Understanding Agricultural Drainage

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U of M Extension Drainage Design Workshop

2011 – 2014 Participants
WORKSHOP GOALS

- Expand knowledge
- Nail the concepts
- Build on fundamentals
- Learn new tools
- Learn new practices
- Learn from others
Learning Units for Workshop

- Safety
- Design 1: Soils & principles and tools
- Design 2: Intro to drainage design
- Design 3: Whole-class design project
- Design 4: Managed drainage design
- Design 6: Team design project
- Design 7: Lift station design
- Design 8: Subirrigation design
- Conservation drainage practices
- Legal updates and perspectives
- Drainage Software
Take Home Points

• **Be safe in the field (esp. trench safety)!**
• Be kind to your neighbors
• Generally, state laws support drainage, but there are limits
• Drainage spacing may be the hardest and the most important decision; layout comes next
• Make your drainage systems function as uniformly as possible
• Design with conservation drainage in mind
• Drainage isn’t rocket science, but there is plenty of room for excellence!
• If going to self-install, walk before you run!
Poorly Drained Soils in the Upper Midwest

Agricultural land benefiting from improved drainage

Drainage Class: Poor, Very Poor, Poor/Very Poor, Very Poor/Poor
Hydrologic Group: A/D, B/D, C/D, D
Slope: Less than or equal 2

Percent
0 or not agricultural
1 - 2
2.1 - 5
5.1 - 10
10.1 - 20
20.1 - 40
40.1 - 60
more than 60

Courtesy of Dan Jaynes, ARS – Ames, IA
Arable Land
450 mil ac

U.S. Water Management

World (30% land)
- 11% arable
- 18% irrigated
- ~25% drained

Irrigation (13%)
Subsurface Drainage (9%)
Drainage (25%)
Soil Water and Drainage

Saturation

Field Capacity

Wilting Point
What is a Water Table?

- “Gravitational” water drains from larger pores
- Water remains in smaller pores
- Water table drops over hours to days
  - Faster at first, then more slowly
Drainage Flow: Water Flows “Up”
Introduction to Drainage Design
A New Age of Drainage

- Water still flows downhill, but …..
- Today’s issues call for new approach
- **Golden Rule of Drainage**
How do you know when you’ve done a good job with drainage design?

- Maximizes net returns?
- Reduced annual variability? Reduced Stress?
- Maintenance free?
- Reduces risk of crop loss?
- Improves field operations?
- Environmental effects minimized?
- Ability to manage the system?
Drainage Design Choices

Design Choices (controllable factors):

- Areas to be drained
- Drainage rates (coefficients)
  - Drain depth
  - Drain spacing
- Drain size

Which choices are most important?

Design Choices (cont.):

- Drain grades
- Drain materials
- Drainage system layout
- Outlet configuration
  - (elev, pumped, natural)
Drainage Design Conditions

- Rainfall/climate factors
- Soils
- Topography
- Outlet condition
- Legal & regulatory framework
- Client’s risk aversion?
- Landowner’s priorities?
Design Process Flowchart

Background Information
(soils, topo, crops)

Select DC, Spacing & Depth

Determine Drain Sizes

Drainage Needed

Develop System Layout

NO

Confirm Outlet

Determine Grades & Depths

Installation

NO

NO

NO
Selection of Drain Depth & Spacing ...

- Determines drainage rate/coefficients
- Influences cost of system
- Influences performance and impact
Effect of Drain Spacing

- Profitability
- Downstream or unwanted effects?
Drain Spacing: How close is close enough? How close is too close?

- Good Crops
- Drains Spaced Correctly
- Area of Severe Crop Damage
- Good Crops
- Drains spaced too far apart

--- Water table 24 hours after a heavy rain
--- Water table 48 hours after a heavy rain
“Optimized” Drainage Design

- Annual Nitrate Loss
- Benefits
- Capital Cost
- Net Return

Drain Spacing

Annualized $\$

N Loss
How do you come up with drain spacing?
Drain Spacing Equation

Drain Spacing, $L$

confining layer

equivalent confining layer

soil surface

$D_d$

$D$

$d$

$m$

$h$

water table

tile drain

equivalent confining layer

confining layer

$2 \times 2 \times (L h k 4 L h) d k (8 D C 2 1 2 \times \times \times \times \times \times \times \times = 22)$
Estimating Drain Spacing: SDSU/U of M

Drainage Calculators
igrowdrainage.org
Drain Spacing

Drainage Coefficient: 0.5 in./day
Tile Diameter: 3 in
Tile Depth: 3 ft
Depth to Restrictive Layer: 12 ft
Minimum Water Table Depth: 1 ft
Hydraulic Conductivity Units: mm/hour
Hydraulic Conductivity Value: 33

Results:
Drain Spacing: 63 ft

Clear All Fields
Resources for Soils Data

• NRCS Web Soil Survey
• Soilweb (ARS) (www, Google Earth, smartphone)
• Illinois Online Drainage Guide (U of IL)
Welcome to Web Soil Survey (WSS)

Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

Three Basic Steps

1. Define.
   Use the Area of Interest tab to define your area of interest.

2. View/Explore.
   Click the Soil Map tab to view or print a soil map, or click the Soil Data Explorer tab.
Soilweb:
http://casoilresource.lawr.ucdavis.edu/soilweb-apps
Google: Soilweb, Soilweb.kmz, or use:
## Saturated Hydraulic Conductivity

- **Permeability**

<table>
<thead>
<tr>
<th>Organic Matter (%)</th>
<th>Percent Clay</th>
<th>Percent Sand</th>
<th>$K_{sat}$ (mm/hr)</th>
<th>$H$ (2-1 H2O)</th>
<th>$K_y$ Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>7.6</td>
<td>3</td>
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<td>0</td>
<td>33</td>
<td>7.6</td>
<td>3</td>
</tr>
</tbody>
</table>

**Legend**:
- Organic Matter (%) range from 0 to 15%
- Percent Clay and Percent Sand range from 0 to 15%
- $K_{sat}$ (mm/hr) values range from 33 to 33
- $H$ (2-1 H2O) values range from 7.6 to 7.6
- $K_y$ Factor values range from 3 to 3
Drainage system layout & design is about matching field topo with desired drain grades and depths so system works well and is economical!

Drain Layout, Grades & Depths
DRAINAGE DEPTH:
GOING FOR UNIFORMITY
Drain Depth

- Design for uniform depth throughout system (depends on layout)
- Depth will of course vary on flat and rolling topography
Design Process Flowchart

1. Background Information (soils, topo, crops)
2. Select DC, Spacing & Depth
3. Determine Drain Sizes
4. Drainage Needed
5. Confirm Outlet
6. Develop System Layout
7. Determine Grades & Depths
8. Installation

NO NO NO
Most important step (besides determining an outlet!)
Where the real brains are needed!
Matching field grades with desired tile grades
Layout determines uniformity of drainage

- Consistent depth throughout field
Uniform Drainage Example: Long Fields

No Appreciable Grade

- 2000-ft laterals:
  - @ 0.08% = 1.6 ft of fall
  - @ 0.1 % = 2.0 ft of fall
Possible Solution for Long Fields

- Split the feet of fall in half
- More uniform drainage coefficient
- Yes, more connections and feet of collector (but collectors are smaller)
Another Example: Long Fields

- Natural field grade is \(2.0 \div 2000 \times 100\% = 0.1\%\)
- Easy to keep laterals at uniform depth and maintain plenty of grade
Layout

- Should start with contour (topo) map of field
  - *Only way to look at entire field at once*
- Put (sub)mains on steepest grades
- Field laterals more on contours (intercept water)
Layout

- Consider & plan for future needs
- **Make maps of everything:**
  - As designed
  - As built

Figure 1. Various drainage system layout alternatives.
Design Process Flowchart

Background Information (soils, topo, crops)

- Drainage Needed
  - NO

Select DC, Spacing & Depth

- Develop System Layout
- Determine Grades & Depths

Determine Drain Sizes

Installation

- Confirm Outlet
  - NO
  - NO
Drain Sizing

To determine tile capacity, we need:

- Grade (get from layout)
- Material (we choose)
- Pipe Size (what we’re after)
Design Tools
Design Tools

- Acres Drained
  - DC
  - Grade
  - Material
  - Pipe size

- Pipe Size
  - DC
  - Grade
  - Material
  - Area Drained
Design Tools (cont.)
Estimating Drain Spacing: **SDSU/U of M**

Drainage Calculators

igrowdrainage.org
Computer-aided Design
Agricultural Drainage

The Agricultural Drainage series covers economics, environmental impacts, and safety.

WHAT IS AGRICULTURAL DRAINAGE?

Agricultural drainage is the use of subsurface pipes, tiles, or both, to drain water from an agricultural area. Subsistence drainage can be used for a variety of purposes, including:

- Reducing soil compaction
- Improving crop yields
- Reducing erosion
- Controlling ponding and flooding
- Maintaining wetlands

GENERAL CONSIDERATIONS

- Subsistence drainage is often used to control water levels in agricultural areas.
- Proper design and installation are crucial for effective drainage.
- Drainage systems should be checked regularly for maintenance.

QUESTIONS AND ANSWERS


text from the document

Evaluating a Subsurface Drainage Project and Its Alternatives

Brad Carlson, Extension Educator, and Gary Sand, Professor & Extension Engineer, University of Minnesota Extension

THE FIRST STEP

The benefits of agricultural subsurface drainage (a.k.a. "tile" drainage) include reduced crop labor costs, increased crop yields, enhanced crop quality, reduced soil erosion, and improved water quality. Additionally, subsurface drainage can help control weeds and improve soil aeration, which can lead to increased crop yields and reduced soil compaction.

Subsurface drain systems can be installed using a variety of methods, including:

- Trenching
- Boring
- Trenchless technology

Each method has its own advantages and disadvantages, so it is important to choose the method that is best suited for your specific needs.

The cost of a subsurface drainage project can vary depending on several factors, including:

- The size of the drainage area
- The complexity of the drainage system
- The type of soil in the area
- The availability of labor

In addition to the initial cost of installation, subsurface drainage systems require regular maintenance to ensure they continue to function properly.

CONCLUSION

Subsurface drainage systems can be an effective way to drain water from agricultural areas. However, it is important to carefully consider the benefits and costs of installing a subsurface drainage system before making a decision. Consulting with an extension educator or other experts can help you make an informed decision about whether subsurface drainage is right for your needs.
Agricultural Drainage

Drainage calculators
Drainage industry
Drainage laws
Economics
Gulf hypoxia

History
Science and drainage
Technical, planning, and design
Water quality and environment
Reports

Two-stage drainage ditches can be a win-win
Reduce crop and nutrient losses and ditch repair costs by modifying traditional drainage ditches.

Conservation drainage in Minnesota: CNN.com article
Minnesota farmer battles Gulf ‘dead zone’.

Controlling farm runoff could have multiple benefits
A new approach to farmland drainage may help reduce the Gulf of Mexico’s ‘dead zone.’
Take Home Points

- Be safe in the field (esp. trench safety)!
- Be kind to your neighbors
- Generally, state laws support drainage, but there are limits
- Drainage spacing may be the hardest and the most important decision; layout comes next
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Questions?