The Basics of Agricultural Tile Drainage

Basic Drainage Science and Principals

John Panuska PhD, PE

Natural Resources Extension Specialist
Biological Systems Engineering Department
UW Madison

Sunrise Acres Farm
Sheboygan Co.
August 22, 2018

Biological Systems Engineering
UNIVERSITY OF WISCONSIN–MADISON

UW Extension

Overview

- Basic Drainage Science -

- ✓ Design objectives, benefits and risks.
- ✓ Drainable water and tile system layouts.
- ✓ Locating tile lines in the field and introduce the drainage coefficient.

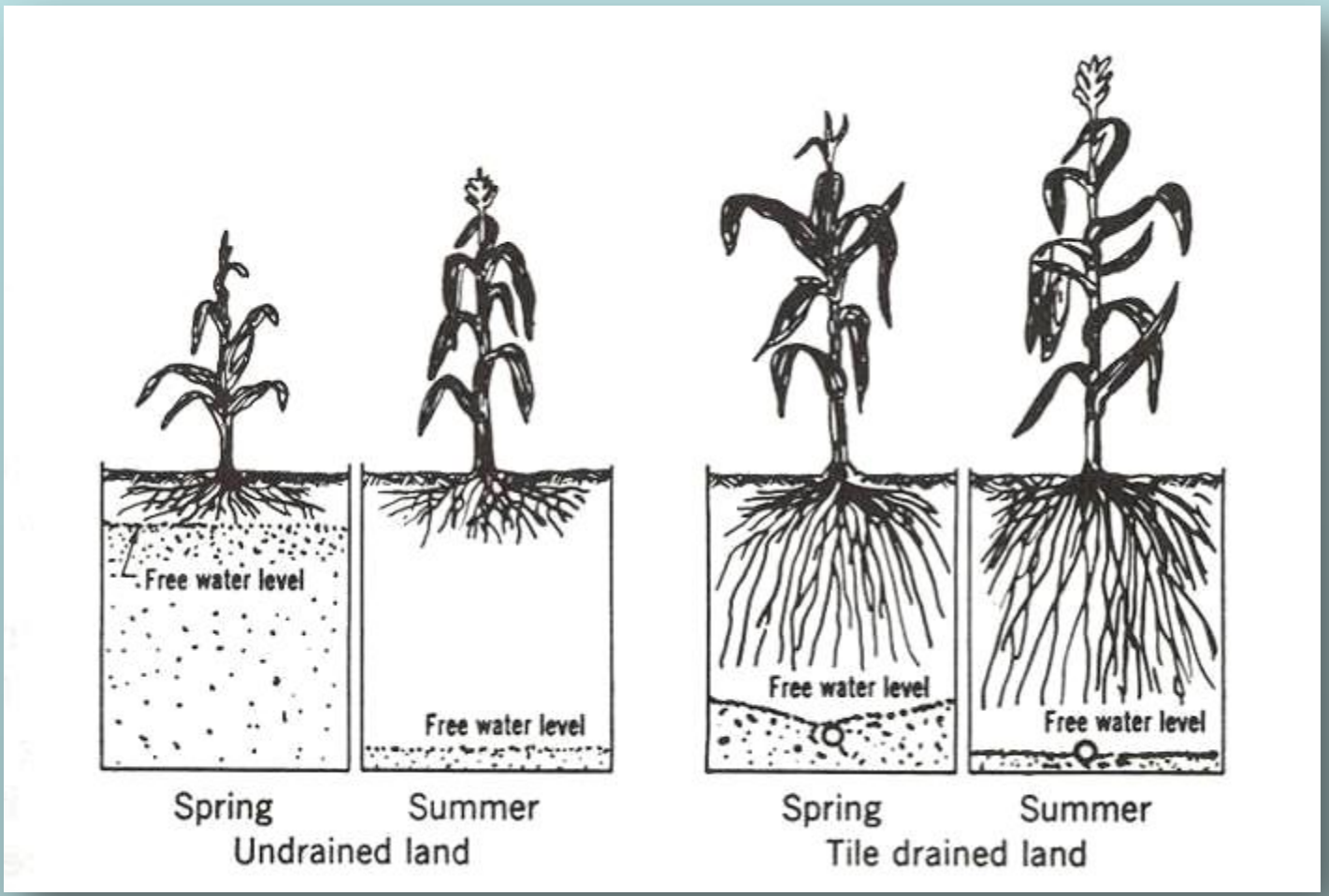
System Design Objectives

1. Maintain water table at proper level for healthiest plant growth.

2. Keep soil voids free of excess water, which permits air flow and allows important biological processes to take place in soil.

3. Minimize inefficient equipment operation caused by wet areas.

System Design Objectives



Improved Root Development

Benefits of Subsurface Drainage

- ✓ Increase crop yields and field trafficability.
- ✓ Greater soil water storage capacity.
- ✓ Conserve topsoil by reducing runoff.
- ✓ Raises soil temperature

  Dry soil is warmer than wet soil. It takes 5 times as much heat to raise an equal volume of water 1° as it does to raise an equal volume of soil 1°.

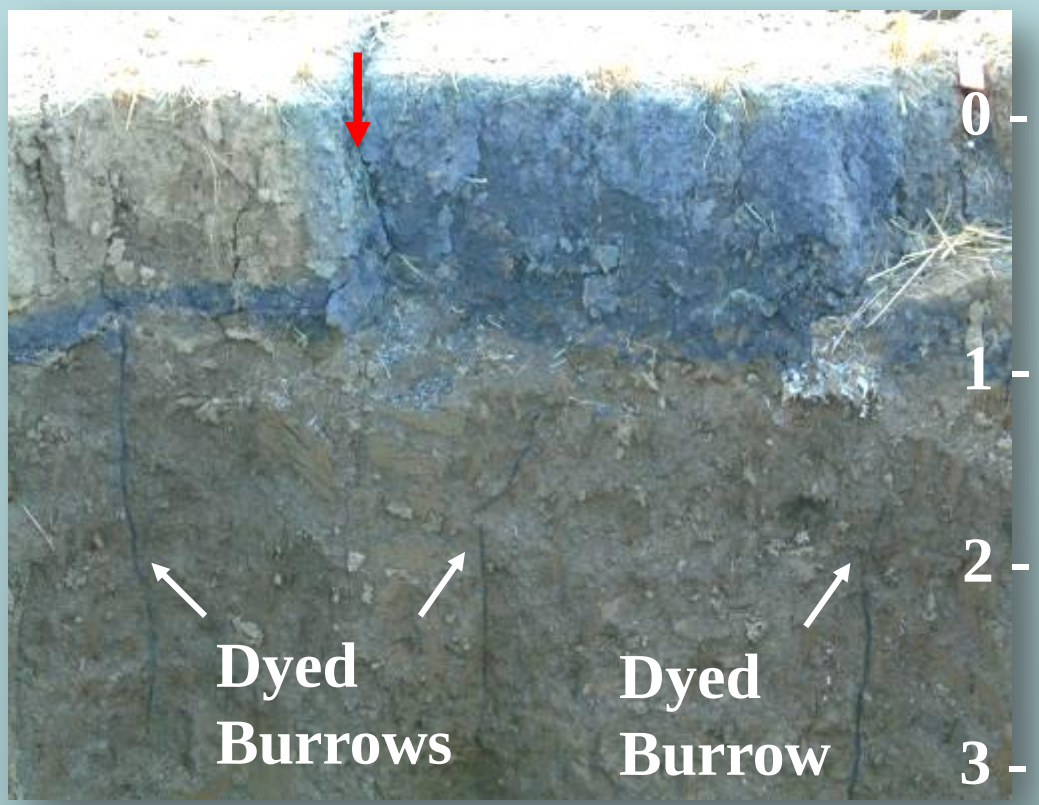
Environmental Risks of Tiles

- ✓ Increased export of nutrients (NO_3 and P), pesticides and pathogens.
- ✓ Surface inlets act direct conduits to receiving waters.
- ✓ Macro-pores (roots and earth worm holes) are natural direct conduits.
- ✓ Drainage of wetlands is illegal !

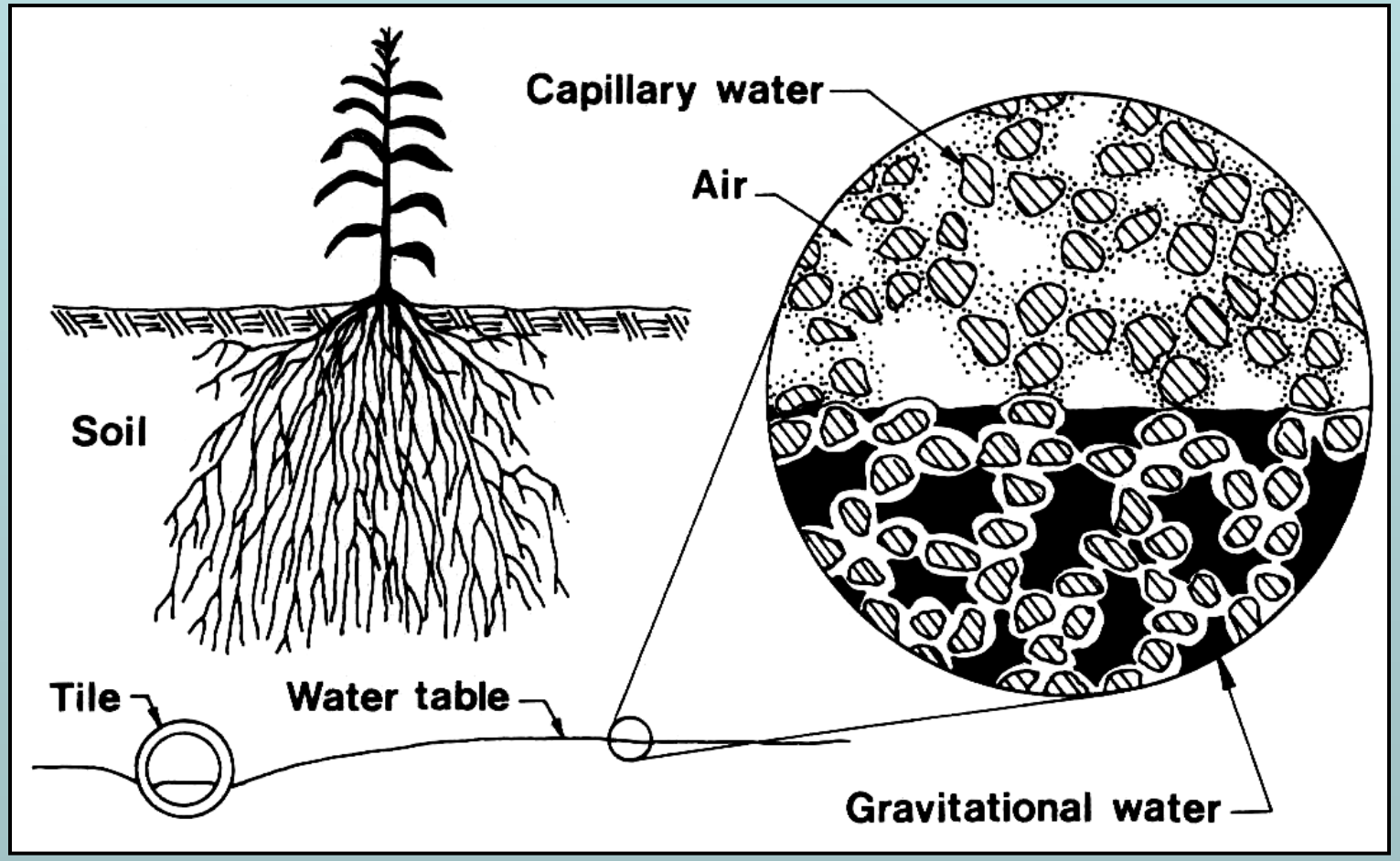
Environmental Risks of Tiles
- Macropores -

Preferential flow

- Earthworm burrows
- Root holes
- Shrinkage cracks
- Structural porosity

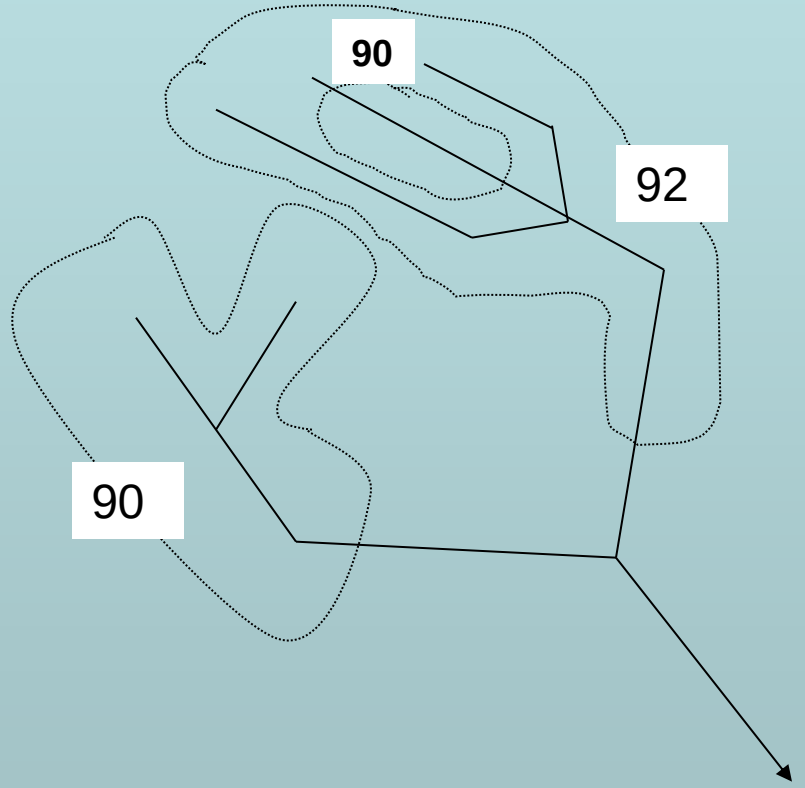


Drainable Water



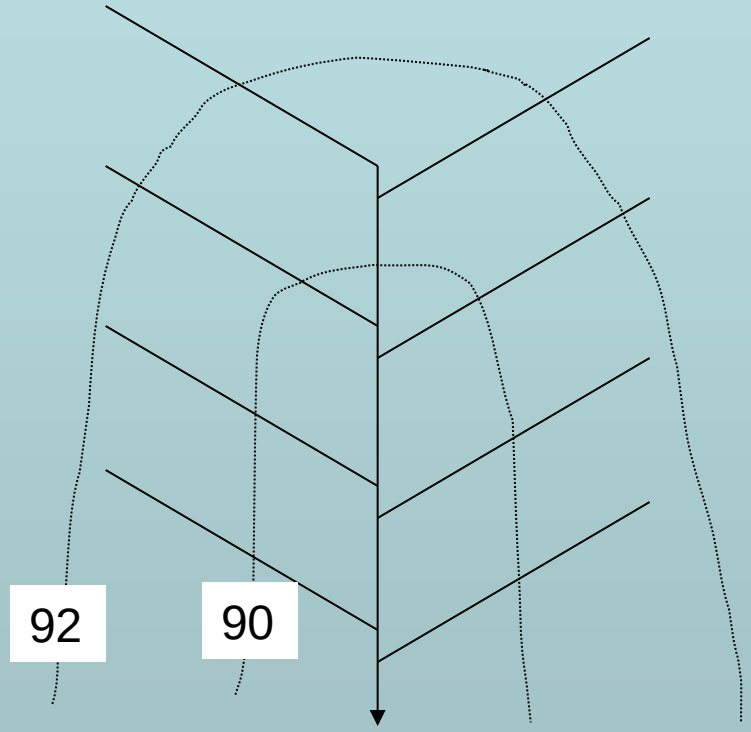
Natural or Random

- ✓ Follow natural depressions.
- ✓ Used frequently in “pot hole” landscapes to drain isolated depressions.



Herringbone

- ✓ Advantageous for heavier soil often found in narrow depressions.
- ✓ Double drainage around main.
- ✓ More junctions – Added cost

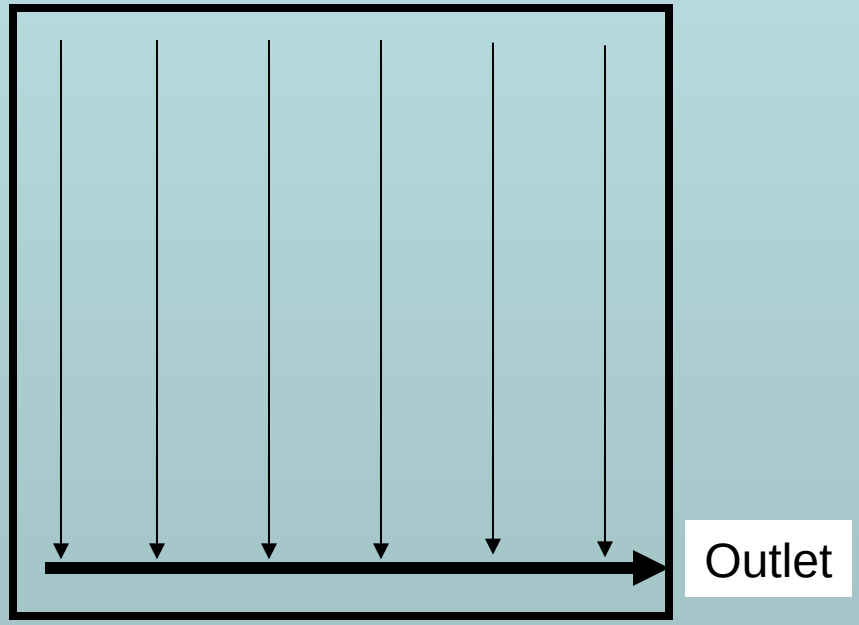


Gridiron

- ✓ Drainage of level areas, uniform slopes

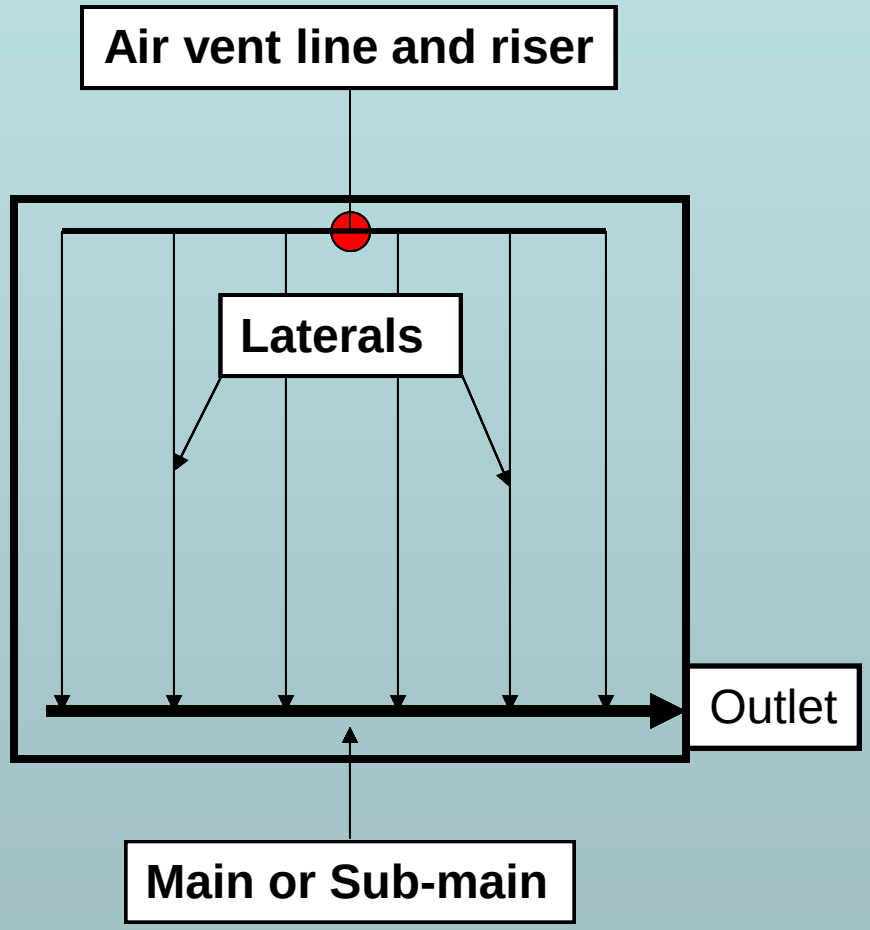
  and soils w/ wide-spread wet areas.

- ✓ One main or sub-main serves as many laterals as possible



Tile System Components

1. Laterals are the initial collectors.
2. Sub-main or collector-main collect from laterals.
3. Mains collect from sub-mains and collector-mains.

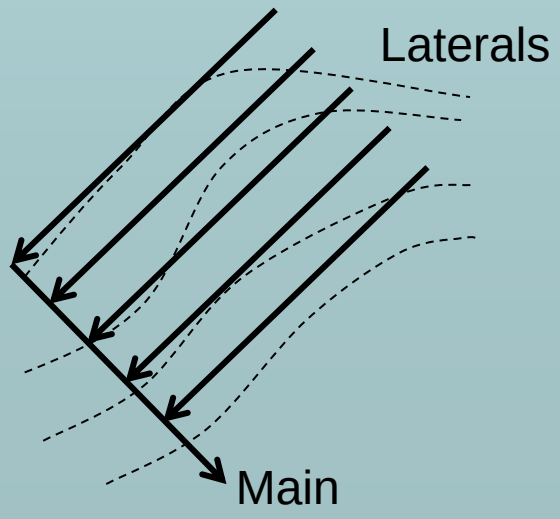


Tile System Layout

Always start with contour map of the field !

When feasible and site conditions allow . . . . .

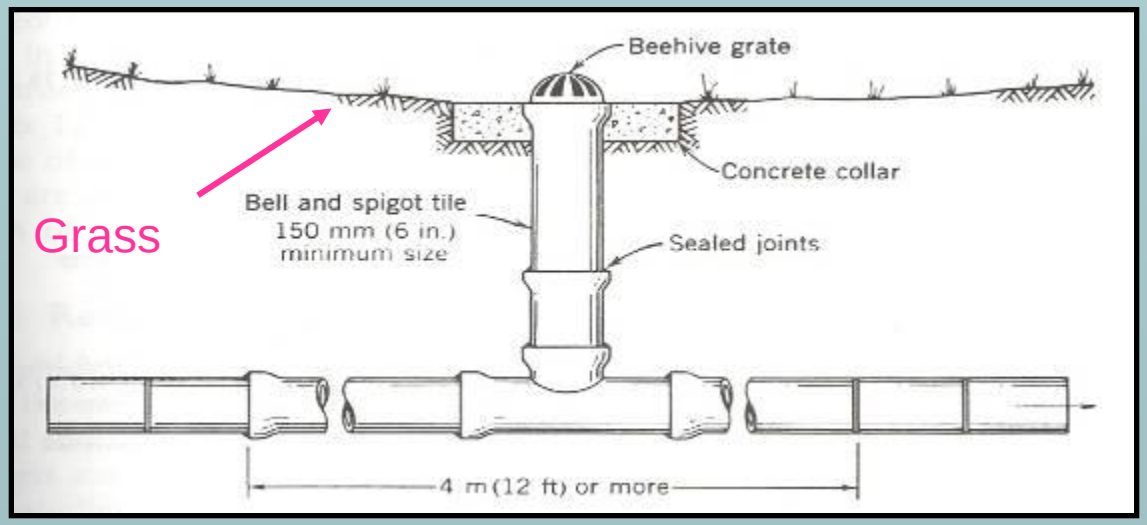
- ✓ **Place field laterals on the contour to maintain a uniform depth and improved drainage uniformity.**
- ✓ **Place mains and sub-mains on steepest grades to decrease pipe size.**



Surface Inlets

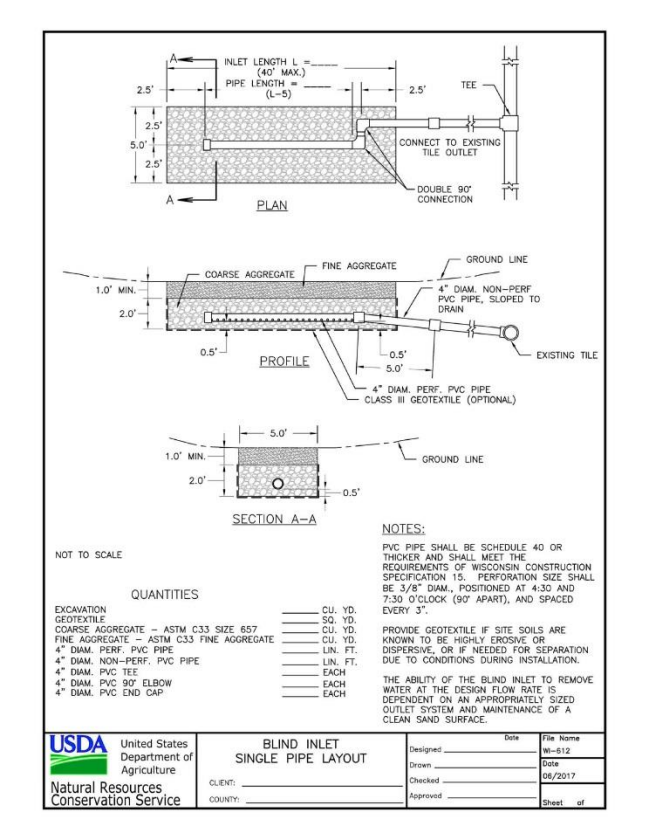
- ✓ Increased potential for water quality impacts.
- ✓ Finer inlet screens and rock filters reduce sediment inflow

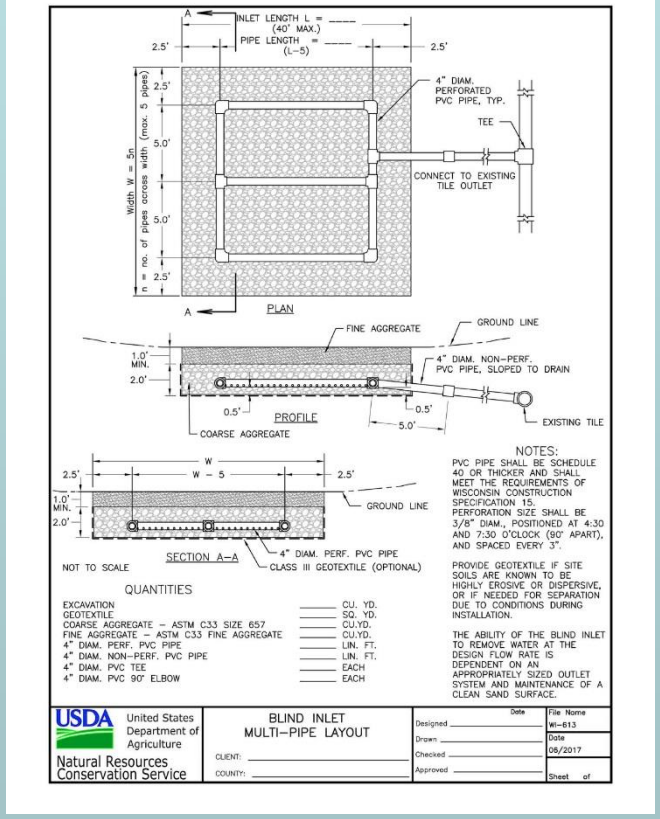
Hickenbottom Inlet



Blind Inlet Design

- Wisconsin NRCS Standard -



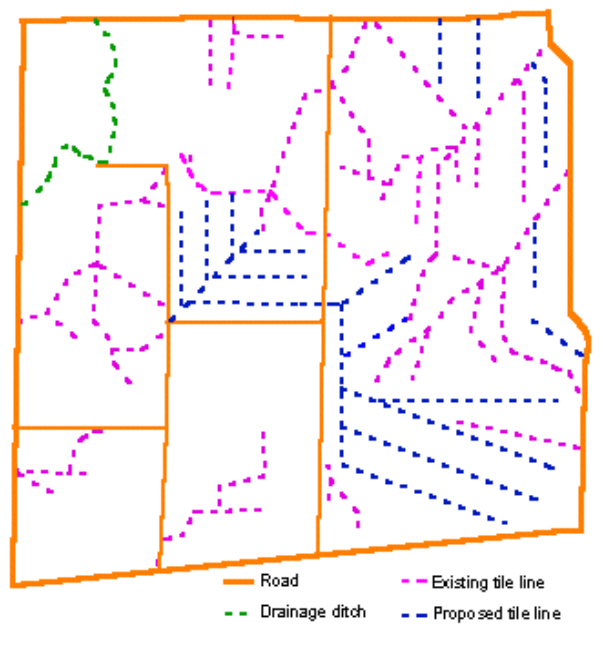


Drawings 612 and 613 on blind inlets for tiles can be found in the Engineering Section of the WI-NRCS Home Page

UW Extension

Field Locating Tile

There is no hard and fast method !!



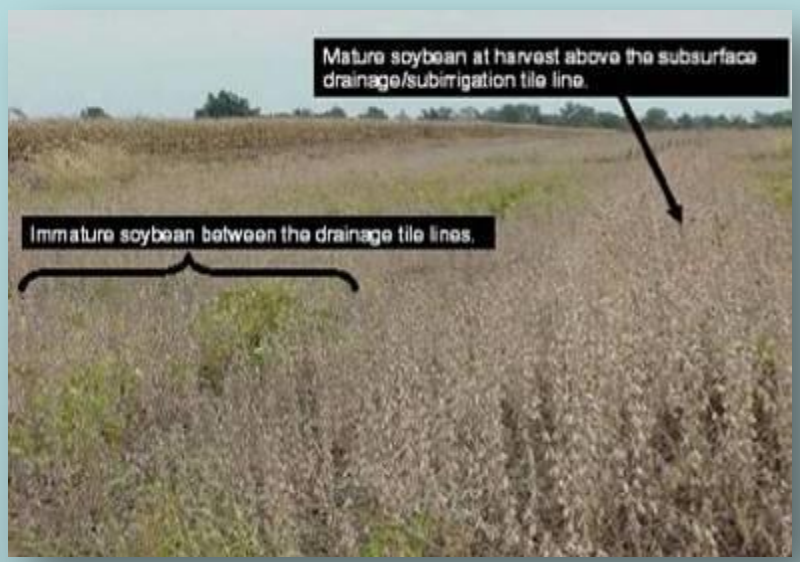
As-Built Plans

Recorded during or shortly after installation.

Not often available

Field Locating Tile

Crop Health

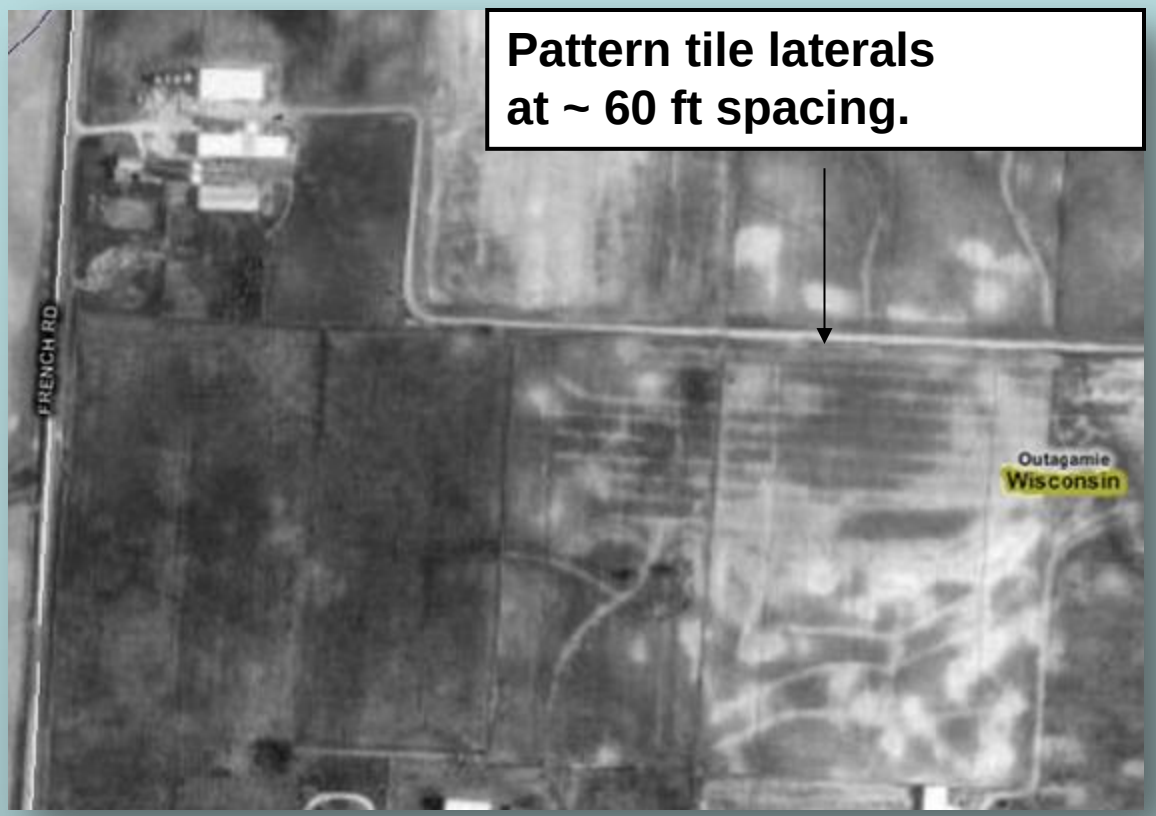


Regular patterns in crop stand health and yields can indicate tile line location.

Yield monitors make this very evident !

Field Locating Tile

Air Photos

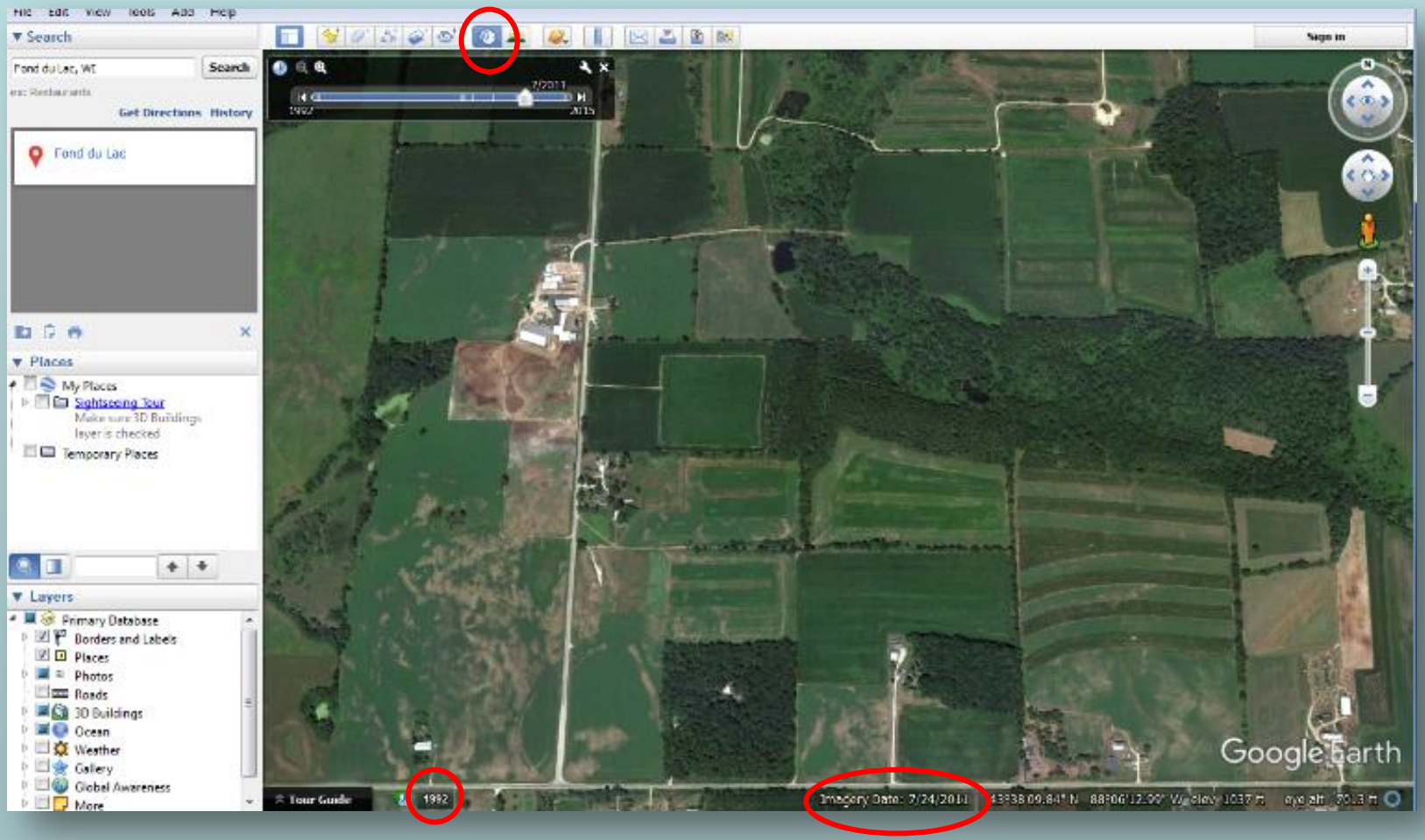


Electronic soil survey map from Outagamie Co., WI

Some counties also have imagery available

Field Locating Tile

Air Photos



Google Earth is another good tool !

Drainage Coefficient

- ✓ *Drainage coefficient* (D_c) or (q) is a desired water removal rate.
- ✓ The Dc equals the volume (depth (in) x area (ac)) of water to be removed from a field in 24 hours.
- ✓ Drainage area can be computed from the length and spacing of the drains.

Drainage Coefficient

- ✓ Where surface inlets are installed, the contributing watershed is the surface drainage area not the pipe drained area and the Dc value is increased.
- ✓ A higher Dc equals greater system design flow rate, larger pipes, quicker water removal and …… a higher cost.

Recommended Drainage Coefficients (in/day) for Pipe Drains in Humid Areas

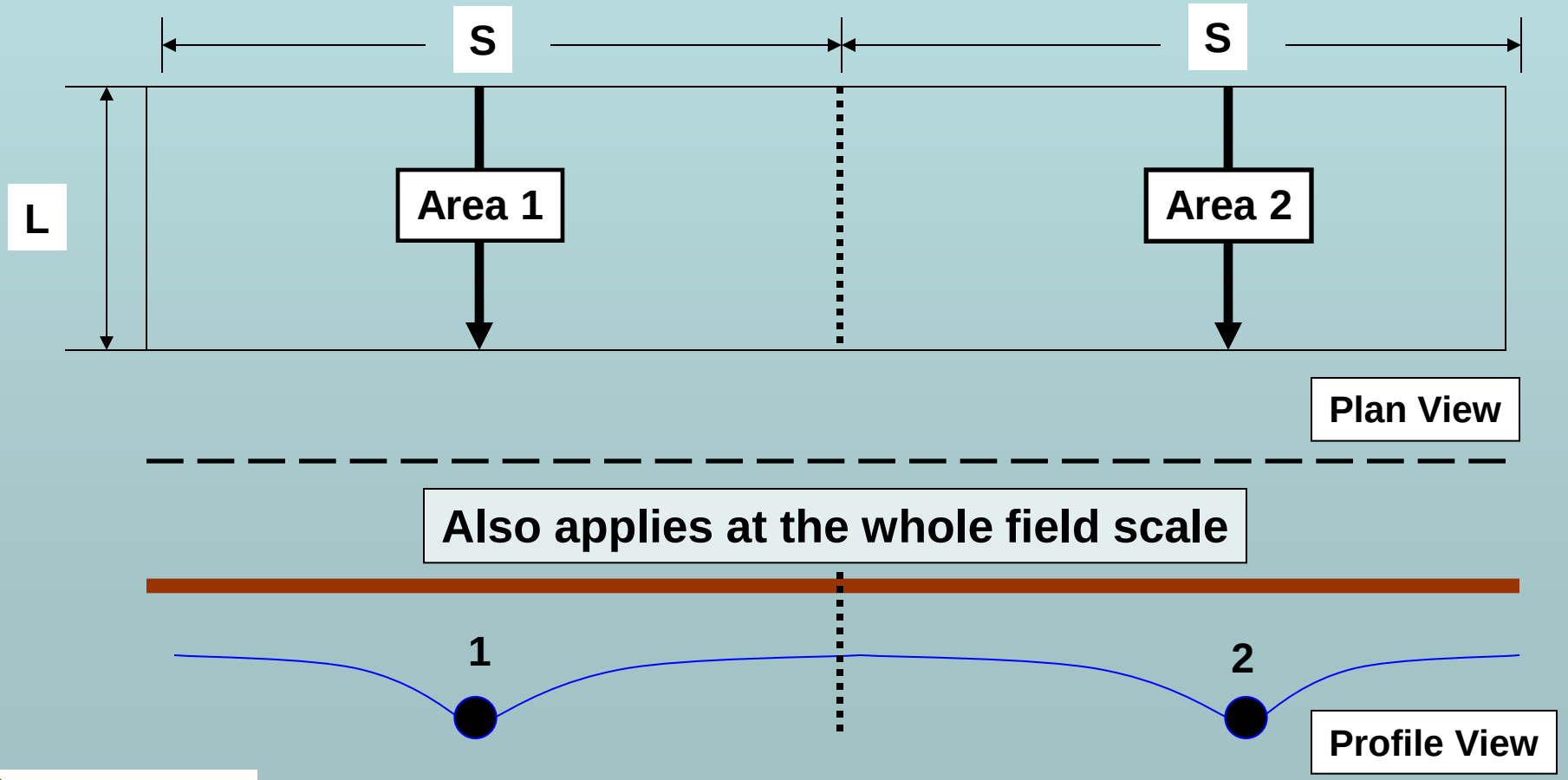
Crops and Degree of Surface Drainage	Mineral Soil (clay and silt)	Organic Soil
Field Crops		
Normal	3/8 – 1/2	1/2 – 3/4
With Blind Inlets	1/2 – 3/4	3/4 – 1.0
With Surface Inlets	1/2 – 1.0	1.0 – 1.5
High Value Crops		
Normal	1/2 – 3/4	3/4 – 1.5
With Blind Inlets	3/4 – 1.0	1.5 – 2.0
With Surface Inlets	1.0 – 1.5	2.0 – 4.0

This is essentially a simple risk management framework

Drainage Coefficient

Drainage Coefficient (Dc) = Depth rate (in/day)

Area x (Dc) = [ac] • [in / day] / 23.8 = Flow rate (ft^3/sec)



Drain System Construction

- ✓ Equipment and materials.
- ✓ Drain outlet, depth and spacing.
- ✓ Installation sequence.
- ✓ Where to get more information.

Drain System Construction

-Things to Think About -

- ✓ You need a good topographic map.
- ✓ You need an accurate way to control grade (Engineer's Level, Laser, RTK GPS).
- ✓ What about pipe layout, locating (mains and laterals).
- ✓ Are there any buried utilities in the field.

  (Power Lines, Gas Pipelines !!)

Drain Tile Installation Equipment

Tractor Backhoe

Tile Plow

Chain Trencher

Wheel Trencher

Drain Tile Materials

Clay Tile (organic soils)

Concrete Tile (mineral soils)

Drain Pipe Materials

- Polyethylene Plastic -

Single wall corrugated

Dual wall (smooth wall)

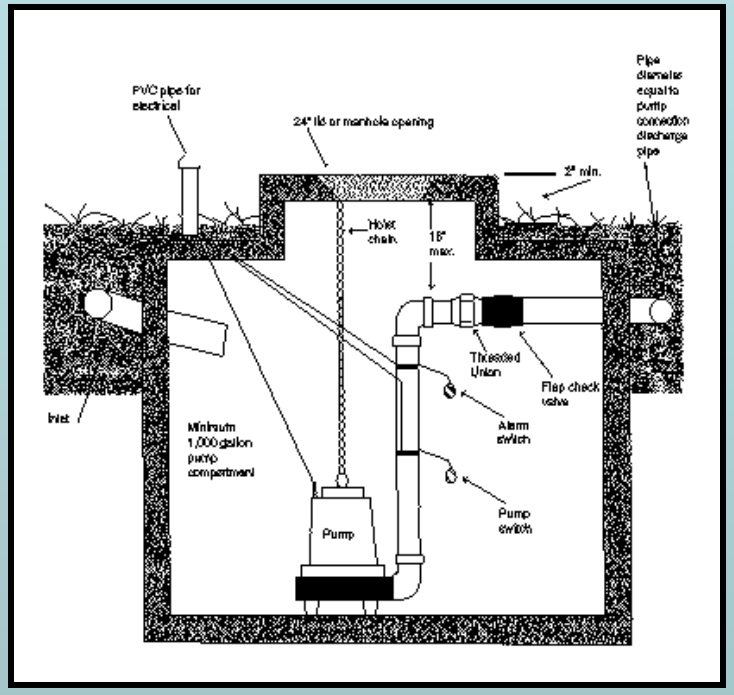
Water enters the pipe through slots in wall

The Drain Outlet

- ✓ MUST have sufficient grade for gravity flow !
  < set preliminary grade>
  - If not, a pump station will be necessary.
- ✓ Receiving water must have adequate capacity.
- ✓ Provide guards to keep animals out.

- ✓ Daylight outlet pipe
  1 ft above base flow
  in receiving channel

Drainage Pump Stations



When you don't have the fall to use gravity ….

The Drain Outlet

State of Wisconsin
Department of Agriculture, Trade and Consumer Protection

ONLINE SERVICES | LICENSES/PERMITS | PUBLICATIONS | PROGRAMS/SERVICES | GROWING WISCONSIN | NEWS/MEDIA | ABOUT US

Search Department of Agriculture, Trade and Consumer Protection

DATCP Home > Drainage Districts

Drainage Districts

About a third of Wisconsin farms depend on constructed drains to remove excess water from their land. Most of these are operated by a single landowner or by voluntary cooperation among neighbors. However, about 10 percent of these drains are organized as drainage districts, governed by county drainage boards. The Wisconsin Department of Agriculture, Trade and Consumer Protection regulates drainage districts under Wisconsin law.

Approved consulting engineers

Annual reporting requirements

Training materials

Additional Resources

Drainage program factsheet

Interactive map of Wisconsin drainage districts

Drainage board handbook

List of approved consulting engineers

WI Statutes Chapter 88

Administrative rule ATCP 48

Drainage Board Directory

Contacts

christopher.clayton@wi.gov
(608)224-4630

https://datcp.wi.gov/Pages/Programs_Services/DrainageDistricts.aspx

Lateral Depth and Spacing

Varies with soil permeability, crop and soil, kind of management practices crop, extent of surface drainage.

Typical drain depth range = 3 to 5 ft.

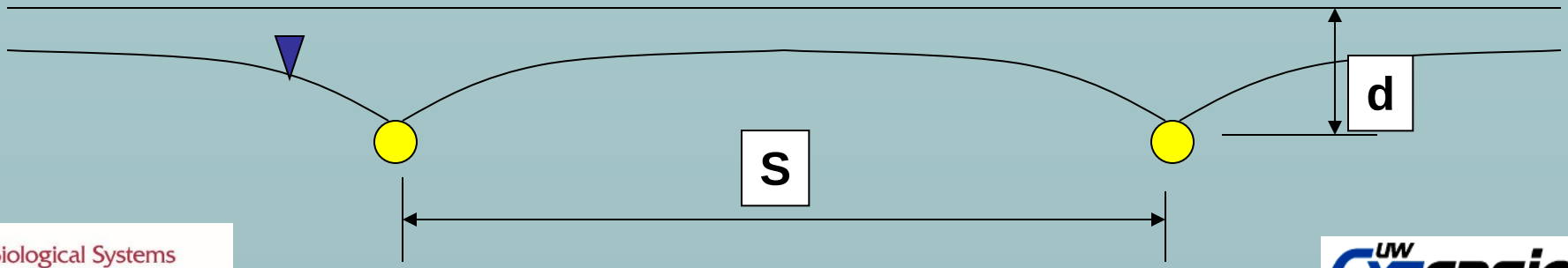
Typical spacing = 30 to 100 ft.

Depth / spacing balance to minimize cost.

Minimum cover greater than 2.5 ft.

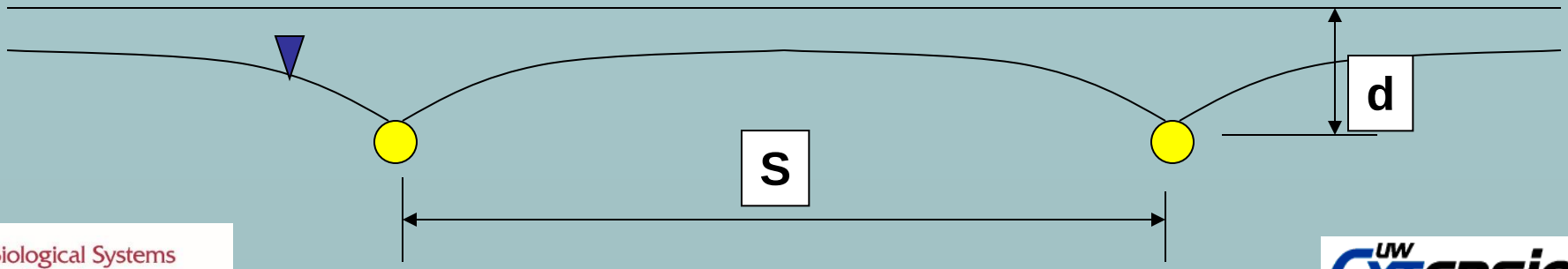
Lateral Depth and Spacing

- ✓ A relationship exists between depth and spacing of drains.
- ✓ For soils of uniform permeability, the deeper the drains, the wider the spacing (within limits).
- ✓ Higher permeability soils can have greater spacing.
- ✓ Need to provide adequate root depth above the saturated zone.



Lateral Depth and Spacing

The goal is to maintain as consistent a Dc value across the field as possible.



Drain System Construction

- More Things to Think About -

- ✓ What Dc should I use for the system.
- ✓ A pipe at a steeper grade will carry more flow one at a flatter grade.
- ✓ A pipe with a smooth interior will carry more flow than one with a rough lining.

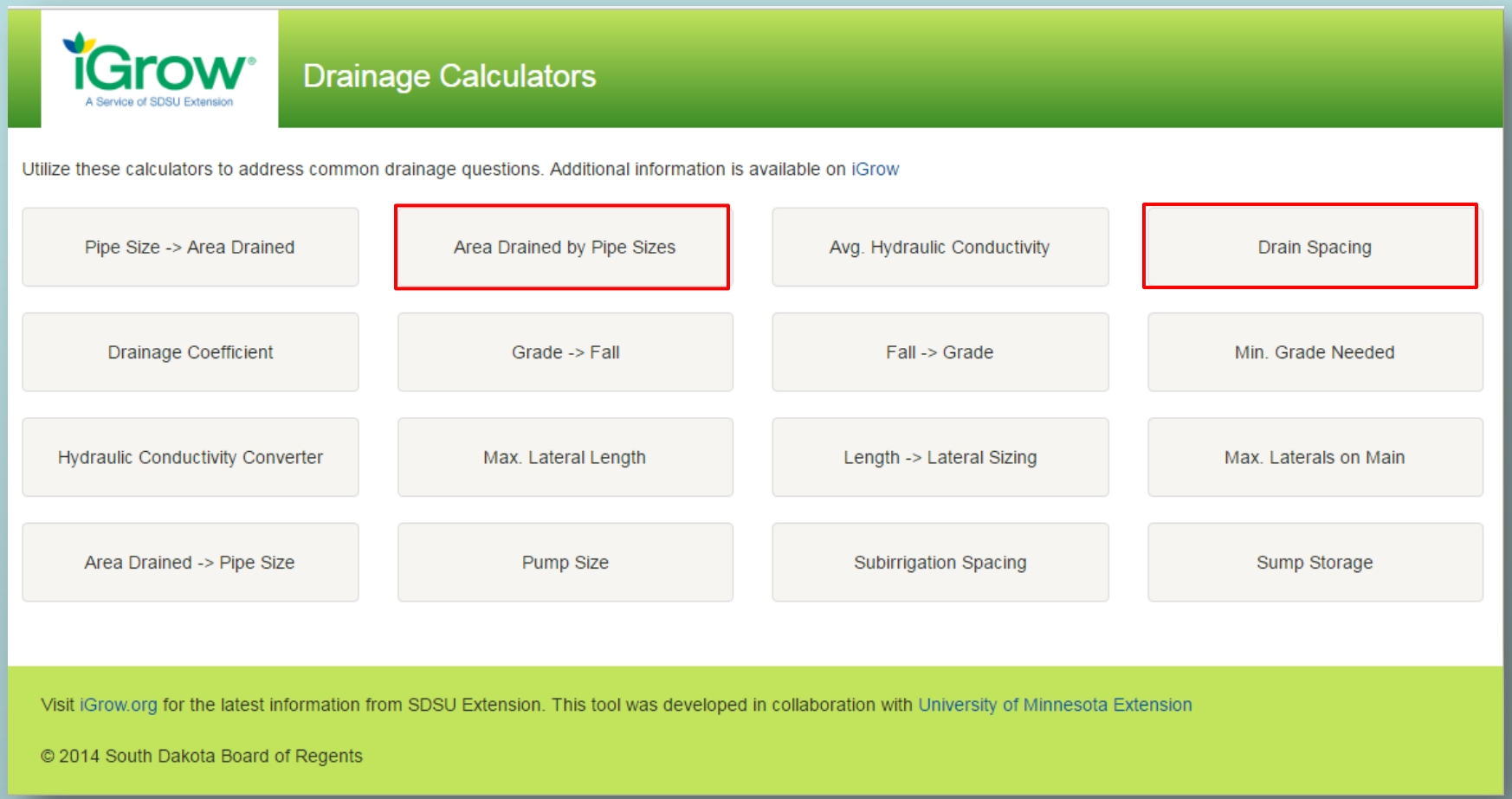
Drain System Construction

- More Things to Think About -

- ✓ A larger diameter pipe will carry more flow at the same grade than smaller diameter pipe.
- ✓ The capacity of the tile main line will need to increase going downstream as drained area increases, “telescoping the main”.
- ✓ Maintain minimum velocity to clean pipe.

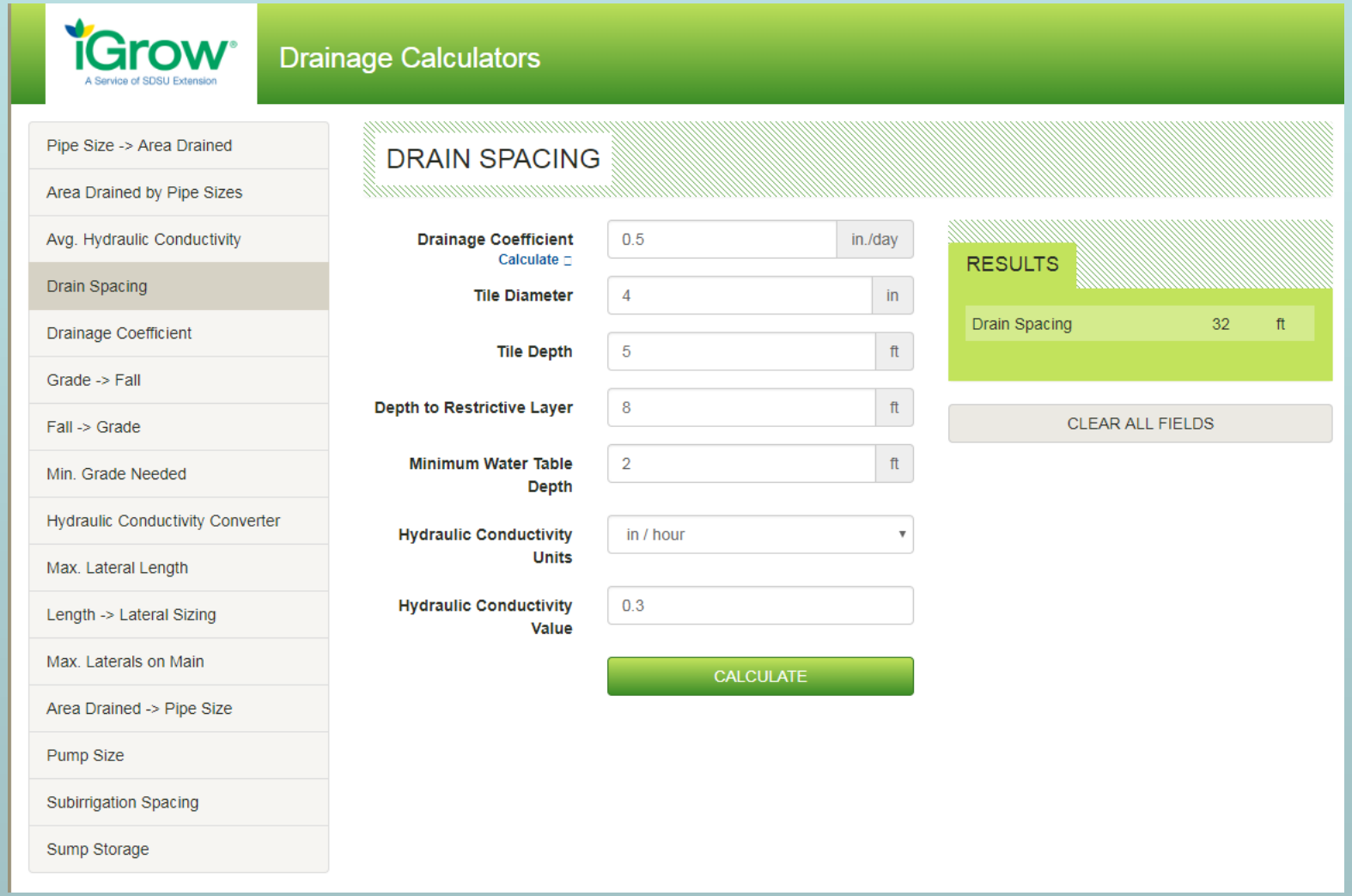
  (0.5 ft / s - No silt; 1.4 ft / sec - w/silt)

Drainage Calculator

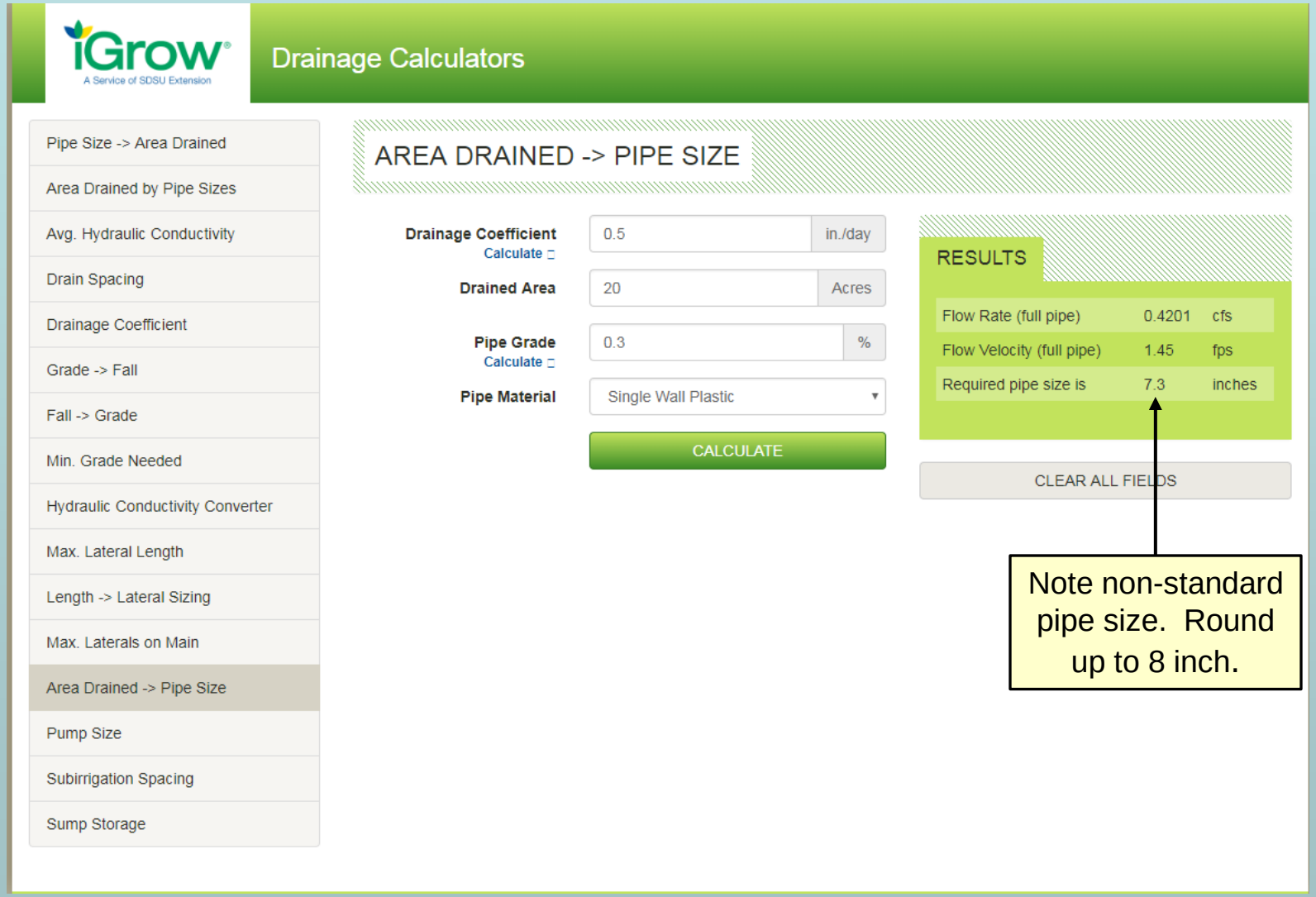


http://www.igrowdrainage.org/

Tile spacing - Example



Area Drained – Pipe Size - Example



Note non-standard pipe size. Round up to 8 inch.

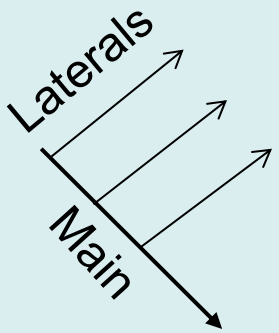
Lateral Depth and Spacing

The tile installation process

1. Mains are typically installed first and buried.

2. Laterals are then installed at the predetermined spacing.

3. Lateral installation involves:



- Excavating down to the main.
- Connecting into the main using a tee.
- Install lateral (typically via tile plow) moving at a right angle away from the main.

Drainage Resources

fyi.uwex.edu/drainage/

Biological Systems Engineering
UNIVERSITY OF WISCONSIN–MADISON

UW Extension

Drainage System Cost

- Approximate ! -

Drainage system installation costs can vary ***significantly*** based on terrain, soils, outlet availability, etc.

Rough Range

~ $1,000 - 1,500 / ac

QUESTIONS ? ? ?