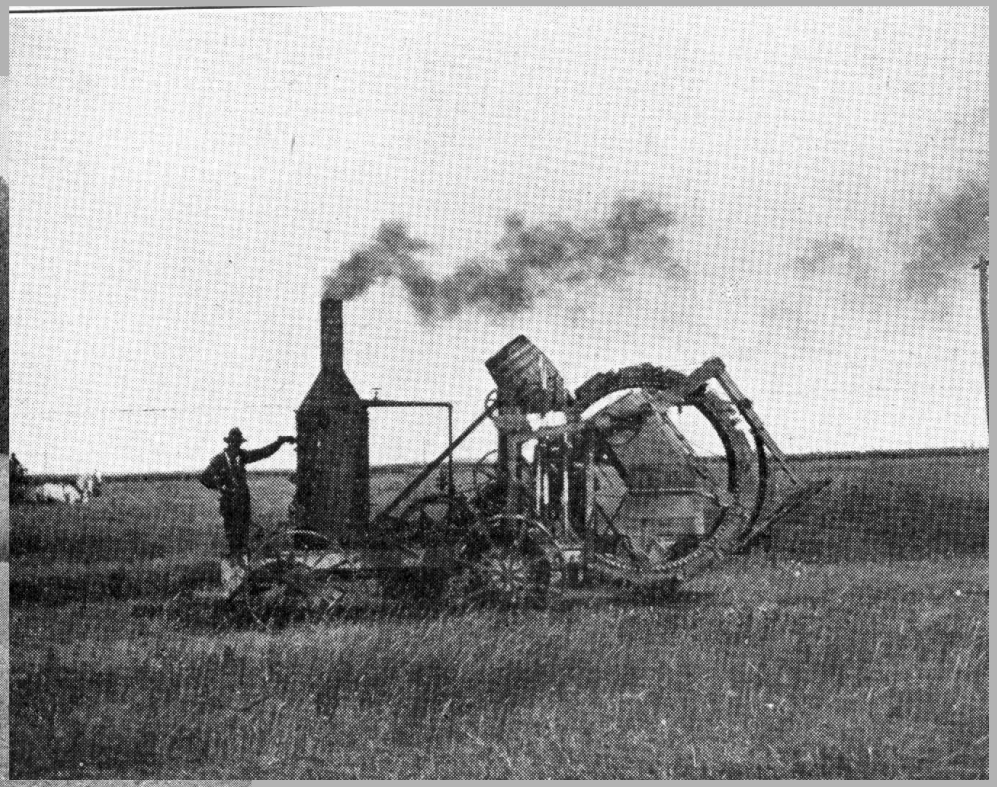
W.G. Crumpton, Iowa State University

Iowa CREP – Current Status

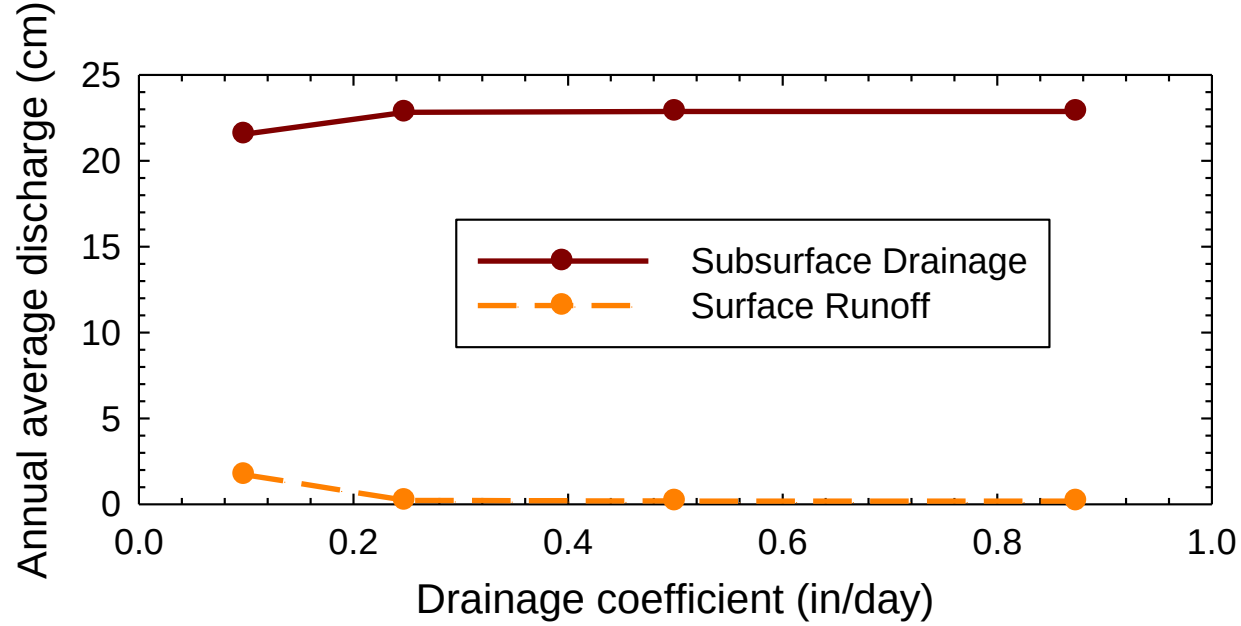
- 66 wetlands restored/constructed
- Currently over $7M ‘waiting list’ of landowners for enrolling
- 84 wetlands restored, under construction or design
  - 840 acres total wetland pool
  - Remove 40-90% of nitrate from 86,100 acres
  - Annually remove over 1,000,000 lbs N
  - Estimated nitrate removal over practice lifetime is 90,000 tons
  - Nitrogen removal cost $0.23/lb, below current cost of fertilizer N

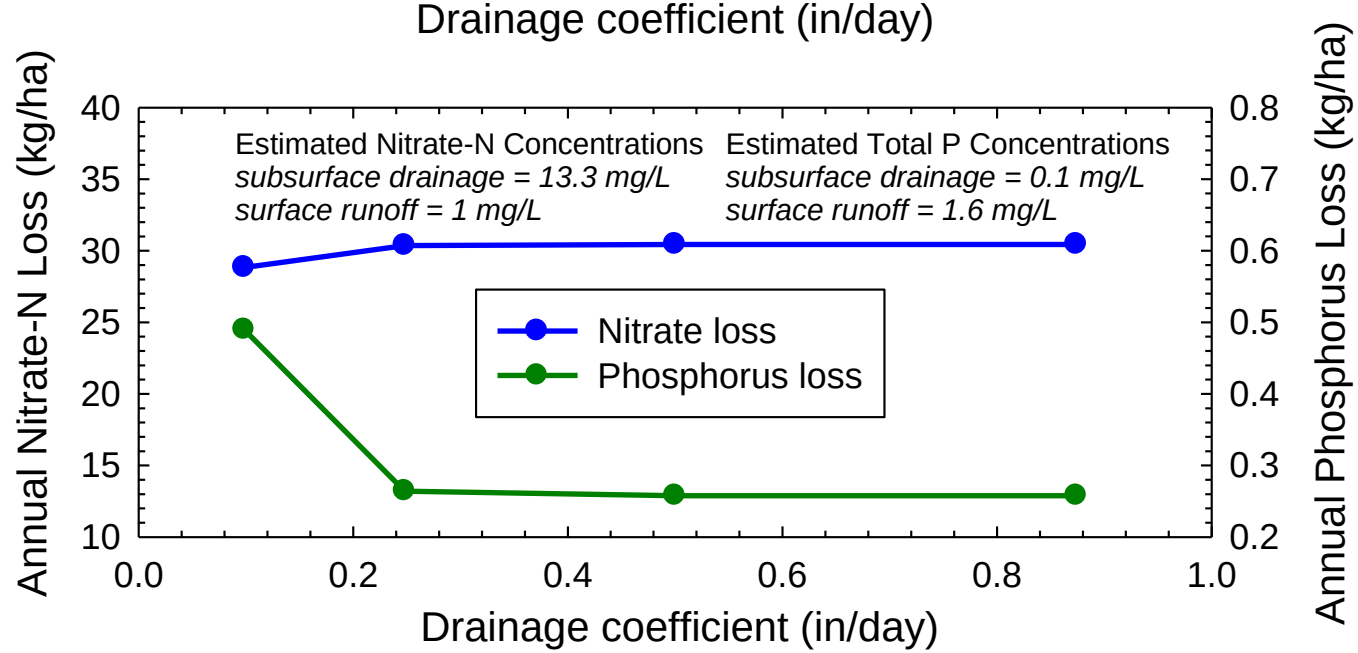
Drainage Design

- Majority of Des Moines Lobe is artificially drained with tile drainage systems installed in early to mid-1900's
- From surveys performed in 1980's many drainage systems have a drainage coefficient of <0.25 in/day (some <0.10 in/day)
- Modern drainage systems will be designed with a drainage coefficient of 0.5-1.0 in/day

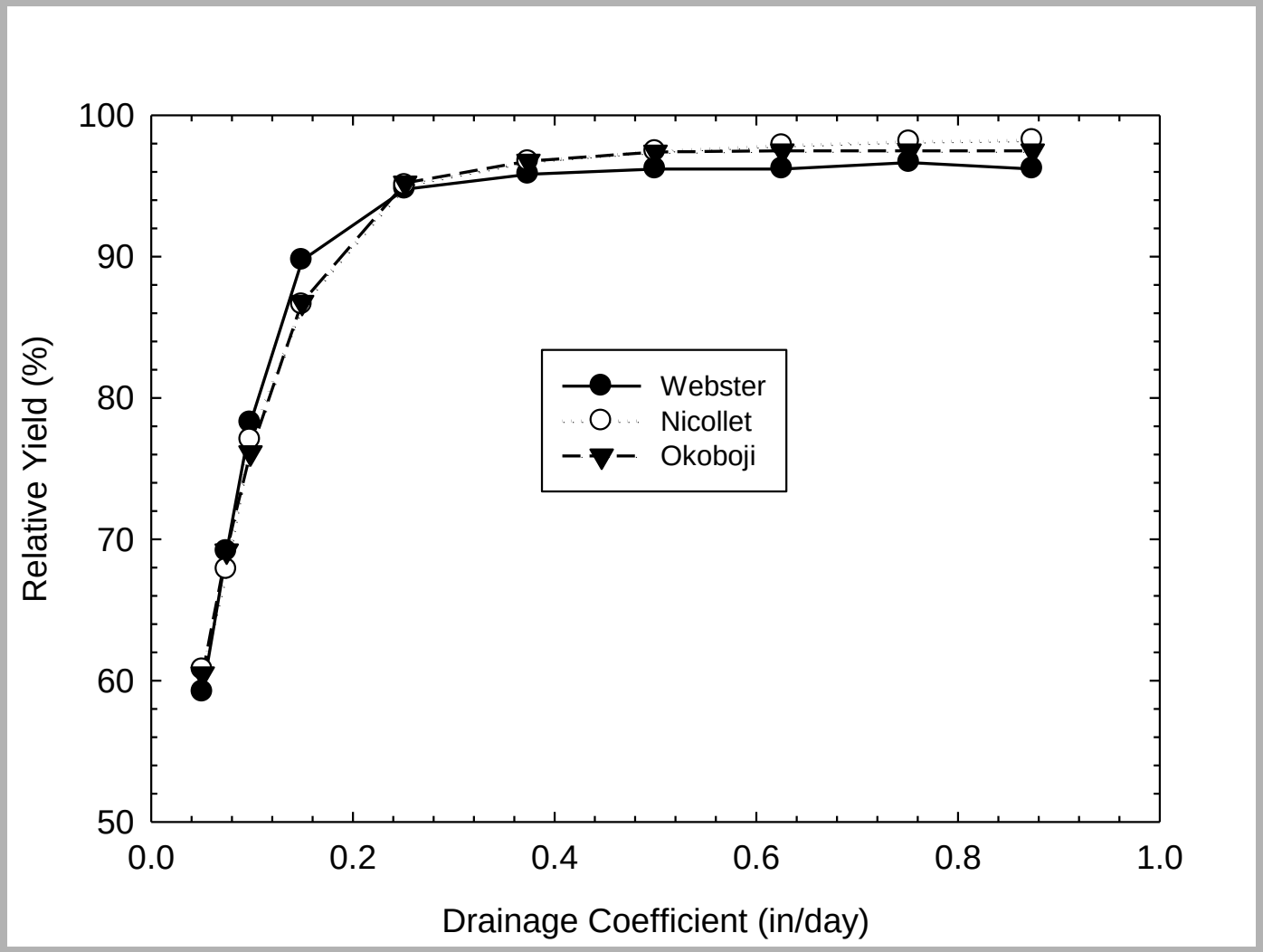


Impacts of Drainage Design





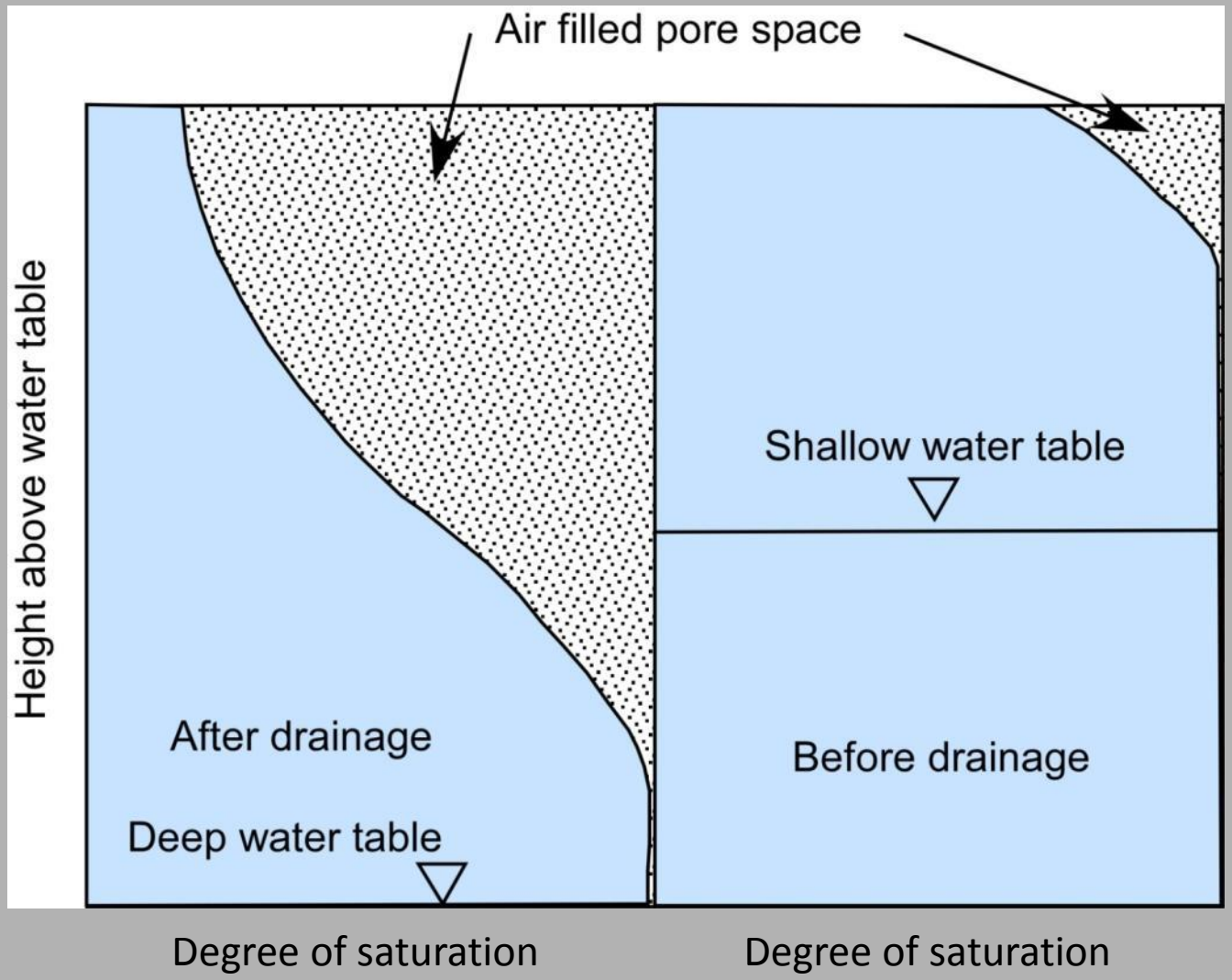
How much do Under Designed Systems Impact Yield?



These estimates are likely on the conservative side.

Yield impacts may be greater.

Why do we get less surface runoff?

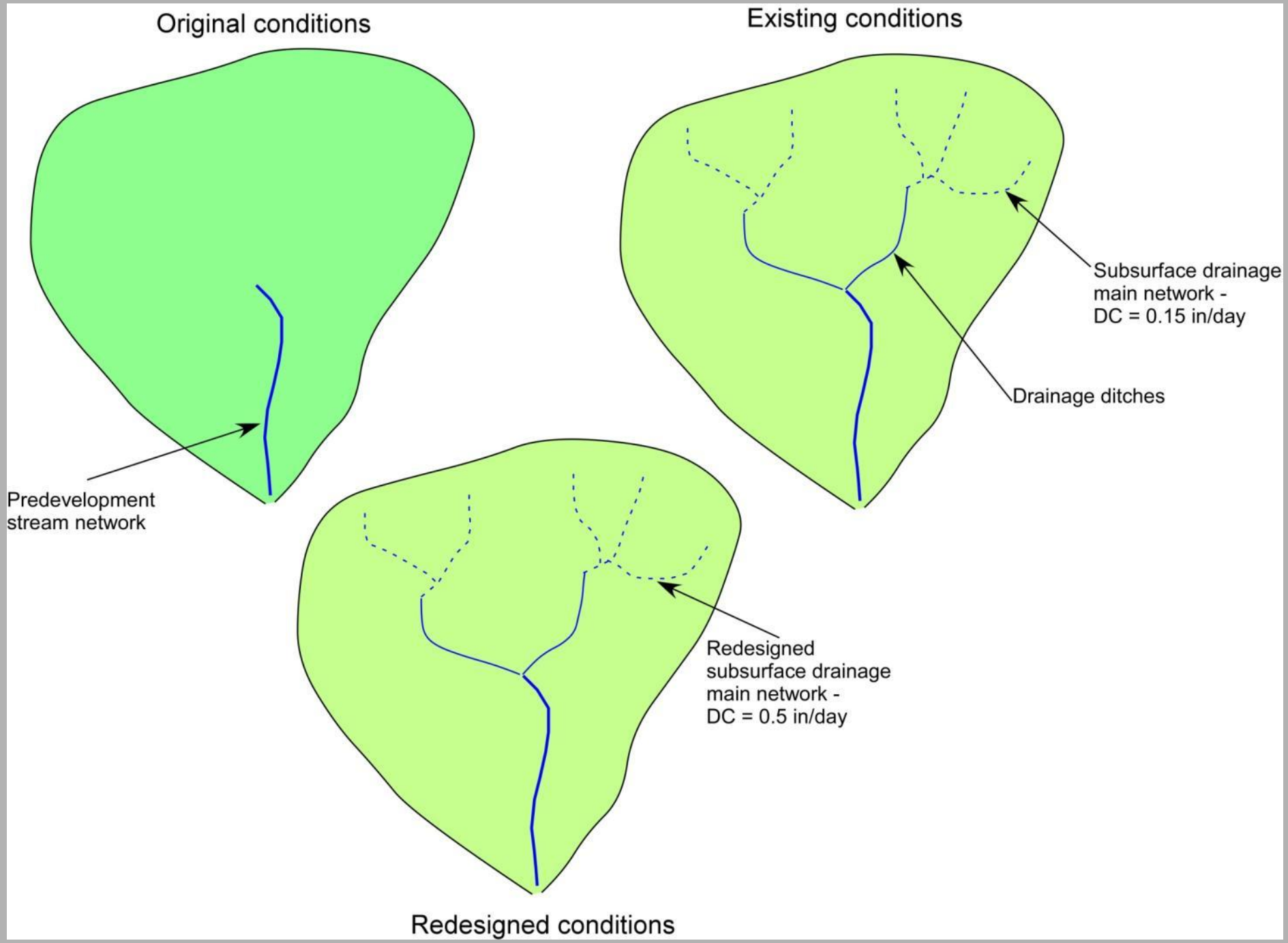


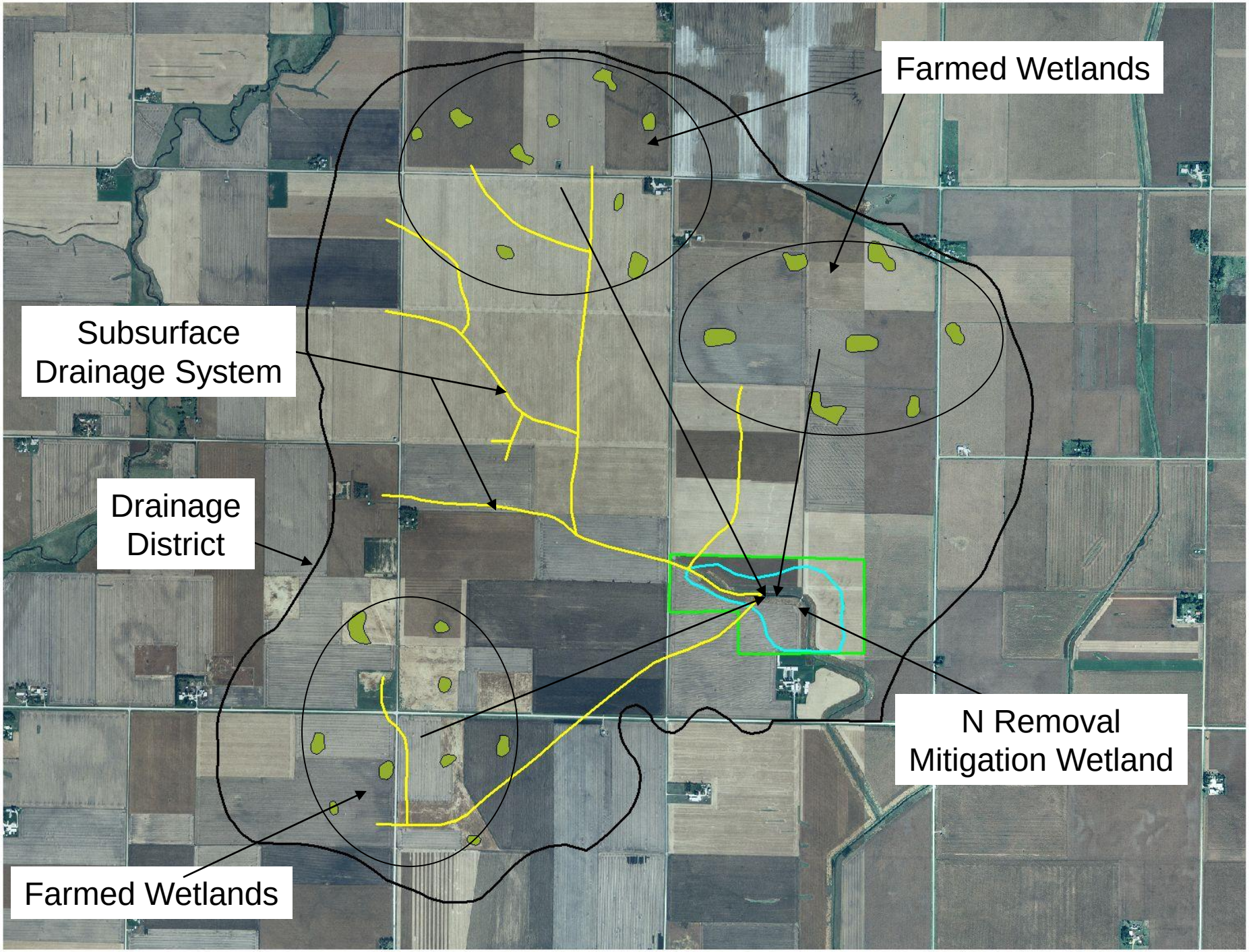
Average Annual Water Balance Averaged over Two Soils (Average rain = 110 cm)

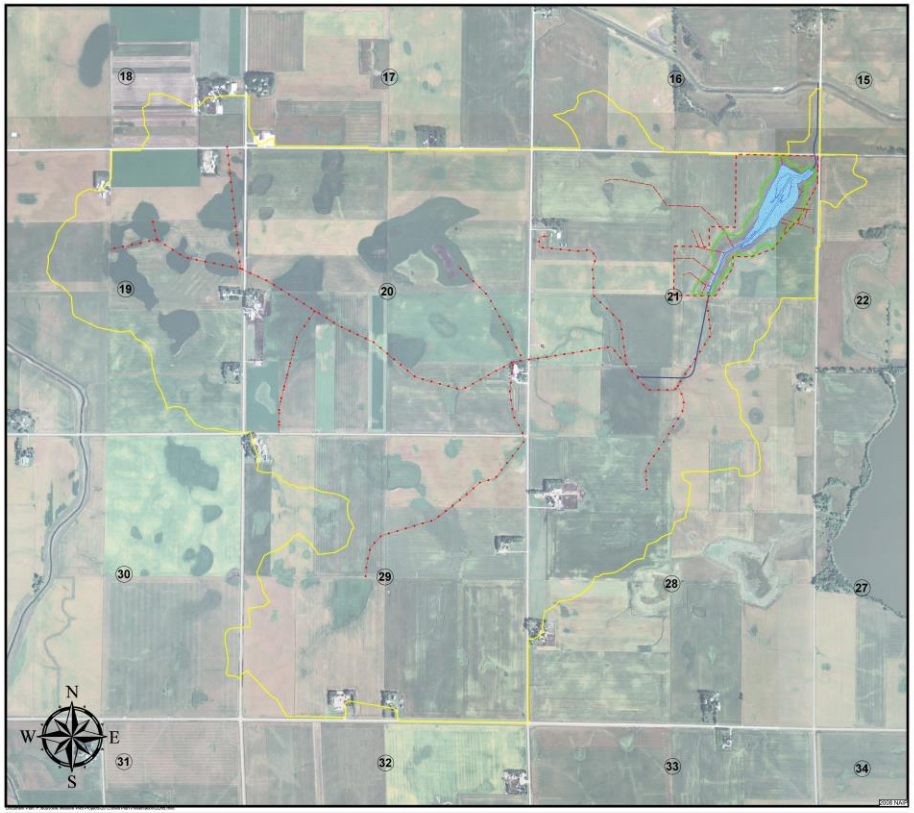
Drainage Plan	ET (mm)	Total outflow (mm)	Surface runoff (mm)	Subsurface flow (mm)	Average Water Table Depth (mm)
Conventional	690	411	184	227	845
Improved	667	433	73	361	965

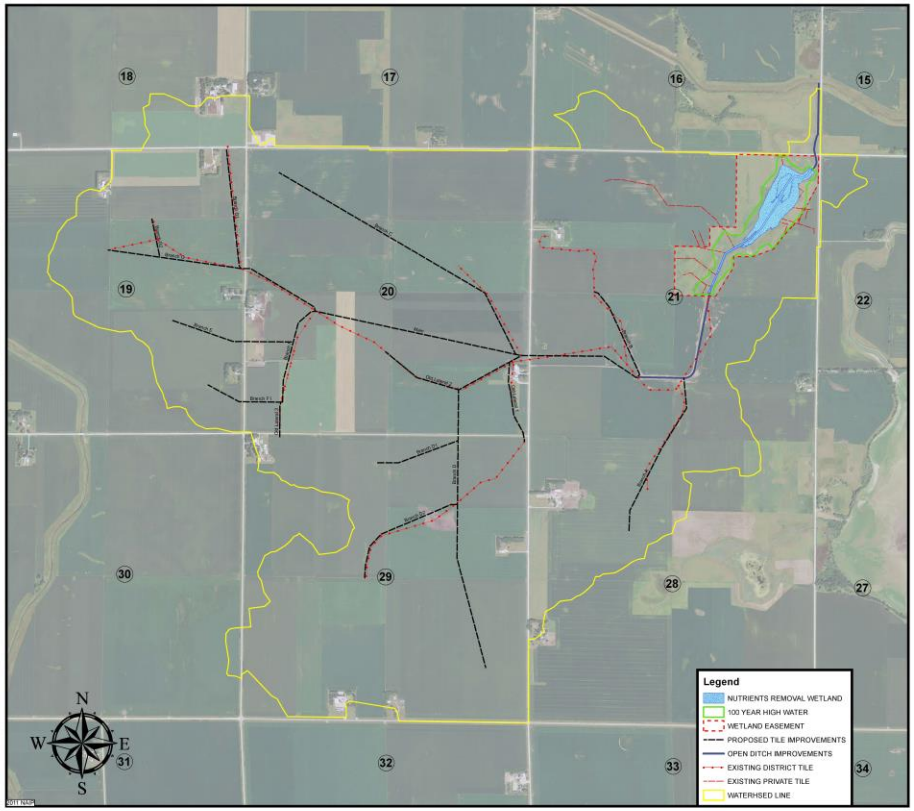
Integrated Drainage and Wetland Landscape Systems

- Extent of drainage will not be increased
- Drainage district main network redesigned to modern drainage coefficient to allow for greater infiltration of water and thereby increased crop productivity
- Nutrient removal wetlands incorporated below outlets and utilized to mitigate for “impacts” to continuously-cropped farmed wetlands

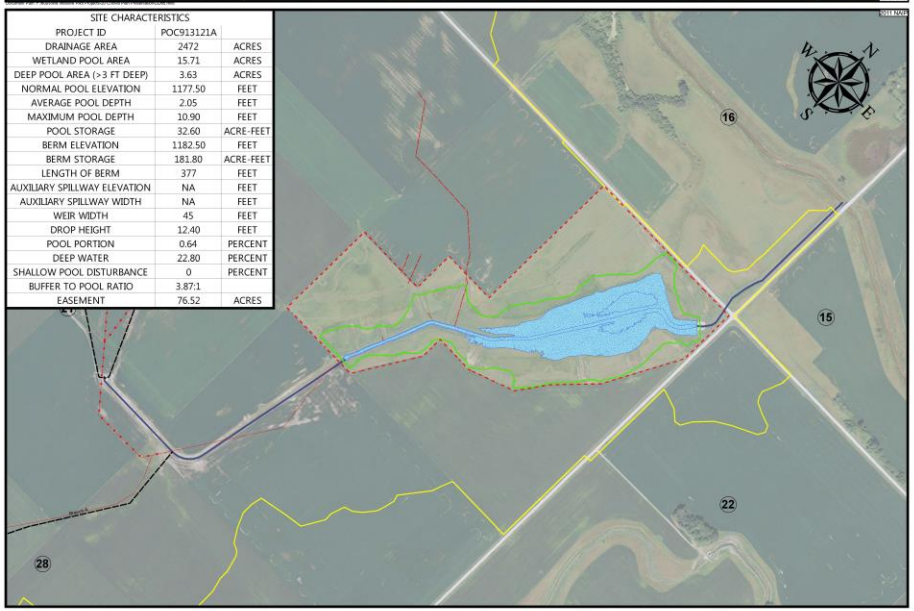

Original conditions
Existing conditions
Subsurface drainage main network - DC = 0.15 in/day
Drainage ditches
Predevelopment stream network
Redesigned subsurface drainage main network - DC = 0.5 in/day
Redesigned conditions


Farmed Wetlands
Subsurface Drainage System
Drainage District
N Removal Mitigation Wetland
Farmed Wetlands





SITE CHARACTERISTICS		
PROJECT ID	POC913121A	
DRAINAGE AREA	2472	ACRES
WETLAND POOL AREA	15.71	ACRES
DEEP POOL AREA (>3 FT DEEP)	3.63	ACRES
NORMAL POOL ELEVATION	1177.50	FEET
AVERAGE POOL DEPTH	2.05	FEET
MAXIMUM POOL DEPTH	10.90	FEET
POOL STORAGE	32.60	ACRE-FEET
BERM ELEVATION	1182.50	FEET
BERM STORAGE	181.80	ACRE-FEET
LENGTH OF BERM	377	FEET
AUXILIARY SPILLWAY ELEVATION	NA	FEET
AUXILIARY SPILLWAY WIDTH	NA	FEET
WEIR WIDTH	45	FEET
DROP HEIGHT	12.40	FEET
POOL PORTION	0.64	PERCENT
DEEP WATER	22.80	PERCENT
SHALLOW POOL DISTURBANCE	0	PERCENT
BUFFER TO POOL RATIO	3.87:1	
EASEMENT	76.52	ACRES



DRAINAGE DISTRICT NO. 65

Pocahontas County, Iowa

EASEMENT BOUNDARY

IOWA Conservation Reserve Enhancement Program

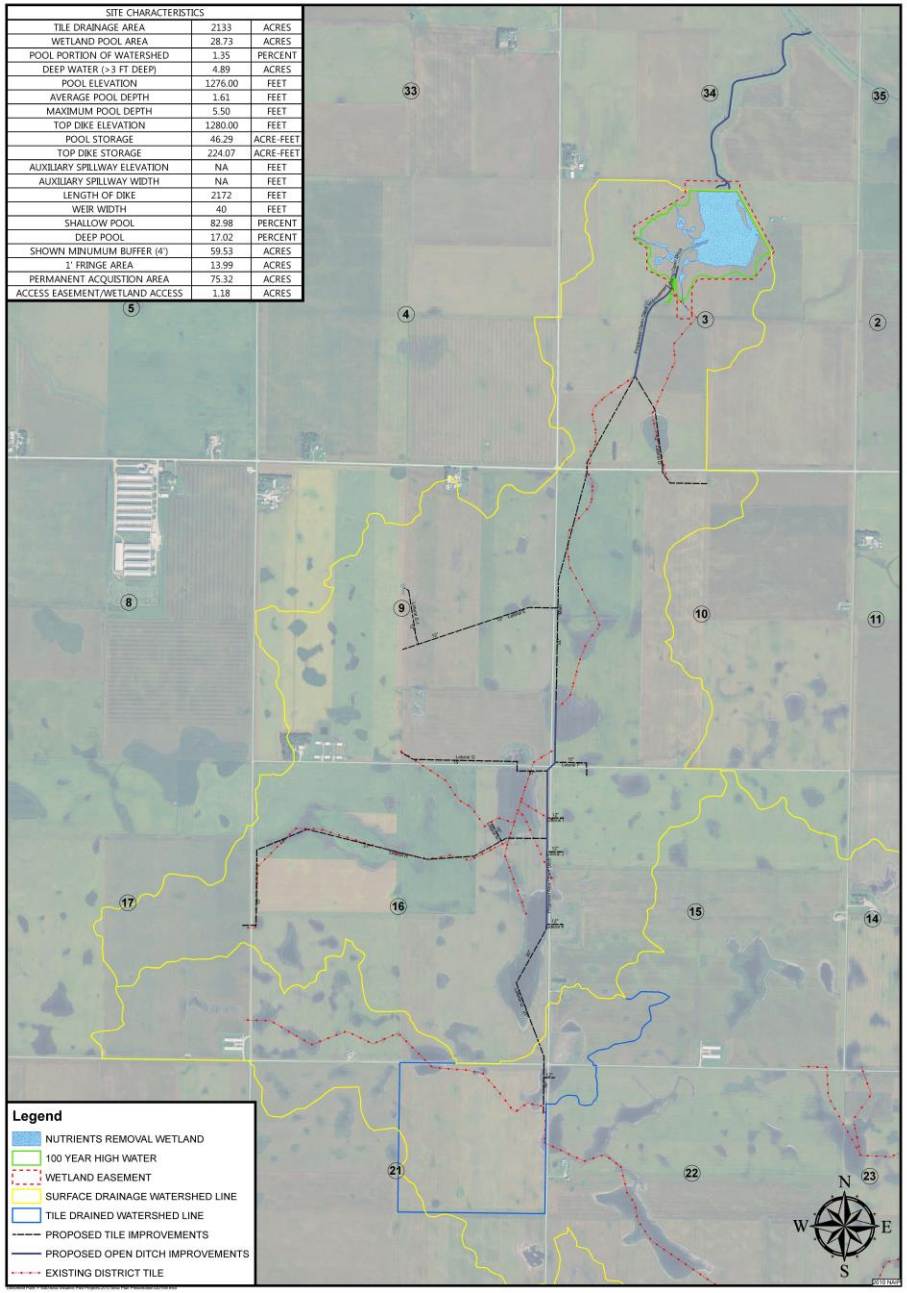
IOWA DEPARTMENT OF AGRICULTURE AND LAND STEWARDSHIP

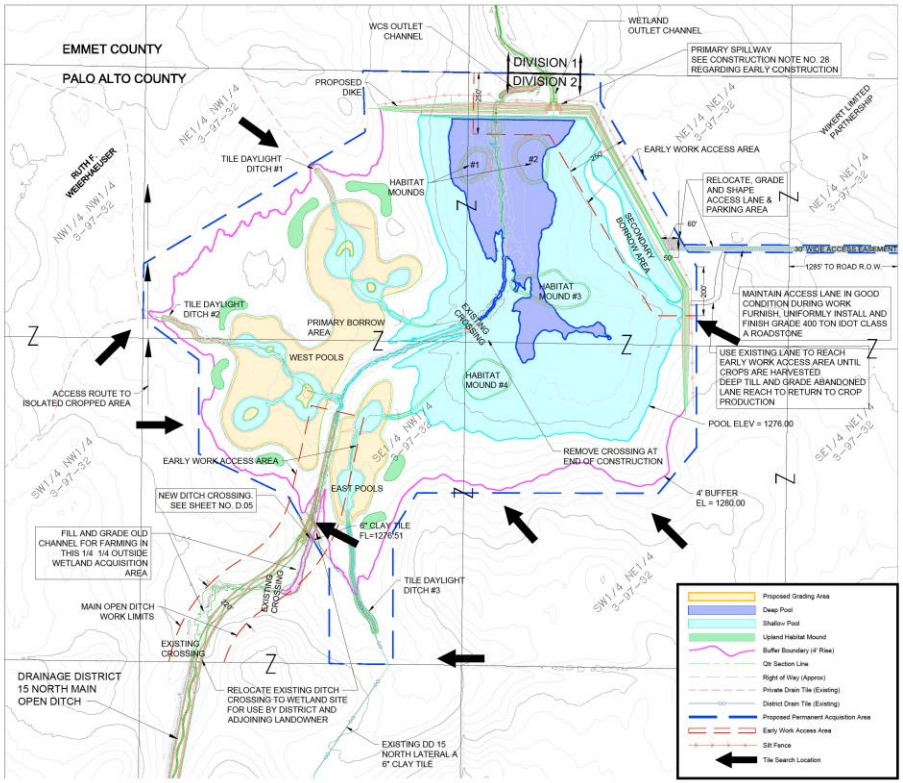
Pocahontas COUNTY

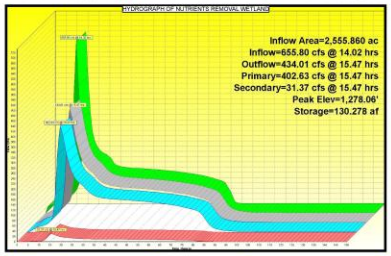
I&S GROUP One firm - start to finish™

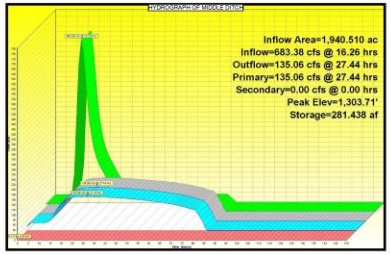
ARCHITECTS · ENGINEERS · PLANNERS · LAND SURVEYORS · SCIENTISTS

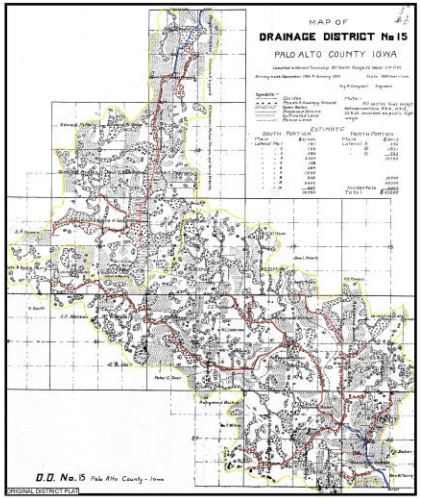
SITE CHARACTERISTICS		
TILE DRAINAGE AREA	2133	ACRES
WETLAND POOL AREA	28.73	ACRES
POOL PORTION OF WATERSHED	1.35	PERCENT
DEEP WATER (>3 FT DEEP)	4.89	ACRES
POOL ELEVATION	1276.00	FEET
AVERAGE POOL DEPTH	1.61	FEET
MAXIMUM POOL DEPTH	5.50	FEET
TOP DIKE ELEVATION	1280.00	FEET
POOL STORAGE	46.29	ACRE-FEET
TOP DIKE STORAGE	224.07	ACRE-FEET
AUXILIARY SPILLWAY ELEVATION	NA	FEET
AUXILIARY SPILLWAY WIDTH	NA	FEET
LENGTH OF DIKE	2172	FEET
WEIR WIDTH	40	FEET
SHALLOW POOL	82.98	PERCENT
DEEP POOL	17.02	PERCENT
SHOWN MINUMUM BUFFER (4')	59.53	ACRES
1' FRINGE AREA	13.99	ACRES
PERMANENT ACQUISTION AREA	75.32	ACRES
ACCESS EASEMENT/WETLAND ACCESS	1.18	ACRES











DRAINAGE DISTRICT NO. 15 NORTH

Palo Alto County, Iowa

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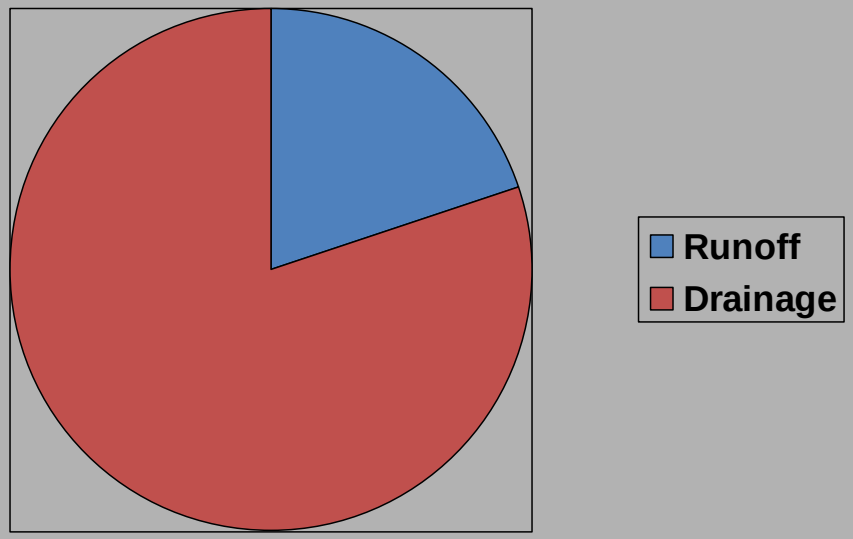
IOWA DEPARTMENT OF AGRICULTURE AND LAND STEWARDSHIP

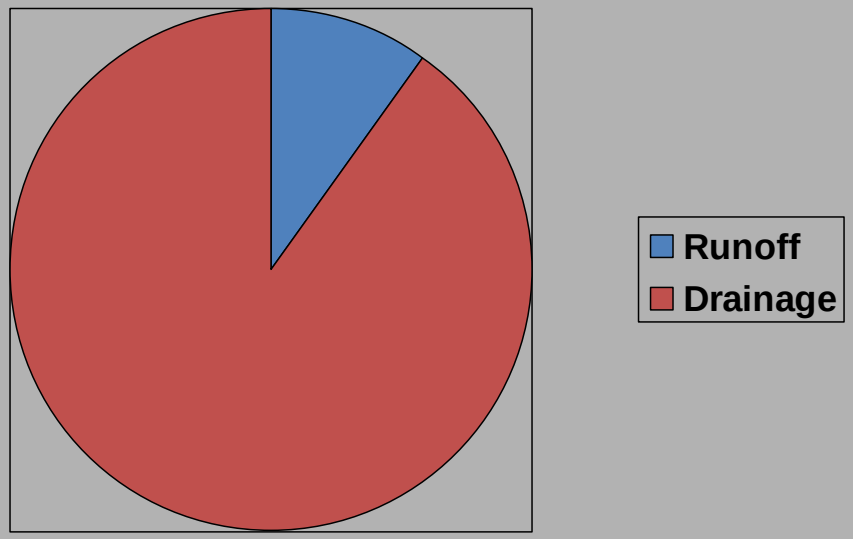
PALO ALTO COUNTY

Challenges

- General societal opposition to agricultural drainage
  - No longer accepted by the public as a conservation practice
  - Cited as primary cause for flooding events by urban/environmental groups
  - Reluctance to accept that environmental and agricultural benefits can coincide
- Misunderstanding of mechanics of agricultural drainage
  - Perception that drainage greatly increases total discharge from a watershed when it is actually more equivalent to reapportioning the flow between surface and subsurface pathways
  - Drainage capacity perceived to be the normal flow rate



Annual Flow (10 inches)



Annual Flow (10 inches)

Existing Drainage System
-Reduced infiltration capacity in soil
-No N removal wetland

Modern Drainage System with Wetland
-50% reduction in surface runoff
-Small % increase in subsurface drainage
-40-70% N reduction in wetland

Water Quality and Quantity Impacts of Agricultural Subsurface Drainage

- Fausey, Brown, Belcher and Kanwar (1995) reviewed 150+ journal articles and published reports
- From this literature review, water quantity and quality impacts related to subsurface drainage as % change are summarized

Impacts of Agricultural Subsurface Drainage as % Change – Summary of 150+ Journal Articles/Reports

Soil-Bound Nutrients

- Reduction in phosphorus lost by water erosion ranged from 0-45%
- P reduction related to reductions in total soil loss, total runoff, peak runoff rate
- Reduction in soil-bound nutrients ranged from 30-50%

Impacts of Agricultural Subsurface Drainage as % Change – Summary of 150+ Journal Articles/Reports

Water & Sediment

- Reduction in total amount of runoff that leaves site as overland flow ranged from 29-65%
- Reduction in peak overland flow runoff rate ranged from 15-30%
- Reduction in total sediment lost by water erosion ranged from 16-65%

Part 650, National Engineering Field Handbook, USDA-NRCS

- Artificial drainage acts to lower soil erosion by increasing the movement of water through the soil profile and thus reducing runoff.
- Subsurface drainage is a management tool that reduces the potential for erosion and phosphorus enrichment of surface water from agricultural activities.

Challenges

- Wetland and Stream Mitigation
  - Acceptance of multi-purpose wetlands to mitigate for continuously-cropped farmed wetlands
  - Stream mitigation implications
    - Example of water quality wetland replacing a portion of a 100-year-old man-made ditch being deemed an impact that must be mitigated
    - Man-made conveyances being forced to mitigate to a “natural” stream state to satisfy regulators

Pothole
Depression
Typical of Farmed
Wetland
May 2007

Same
Pothole
Depression
June 2007

DD#15 FW#1
June 13, 2011

DD#15 FW#1
June 20, 2011

DD#15 FW#1
July 3, 2011

DD#15 FW#1
July 17, 2011

DD#15 FW#1
August 13, 2011

CREP Wetland

CREP Wetland

CREP Wetland

CREP Wetland

CREP Wetland

Challenges

- Regulatory
  - Cumbersome permitting process for individual permits
  - Wetland determinations
    - Ability of DDs to obtain NRCS determinations
    - Corps acceptance of NRCS determinations >5 years old
    - Ability to substitute NRCS determinations for private delineations
    - Jurisdictional Determination process
  - Forthcoming proposed rulemaking on defining waters of the US subject to CWA jurisdiction
    - Significant nexus alone or in combination
    - Chemical, physical, biological effect

Draft CWA Guidance Excerpts

- “Waters…have a significant nexus if they alone or in combination with other similarly situated waters in the same watershed have an effect on the chemical, physical, or biological integrity of traditional navigable waters or interstate waters that is more than “speculative or insubstantial.”
- “An unbroken surface or shallow sub-surface hydrologic connection to jurisdictional waters may be established by a physical feature or discrete conveyance that supports periodic flow between the wetland and a jurisdictional water.”
- “The hydrologic connection need not itself be a water of the U.S.”

Draft CWA Guidance Excerpts

- “Functions of waters that might demonstrate a significant nexus include sediment trapping, nutrient recycling, pollutant trapping and filtering, retention or attenuation of flood waters, runoff storage, and provision of aquatic habitat.”
- “A hydrologic connection is not necessary to establish a significant nexus, because in some cases the lack of a hydrologic connection would be a sign of the water’s function in relationship to the traditional navigable water or interstate water, such as retention of flood waters or pollutants that would otherwise flow downstream to the traditional navigable water or interstate water.”

Draft CWA Guidance Implications

- Water quality standards including future nutrient standards will apply to waters of the U.S., which through this guidance are moved closer to and in some circumstances into cropped fields and road ditches adjacent to cropped fields.
- Guidance moves jurisdictional waters of the U.S. into cropped fields upstream of where off-field buffers can be placed, rendering these technologies inoperable to achieve future water quality nutrient standards

Opportunities

Environmental, Wildlife and Recreation

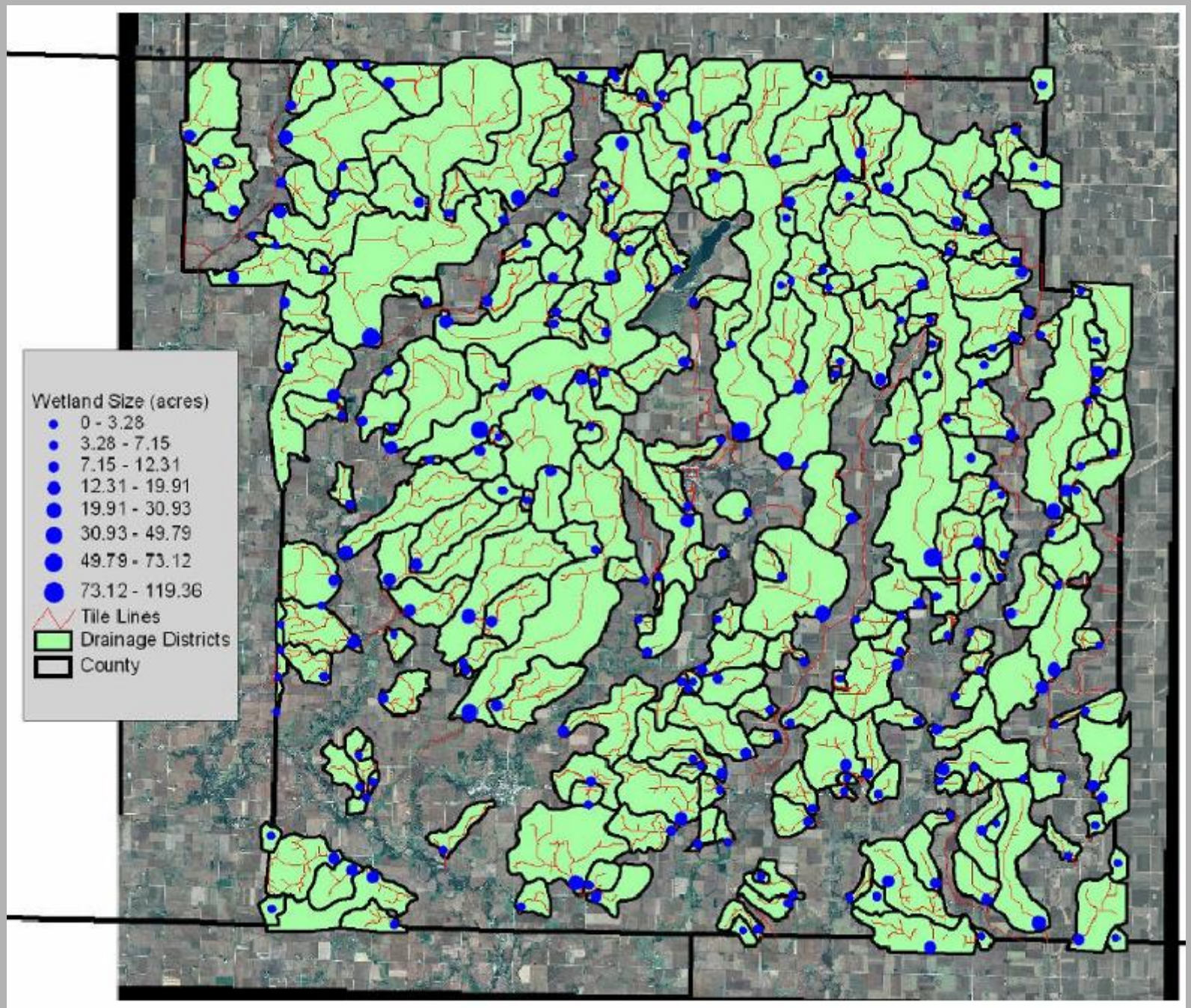
- *Decreased*
  - nitrogen transport to water resources
  - surface runoff, soil erosion, phosphorus transport
  - pesticide and pathogen delivery to water resources
  - N_2O greenhouse gas emissions
- *Increased*
  - wetland function and wildlife habitat
  - potential to move to less intensive tillage
  - landscape diversity
  - recreational opportunities

Opportunities

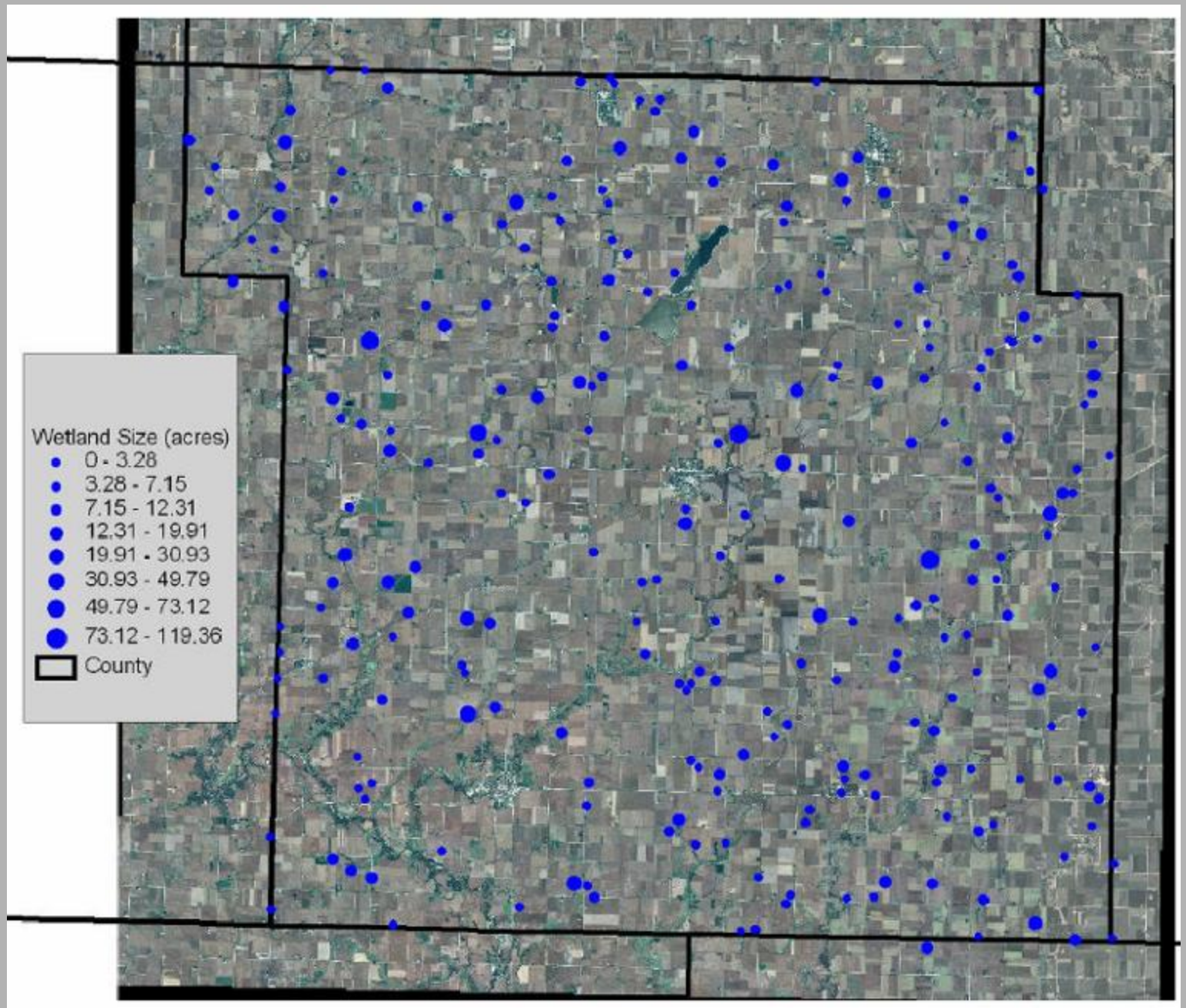
Environmental, Wildlife and Recreation

- Increase the number of potential sites for nutrient removal wetlands by integrating drainage system re-design with wetland development to overcome topographic limitations of current retrofit approach.
- Increase the number of high-value wetlands and the total wetland functional values across the region. These wetlands would serve the multi-purpose functions of enhanced water quality, mitigation for the conversions of nearby low-value wetlands and increased wild life habitat and recreation.

Calhoun County – Drainage Districts & Potential Nitrate Removal Wetlands



Calhoun County – Potential Nitrate Removal Wetlands



Opportunities

Food and Bio-energy Feedstock Production

- 7-20% increase in grain stocks available to reduce the consumer costs of food and bio-energy feedstocks across the targeted landscape.
- Optimize production and crop yields in lands that have been and will continue to be continuously-cropped.
- Reduce market economic pressures to convert highly-erosive lands that are currently in CRP, pasture, or wildlife use to row-crop production

Opportunities

Economic Benefits and Costs

- At the 7-20% increases in annual crop yields resulting from improved subsurface drainage predicted by ISU studies, annual increases in net income to growers from crop production across the 6 million acres of the Des Moines lobe estimated close to $500 million/year.
- Reduced public sector cost of developing nitrate-removal wetlands under the Iowa CREP by shifting a portion of the expenses to private landowners, driven by the enhanced economic returns from corn and soybean production from bio-energy and global food demand for grain.
- Economic returns from enhanced wildlife, waterfowl and associated recreation returns from increased wetland function and habitat values.

Example Yield Increases

Calhoun

District Size (acres)	Outlet Capacity (in/day)	Relative Yield	Inc in Rel. Yield if 0.5 in/day coefficient
1860	0.22	94	2
1025	0.18	92	4
1920	0.1	79	17
1600	0.09	76	21
2000	0.05	56	41
1920	0.13	86	10
1760	0.11	82	15
1120	0.44	97	0
1120	0.24	95	2
960	0.27	96	1
400	0.25	95	1

What Might $ Impacts of Optimized Drainage Systems be on a County?

Acres in DD	250,411
Yield Increase (%)	7.7
Base Corn Yield	190
Base Soy Yield	55
Corn Price	$4.95
Soy Price	$13.20
Acreage in corn (%)	65
Acreage in Soy (%)	35

Total Annual Increase in Corn Yield (bushels)	2,381,283
Total Annual Increase in Soy Yield (bushels)	371,172
Annual Increase in Income ($)	$16,686,819

What Might $ Payback of Optimized Drainage Systems be to Landowners?

Estimated cost of optimized drainage mains	$600/acre
Estimated cost of “status quo replacement” drains	480/acre
Optimization cost	120/acre
Estimated net income increase*	60/acre/yr
Projected payback for drain optimization**	2-3 yrs

*Basis

7.7% yield increase

190 bu corn @ $5/bu

55 bu soy @ $$10/bu

**Note - does not include wetland mitigation costs

Economics of Drainage Improvements

- Payback on tile investment can be achieved utilizing <u>increased revenue only</u>
- Payback period utilizing <u>increased revenue only</u> is relatively short (10-20 years)
- Payback period is much shorter than the 125+ year service life of the new drainage system
- Drainage warrants allow for up to 20-year financing, longer than typically needed to payback from increased revenue

Opportunities

Market Driven Frameworks & Partnerships

- Support voluntary, incentive, and market-based efforts for reducing nutrient loading and achieving enhanced environmental stewardship.
- Improve the availability and affordability of mitigation for the conversions of farmed wetlands in and near the treated watersheds by authorizing the banking and marketing of treatment wetland functional values.
- Utilize “market-driven” economic returns to support a portion of the cost for water quality improvement of strategically-located and designed nutrient-removal wetlands. This portion would be paid by landowners through mitigation of existing farmed-wetlands.

Opportunities

Market Driven Frameworks & Partnerships

- Potential to implement “Water Quality Trading” on a market-driven basis within small watersheds by facilitating landowners “trading” their nutrient contributions to water resources from croplands, to other lands in the watershed that perform “nutrient removal” function through strategically-targeted nutrient removal wetlands.
- Engage and empower the existing, locally-led watershed management institutional capacity of Iowa’s 3,000 drainage districts to develop, manage and maintain the necessary landscape modifications

Opportunities

Demonstration of a potential model for adoption across the U.S. corn belt for reducing nitrate export to downstream water resources, addressing Gulf hypoxia nitrogen reduction targets and protecting drinking water.

Summary

- Flat, low-erosion drained landscapes are environmentally-preferred for production of row crops
- Over the next decades the existing drainage systems in Iowa's drainage districts will be replaced due to age and structural failures
- Critical Issue – will these replacement systems be designed to maintain the 'status quo' or to optimize these landscapes for both environmental benefits and crop production?

For More Information

http://iowalandscapeinitiative.com/