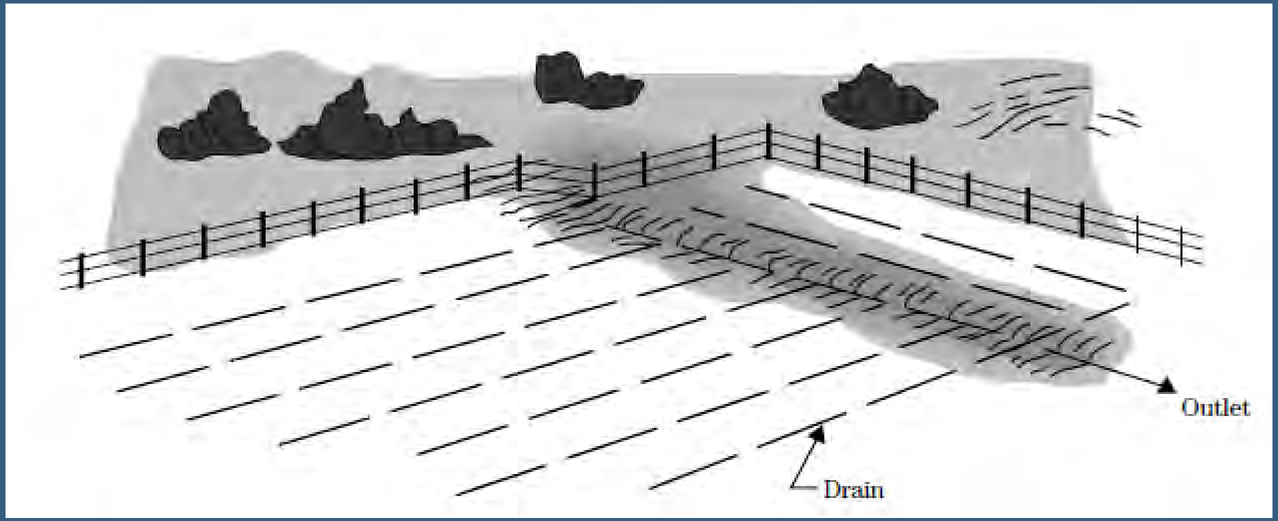
DRAINAGE & LATERAL EFFECTS DETERMINATIONS

CHRISTI FISHER, P.E.   ND STATE ENGINEER

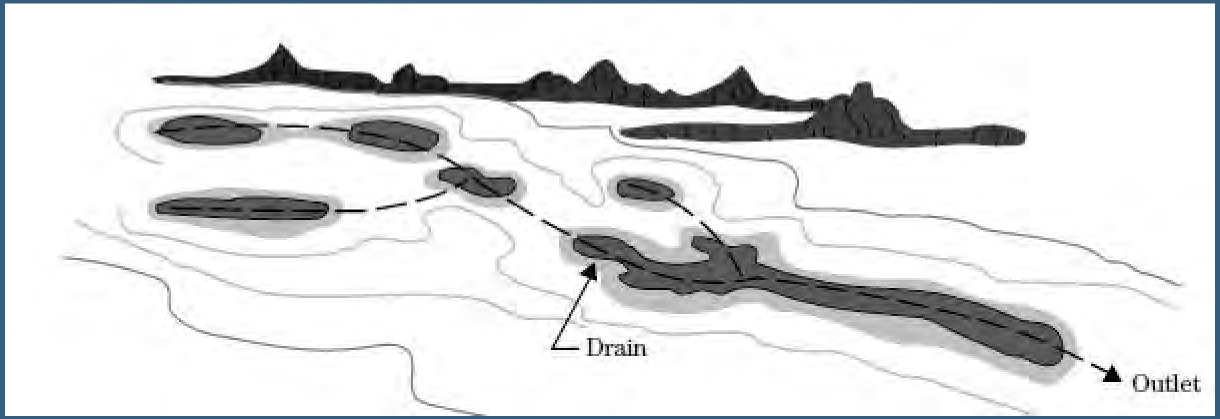
USDA United States Department of Agriculture
Natural Resources Conservation Service

TYPICAL ND DRAINAGE PROJECTS:

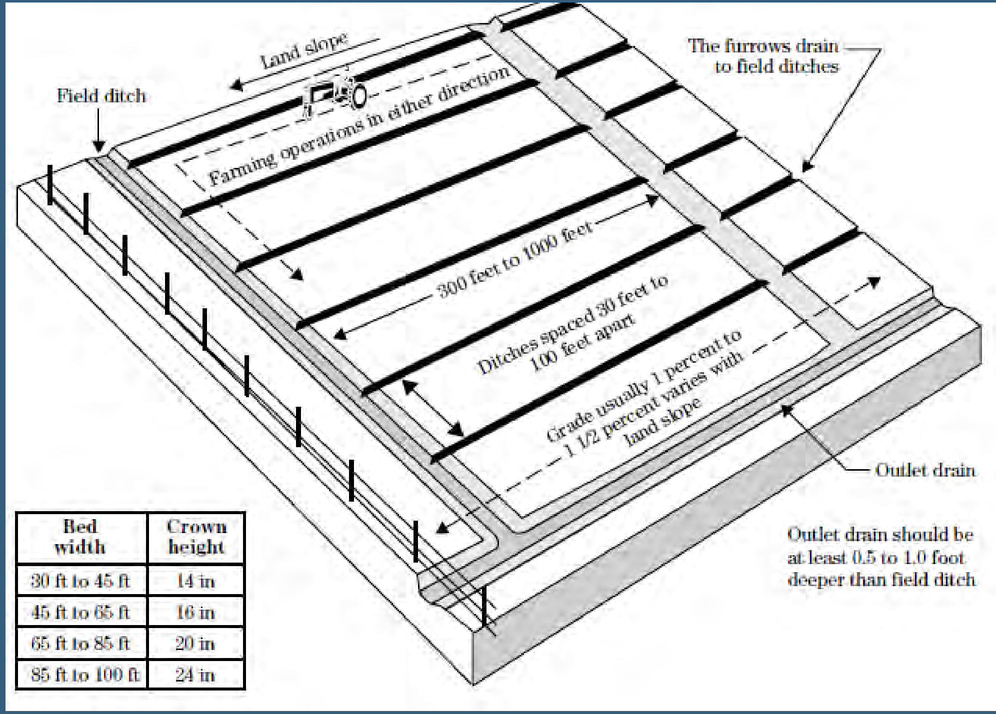
Pattern Tiling



Spot Tiling

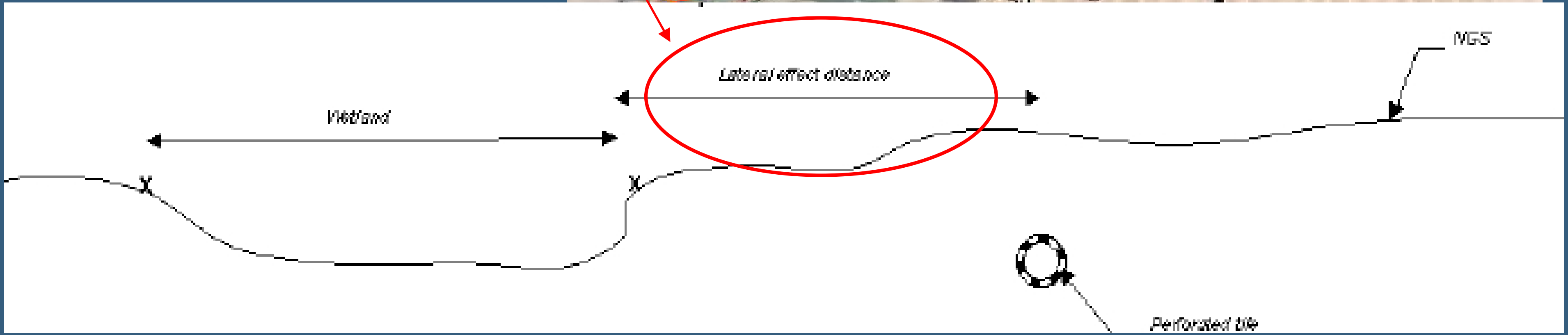


Surface Ditches



Bed width	Crown height
30 ft to 45 ft	14 in
45 ft to 65 ft	16 in
65 ft to 85 ft	20 in
85 ft to 100 ft	24 in

TYPICAL QUESTION:



HOW DOES NRCS ANSWER?

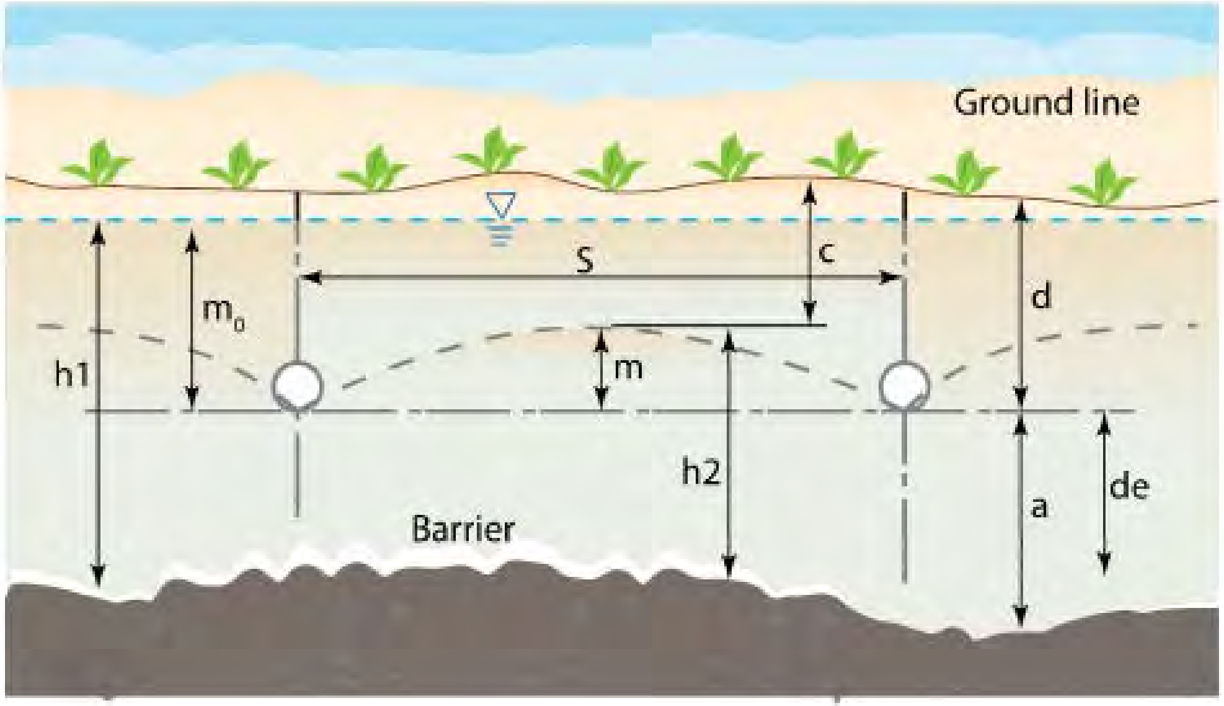
NATIONAL GUIDANCE: NATIONAL ENGINEERING HANDBOOK CH 19, HYDROLOGY TOOLS FOR WETLAND DETERMATION (2004)

DEPENDING ON WETLAND TYPE AND HYDROLOGIC REGIME:

- STREAM/LAKE GAGE OR MONITORING WELL DATA BASED STATISTICAL DETERMINATION OF THE ELEVATION, FREQUENCY, AND DURATION OF INUNDATION
- SCOPE AND EFFECT EQUATIONS: ELLIPSE, HOGHOUDT, VAN SCHILFGAARDE, KIRKHAM
- DAILY WATER BALANCE MODELING- PRECIP, RUNOFF, GW INFLOW, EVAP, ET, SOIL PARAMETERS, DRAINAGE SYSTEM PARAMETERS (SPAW, DRAINMOD)

HOW DID/DOES NORTH DAKOTA NRCS ANSWER?

- 2004-2015:
  - ✓ RIPARIAN WETLANDS- USE STREAM/LAKE GAGE DATA (??)
  - ✓ OTHERS- USE VAN SCHILFGAARDE SCOPE AND EFFECT EQUATION



VAN SCHILFGAARDE EQUATION:

$$S = \left[\frac{9Ktd_e}{f'\left[\ln m_0 \left(2d_e + m\right) - \ln m \left(2d_e + m_0\right)\right]} \right]$$

$$d_e = \frac{a}{1 + \frac{a}{S'}\left(\frac{8}{\pi}\ln\frac{a}{r_e} - 3.4\right)}; \text{for } a/S' < 0.3$$

$$d_e = \frac{S'\pi}{8\left[\ln\frac{S'}{r_e} - 1.15\right]}; \text{for } a/S' > 0.3$$

S = drain spacing, feet
K = hydraulic conductivity in feet per day
de = equivalent depth, feet, from drainage feature to impermeable layer
m = height of water table above the enter of the drain at midplane after time t, feet
mo = initial height of water table above the center of the drain, feet
t = time in days for water table to drop from mo to m
f = drainable porosity for the given water table change
a = depth from free water surface in drainage feature to impermeable layer, feet
f' = drainable porosity adjusted for surface roughness, = f + {(s/12)/(mo – m)}
(12 is conversion for inches to feet)
(f' modification by Tom Keep, NRCS)
s = water trapped on the surface by soil roughness, inches
Note: use zero if unsure
S' = estimated drain spacing, feet

ITERATIVE CALCULATION PROCESS:

1) Use with the known depth, “a”, in place of “d_e” to determine Estimated spacing, S’

2) Use Estimated spacing, S’ in Appropriate Equation to determine Equivalent Depth “d_e” , which replaces “a” in the van Schilfgaarde Equation for final computations

3) Use “d_e” to determine the Spacing, S, in the van Schilfgaarde Equation

4) Compare the Estimated S’ to S, if they are within 10% of each other, the Difference Can Be Assumed to be Negligible. If the Difference is More Than 10%, use the Calculated S Value as S’, Repeat Calculations until the S’ and S Values are Within 10%

IN 2006, ND HY ENGINEER MADE STATEWIDE RUNS OF ND DRAIN BASED ON SOILS DATA AT THE TIME AND CREATED COUNTY WIDE SPREADSHEETS DISTRIBUTED PUBLICLY VIA EFOTG:

Cass County

Lateral Effects Determination

Selected (highlighted) component is greater than or equal to 10 percent of the map unit

Criteria Section Date Calculated: October 27, 2015

Map Unit	Tile Bury Depth (feet)	Tile Diameter (inches)
6	5	4

Calculate | Clear Results | Print Results

Results

Map Unit	Soil Name	Percent	Tile Bury Depth (feet)	Tile Diameter (inches)	Lateral Effect (feet)	>= 10%
6	Parnell,-ponded	85	5	4	145	Yes
6	Hamerly,-saline	5	5	4	137	No
6	Vallers,-saline	5	5	4	119	No
6	Vallers	5	5	4	89	No
						No
						No

DID NOT COMPUTE FOR OPEN DITCHES, OR FOR DEPTHS GREATER THAN 6 FT.
SOILS DATA CHANGES AFTER THAT 2006 DATE WERE NOT CONSIDERED.

* LARGEST LATERAL EFFECT OF ANY SOIL WITHIN THE MAP UNIT MAKING UP AT LEAST 10% OF THE UNIT BY AREA GOVERNS

* WINTER OF 2014, WE RECOMPUTED OLD SOILS DATA FOR OPEN DITCHES AND DOWN TO 9 FT IN DEPTH

SOME INPUTS STRAIGHT FORWARD:

t = time allowed for water table to drop from m_o to m (at the time a map was utilized based on the ND county)

d_e = 10 ft assumed depth from drain to impermeable layer

m_o = assumed as depth of proposed ditch or tile (to centerline)

m = m_o minus drawdown of 0.5 to 1.0 ft dependent on soil type

s = 0.1 inch assumption for water trapped due to surface roughness

r_e = based on drainage structure:

Table 2. Effective Radius of Drainage Tile

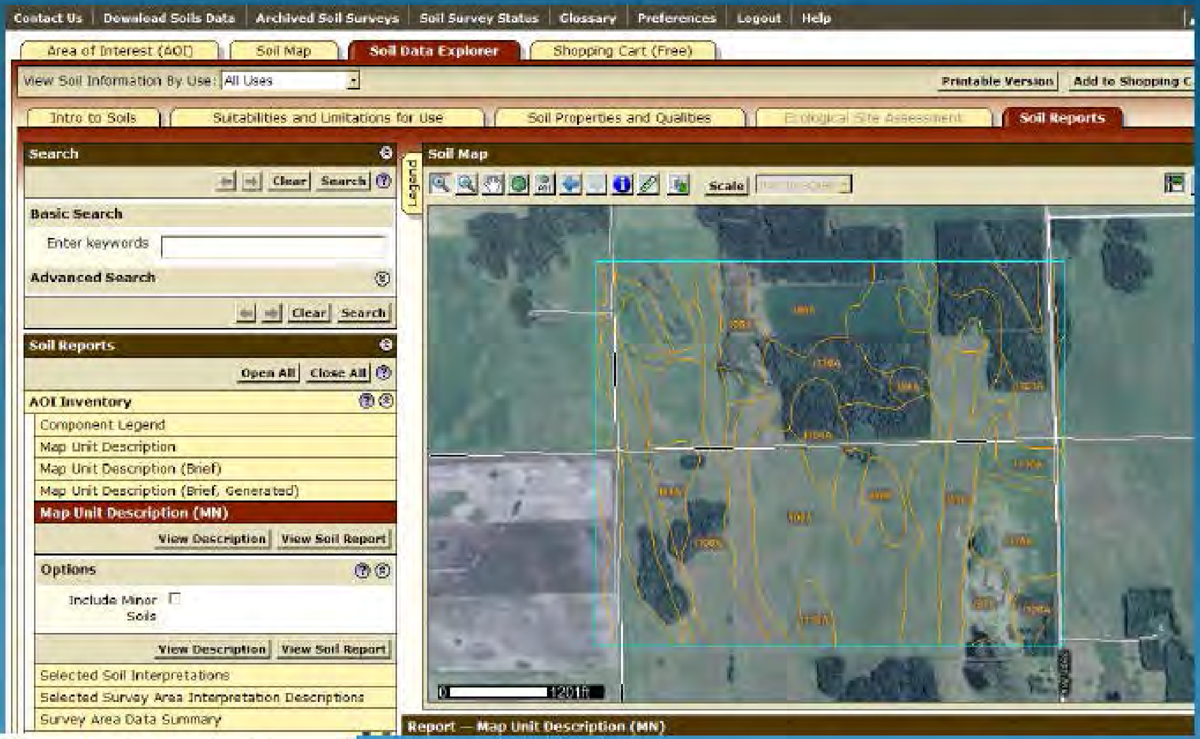
Tile Diameter	Effective Radius, re, inches	Effective Radius, re, feet
4 inches	0.20	0.0167
5 inches	0.41	0.034
6 inches	0.58	0.048
8 inches	0.96	0.080 (extrapolated)
10 inches	1.33	0.111 (extrapolated)
12 inches and larger	1.70	0.142 (extrapolated & limit set)
Ditch, any size	12	1.0 (chosen by experience)
Drain tube	1.177n*	1.177n*

*surrounded by a gravel envelope with a square cross-section of length 2n on each side

SATURATED HYDRAULIC CONDUCTIVITY:

K

- Soil Survey
  - Listed multiple places
  - Use from map unit description



Depth	Texture	Organic matter content	Saturated hydraulic conductivity (permeability)
In		*Pct*	*Um/sec (In/hr)*
Ap — 0 to 10	fine sandy loam	6.00	14.11 (2.00)
Bkg — 10 to 17	fine sandy loam	1.00	28.23 (4.00)
Cg — 17 to 28	fine sand	0.25	91.74 (13.00)
2Cdg — 28 to 80	loam	0.25	2.33 (0.33)

What value to use?

Strathcona, dense till	0-10	-69-	-22-	5-10-18	1.20-1.50	10.00-705.00
	10-17	-70-	-16-	10-14-18	1.50-1.65	10.00-100.00
	17-28	-94-	- 1-	2-5- 8	1.55-1.70	10.00-705.00
	28-80	-46-	-39-	12-15-18	1.75-2.10	0.10-10.00

Pedotransfer Functions

- Mainly statistical relationships based on thousands of data points to relate easy-to-measure variables to hard-to-measure variables
- Download from : http://hydrolab.arsusda.gov/soilwater/Index.htm
- Use %sand, %clay
- Modify w/ & org matter and %gravel
- Will also help with drainable porosity

2.00 in/hr

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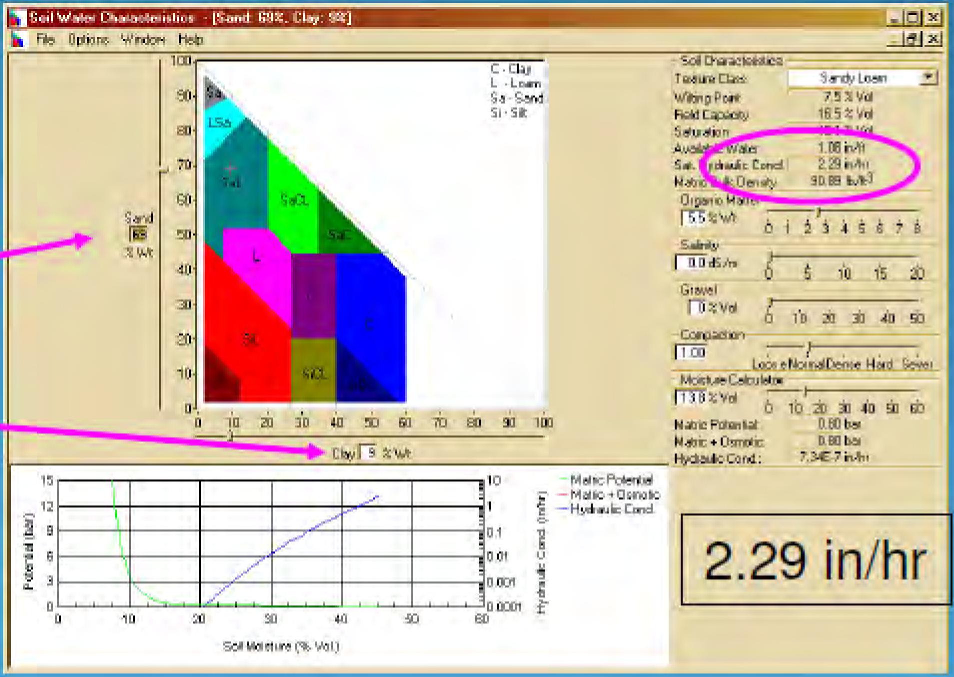
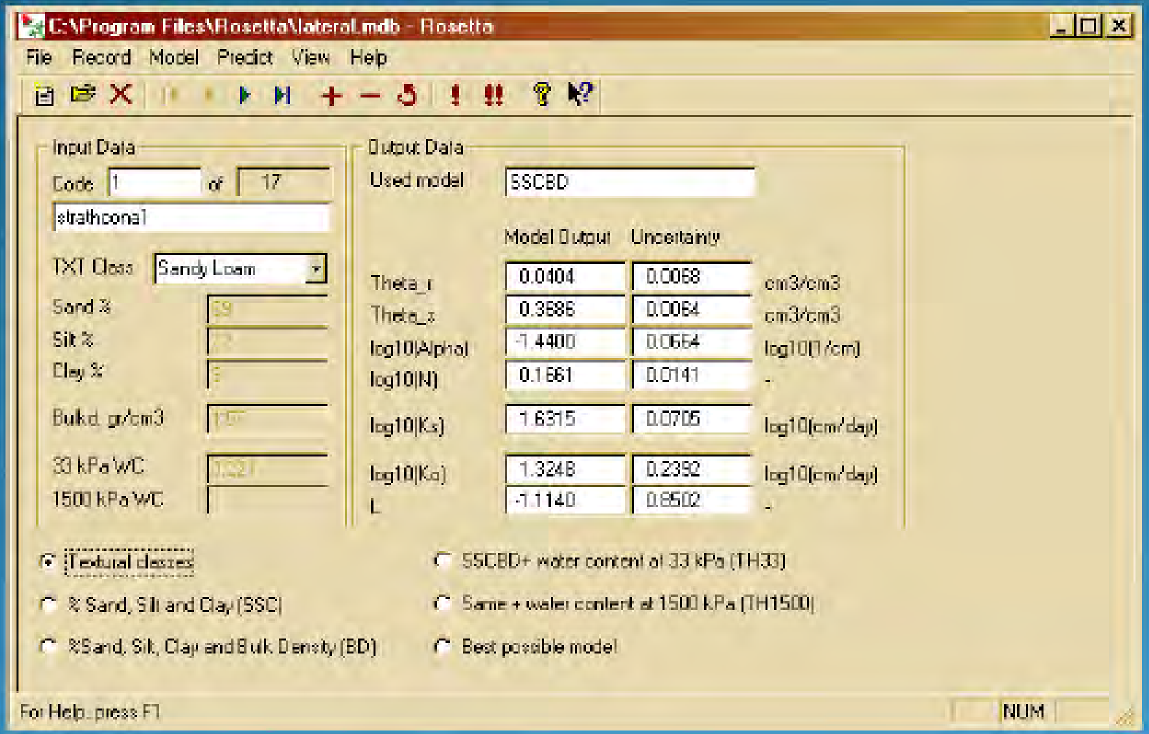


2.29 in/hr

4A—Strathcona fine sandy loam, dense till, 0 to 2 percent slopes									
Strathcona, dense till	0-10	-69-	-22-	5-10-18	1.30-1.60	1.00-100.00	0.16-0.18	0.0-2.9	3.0-8.0
	10-17	-70-	-16-	10-14-18	1.50-1.65	10.00-100.00	0.09-0.17	0.0-2.9	[illegible]
	17-28	-94-	- 1-	2-5- 8	1.55-1.70	10.00-705.00	0.05-0.10	0.0-2.9	0.1-0.5
	28-80	-46-	-39-	12-15-18	1.75-2.10	0.10-10.00	0.05-0.10	0.0-2.9	0.0-0.5

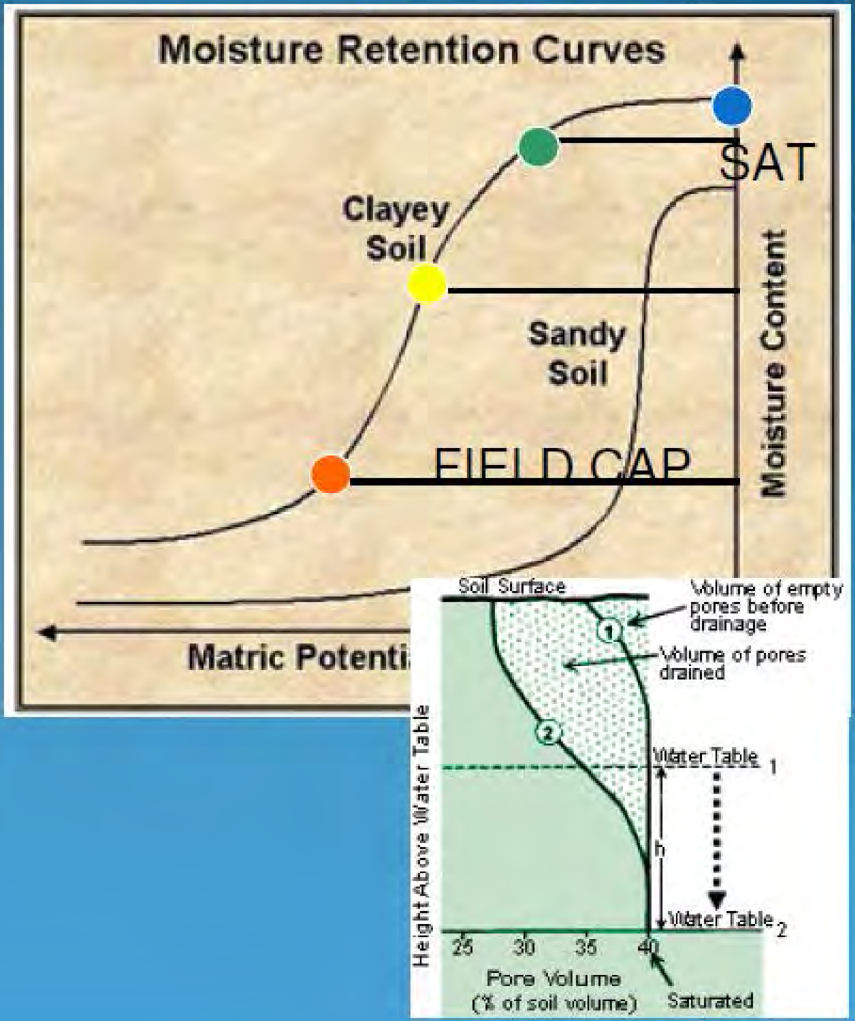
Rosetta Pedotransfer function



- http://www.ars.usda.gov/Services/docs.htm?docid=8953
- USDA-ARS Salinity Lab
- Hierarchical Neural Network Model
- Based on 2,085 data points
- Methodology that NRCS uses

Basics of Drainable Porosity (f)

- The volume of water drained per volume of soil, FOR A GIVEN MATRIC POTENTIAL
  - From Saturation to Field Capacity (gravity drainage ~ 24 hrs)
- f = depth drained water (hw) / total depth (ht)
- Example:
  - If f = 0.10 (10%) and we drain 2 feet (24 inches), what is depth water?
  - = f * ht = 0.10 * 24" = 2.4 inches



2012 PRARIE POTHOLE STATES TILE SET-BACK COMMITTEE CONVENED:

(ND, SD, MN, IA AND NRCS NATIONAL TECHNICAL STAFF)

*GOAL WAS TO DEVELOP TECHNICALLY DEFENSIBLE, CONSISTENT APPROACH ACROSS THE 4 STATES

*COMMITTEE RECOMMENDATIONS:

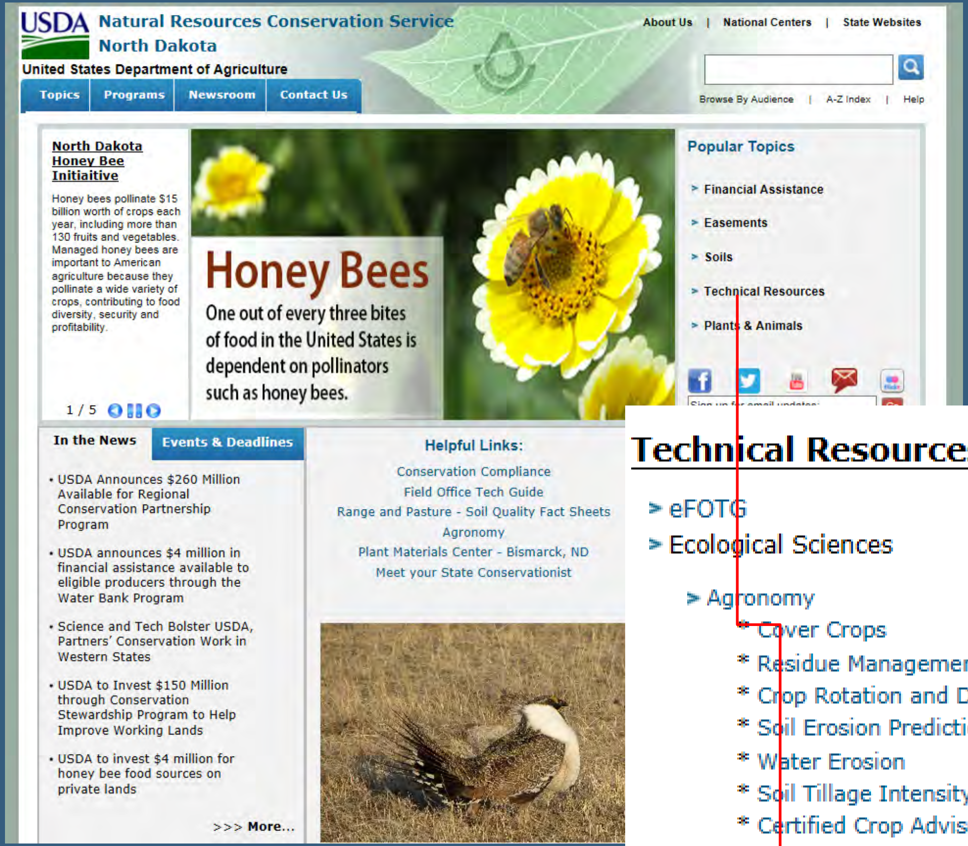
- EACH STATE SOIL SCIENTIST SHOULD DEVELOP A LIST OF SOILS CORRESPONDING TO WETLAND HYDRAULIC FUNCTION
- VAN SCHILFGAARDE SHOULD BE UTILZED ON: RECHARGE, UPLAND, MINERAL FLATS TYPE WETLANDS
- RESULTS OF VAN SCHILFGAARDE SHOULD BE ROUNDED UP TO NEAREST 10 FT AND SET AT MINIMUM 50 FT, MAXIMUM 400 FT BASED ON MODEL LIMITATIONS
- DRAWDOWN OF 1.0 FT SHOULD BE UTILIZED REGARDLESS OF SOIL TYPE
- A DRAWDOWN TIME OF 14 DAYS SHOULD BE UTILIZED, AS OUTLINED IN THE NATIONAL FOOD SECURITY ACT MANUAL

2015/16 ND LATERAL EFFECTS WORK:

- DEVELOPED AN AUTOMATED METHODOLOGY TO TRANSFER WEBSOIL SURVEY INFORMATION, THROUGH ROSETTA AND ND DRAIN…EFFICIENTLY
- UTILIZED THE MOST RECENT METHODOLOGY RECOMMENDED BY NATIONAL EXPERTS FOR SOILS BASED INPUT PARAMETERS
- IMPLEMENTED THE 2012 TILE SETBACK COMMITTEE RECOMMENDATIONS:

THIS WILL ALLOW US TO REGENERATE RESULTS WITH THE ANNUAL REFRESH OF WEB SOIL SURVEY.

POSTED RESULTS ON ND NRCS ENGINEERING WEBSITE



Technical Resources

- eFOTG
- Ecological Sciences
  - Agronomy
    - Cover Crops
    - Residue Management
    - Crop Rotation and Diversity
    - Soil Erosion Prediction
    - Water Erosion
    - Soil Tillage Intensity Rating (STIR)
    - Certified Crop Adviser Program
    - Organic Farming Resources
  - Biology and Wildlife
  - Conservation Planning
  - Cultural Resources
  - Engineering
  - Forestry, Windbreaks, & Agroforestry
  - Plant Materials Center (PMC)
    - National Plant Materials Center (PMC)
    - National Plants Database
  - Range and Pasture
- Sage-Grouse Habitat Management
- Soil Survey and Resource Assessment
- Watershed Approach
  - Rapid Watershed Assessments (RWA)
  - Stream Visual Assessment Protocol (SVAP)

Conservation Practice Standards

Practice standards establish the minimum level of acceptable quality for planning, designing, installing, operating, and maintaining conservation practices. Conservation practice standards are located in Section IV of the North Dakota Field Office Technical Guide (FOTG).

> Go to FOTG national home page

Engineering Manuals and Handbooks / North Dakota Supplements

NRCS uses science-based technology to provide conservation planning and assistance to land owners and operators and others to benefit the soil, water, air, plants, and animal for productive lands and healthy ecosystems. The NRCS manual presents engineering policy clearly and completely so that NRCS engineering activities can be effectively and efficiently implemented. Handbooks provide technical guidance for the planning, design, and implementation of conservation practices.

> North Dakota Summary of Engineering Policy and Technical References (PDF; 150 KB)
> Roles and Responsibilities for Engineering Technical Assistance

Engineering Planning & Design Tools for Conservation Practices

Design tools have been developed to assist with engineering tasks specific to North Dakota. All technical resources are available to the general public, and while all have been examined for technical adequacy the responsibility for proper application remains with the user. Before using any of the technical resources, the designer should verify they are adaptable to the site and that the design limitations are not exceeded.

> Producer's Guide for Structural Conservation Practices (Tri-Fold Brochure, PDF, 1.2MB)

North Dakota Engineering Planning Guides	
ND Engineering Forms	Irrigation and Irrigation Management
Engineering Software	Drainage and Drainage Management

Drainage, Lateral Effects, and Drainage Water Management

Drainage is the practice of removing surface and sub-surface water from an area. Often drainage is used to improve crop production. Lateral effect refers to the extent at which the drainage influences the hydrology.

Common drainage policies and laws in North Dakota as well as information regarding lateral effects are found below.

The following document(s) may require Adobe Reader.

- North Dakota Lateral Effect Policy (ND EFH Part 650 Chapter 19 Supplement) (PDF; 85 KB)
- Memorandum – Tile Drain Systems – State of ND Office of the State Engineer (PDF; 35 KB)
- State of North Dakota Drainage Rules (PDF; 65 KB)

Lateral Effects Determination Sprea

The following document(s) may require Excel Vie

Adams	Barnes	Benson	Bil
Bowman	Burke	Burleigh	C
Dickey	Divide	Dunn	E
Foster	Golden Valley	Grand Forks	Gr
Hettinger	Kidder	LaMoure	Lo
McIntosh	McKenzie	McLean	Me
Mountrail	Nelson	Oliver	Pen
Ramsey	Ransom	Renville	Ric
Sargent	Sheridan	Sioux	Sl
Steele	Stutsman	Towner	T
Ward	Wells	Williams	

USDA

Richland County

Minimal Effects Determination

NRCS Natural Resources Conservation Service

Date Calculated: March 21, 2016

Producer Name	EXAMPLE	Map Unit	G12A
Legal Description	XXX	Average Depth Below Ground (feet)	3
Completed By	CF	Tile Diameter (inches) / Open Ditch	4

Calculate

SETBACK DISTANCE:

For this map unit utilize a minimal effect setback distance of 90 feet from the certified wetland boundary.

Lateral Effect Computations

Map Unit Symbol	Component Name	Percent of Map Unit	Average Depth Below Ground (feet)	Tile Diameter (inches) / Open Ditch	Hydraulic Function
G12A	Parnell11325487	27	3	4	recharge
G12A	Vallers11325492	31	3	4	discharge
G12A	Vallers11325491	14	3	4	discharge
G12A	Tonka11325490	7	3	4	recharge
G12A	Wyard11325486	3	3	4	upland soils
G12A	Southam11325489	4	3	4	flow-through
G12A	Manfred11325488	5	3	4	discharge
G12A	Hamerly11325484	6	3	4	upland soils
G12A	Easby11325485	3	3	4	discharge

USDA

Richland County

Minimal Effects Determination

NRCS
Natural Resources Conservation Service

Date Calculated: March 21, 2016

Producer Name	EXAMPLE	Map Unit	I360A
Legal Description	XXX	Average Depth Below Ground (feet)	3
Completed By	CF	Tile Diameter (inches) / Open Ditch	4

Calculate

Site specific evaluation is required, given that lateral effects equations may not be applicable for the controlling hydrologic function. Contact one the individuals shown on the ND NRCS Engineering-Drainage Website.

In most cases, minimal effects determinations for these types of soils will require an approximate sketch of the proposed tile and/or open ditch layout on an aerial photo for evaluation. Exact location information is not critical, however orientation and approximate depth below ground surface of the drainage features is.

Lateral Effect Computations

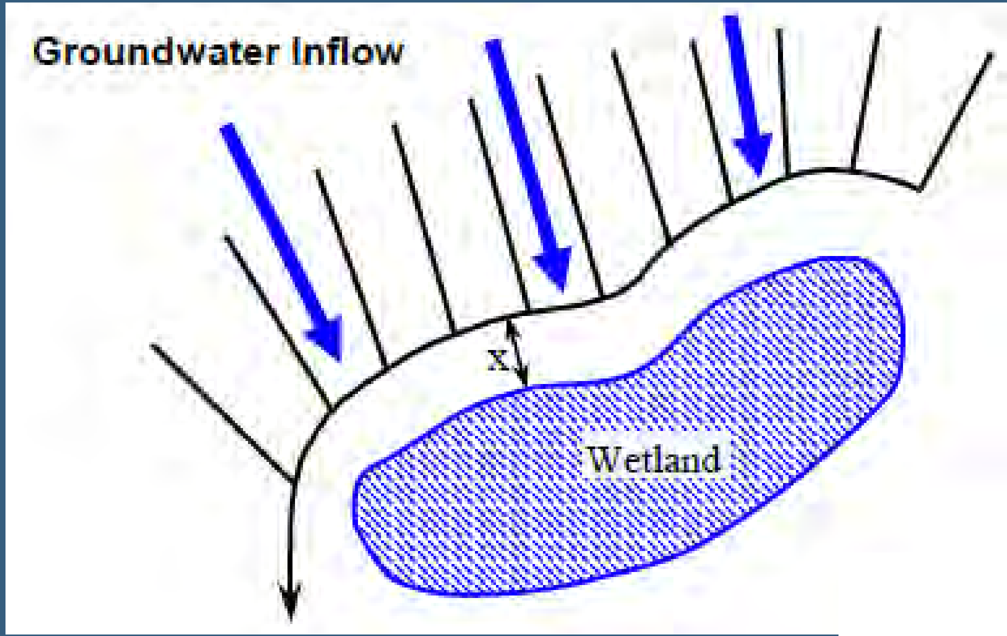
Map Unit Symbol	Component Name	Percent of Map Unit	Average Depth Below Ground (feet)	Tile Diameter (inches) / Open Ditch	Hydraulic Function
I360A	Hamar11324399	80	3	4	high water table sands
I360A	Ulen11324402	3	3	4	upland soils
I360A	Rosewood11324401	5	3	4	high water table sands
I360A	Hamar11324400	5	3	4	high water table sands
I360A	Venlo11324403	1	3	4	high water table sands
I360A	Garborg11324398	6	3	4	upland soils

WETLAND TYPES (PRESENT IN ND) WHERE VAN SCHILFGAARDE NOT APPROPRIATE:

- ✓ RIVERINE
- ✓ DISCHARGE DEPRESSIONAL WETLANDS
- ✓ HIGH WATER TABLE SANDS
- ✓ FLOW THROUGH WETLANDS

LATERAL EFFECTS ESTIMATES BEING HANDLED OUT OF THE STATE OFFICE BY SOILS/ENGINEERING STAFF USING AVAILABLE SOILS DATA, WELL LOGS, GROUNDWATER STUDIES, TOPOGRAPHIC DATA, RIVER GAUGE INFORMATION, ETC.

FLOW THROUGH WETLANDS



SOME RELAVENT QUESTIONS:

- WHICH WAY IS GROUNDWATER FLOWING?
- IS THERE AN IMPERVIOUS LAYER?
- WHAT IS THE FLOW CAPACITY OF THE DRAIN VERSUS THE AVERAGE INFLOW VOLUME?

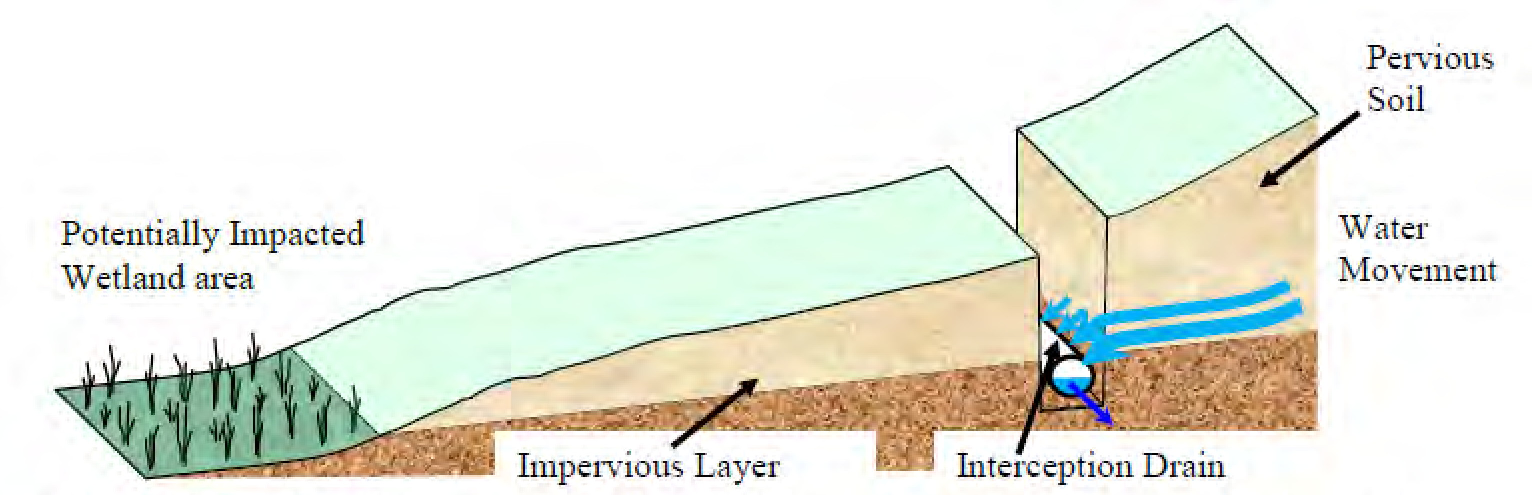
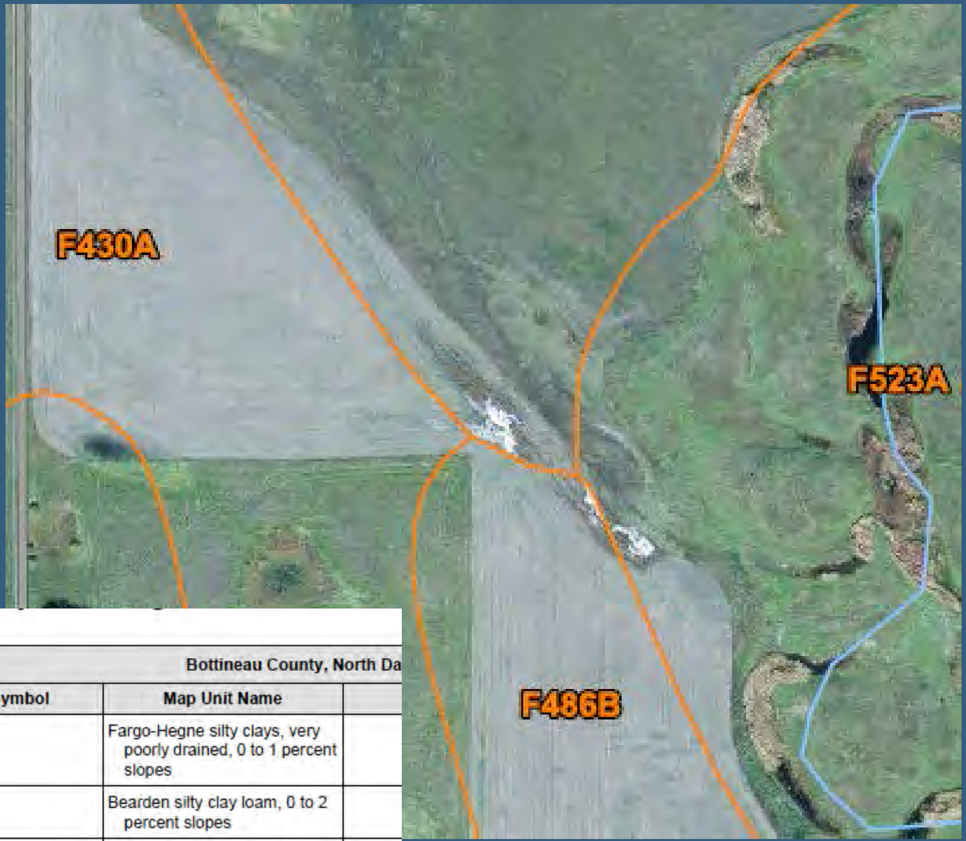


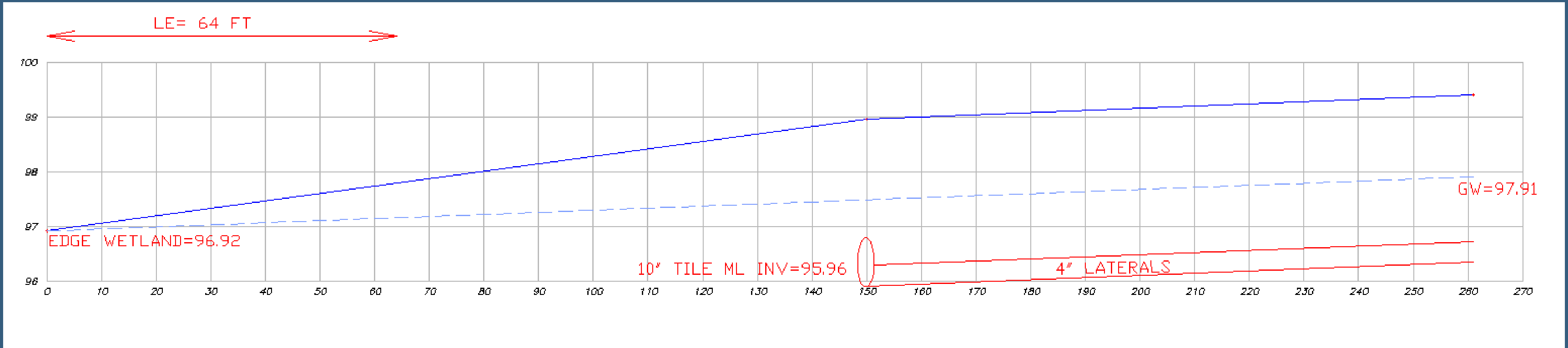
Figure 4. Example of interception and diversion of groundwater away from a wetland area (figure adapted from a Purdue University illustration)

EXAMPLE SITE #1- FLOW THROUGH WETLAND



Bottineau County, North Da		
Map Unit Symbol	Map Unit Name	
F49A	Fargo-Hegne silty clays, very poorly drained, 0 to 1 percent slopes	
F430A	Bearden silty clay loam, 0 to 2 percent slopes	
F454A	Glyndon loam, 0 to 2 percent slopes	
F456A	Glyndon loam, saline, 0 to 2 percent slopes	
F465A	Aberdeen-Overly silt loams, 0 to 2 percent slopes	
F485A	Gardena loam, 0 to 2 percent slopes	
F486B	Gardena-Eckman loams, 2 to 6 percent slopes	
F523A	Lowe-Fluvaquents, channeled complex, 0 to 2 percent slopes, frequently flooded	
Totals for Area of Interest		

PROFILE:



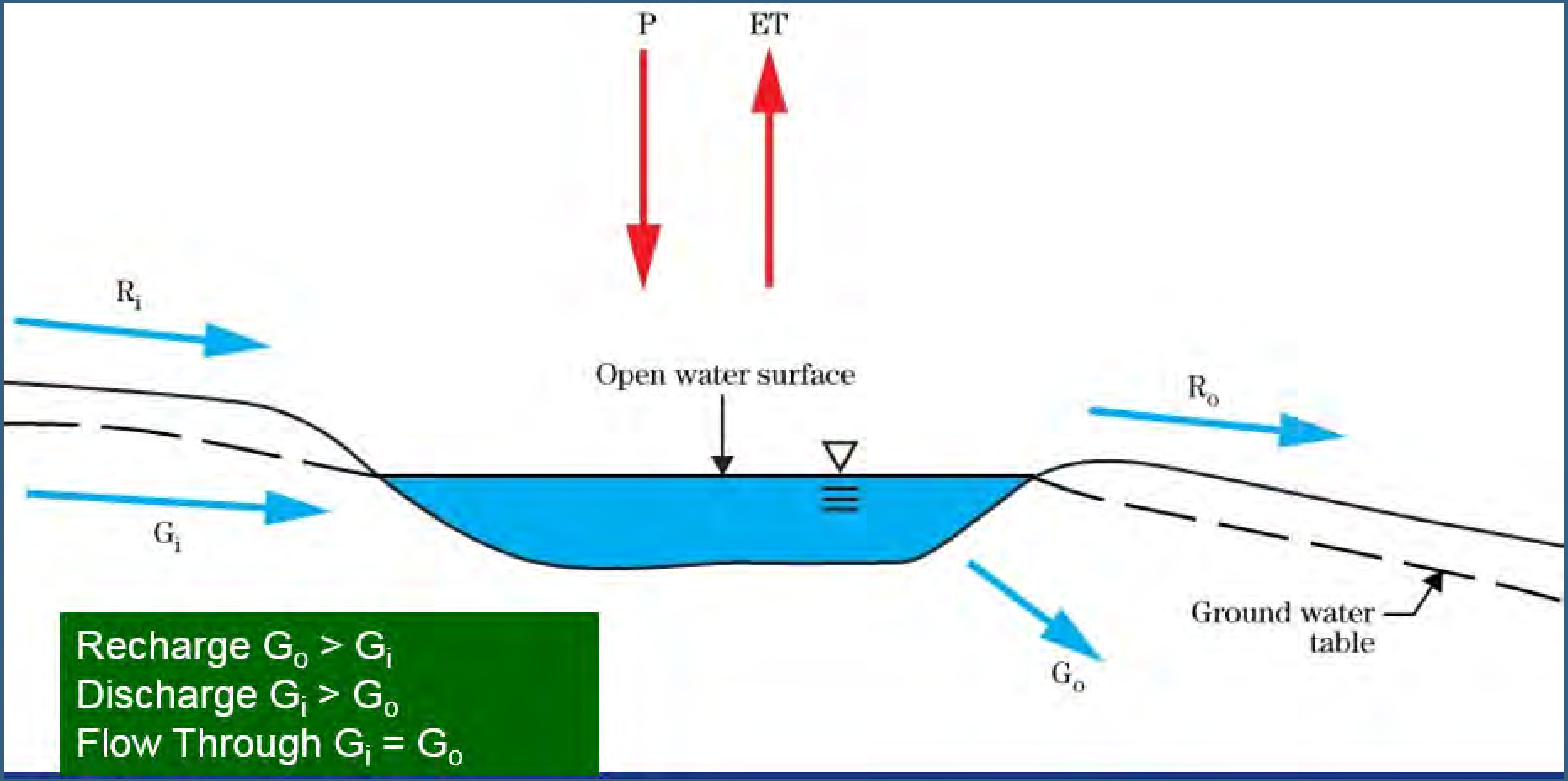
DETERMINATIONS BASED ON FIELD VISIT:

- COMBINATION OF GROUNDWATER AND SURFACE WATER INFLOW FEEDS THIS WETLAND
- BASED ON ELEV OF HYDRIC INDICATORS ON SITE, GROUNDWATER FLOWS WITH SURFACE WATER AND NO IMPERVIOUS LAYER IS PRESENT
- TILE MAY INTERCEPT UP TO 50% OF GROUNDWATER FLOWS FROM THE SOUTHWEST
- TILE NOT LIKLEY TO INTERCEPT OVER 30% OF CONTRIBUTING SURFACE WATER FLOWS HOWEVER
- CURRENTLY PERFORATED MAINLINE IS WITHIN 3 X Le DISTANCE OF WETLAND, SO CONVERT TO SOLID FOR UP TO 64 FT PERPENDICULAR TO WETLAND BOUNDARY

DISCHARGE DEPRESSIONAL WETLANDS

SOME RELAVENT QUESTIONS:

- WHICH WAY IS GROUNDWATER FLOWING?
- IS THERE AN IMPERVIOUS LAYER?
- WHAT IS THE FLOW CAPACITY OF THE DRAIN VERSUS THE AVERAGE GROUNDWATER INFLOW VOLUME?



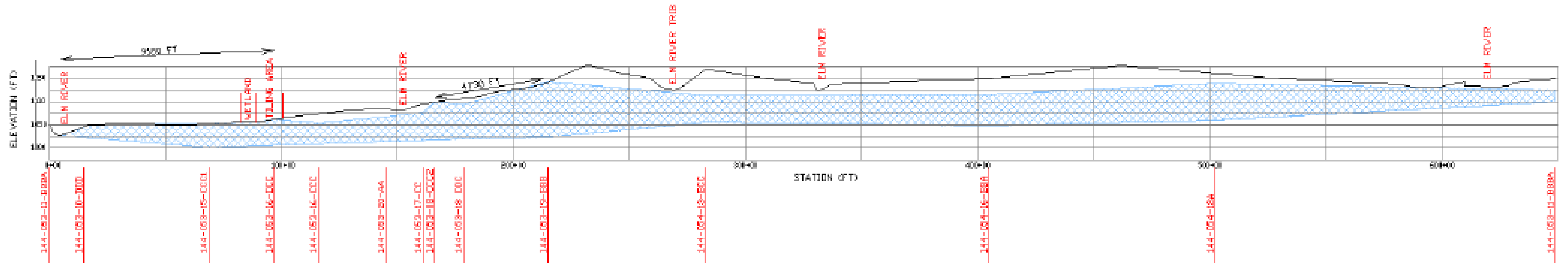
EXAMPLE SITE #2- WETLAND IN HIGH WATER TABLE SANDS

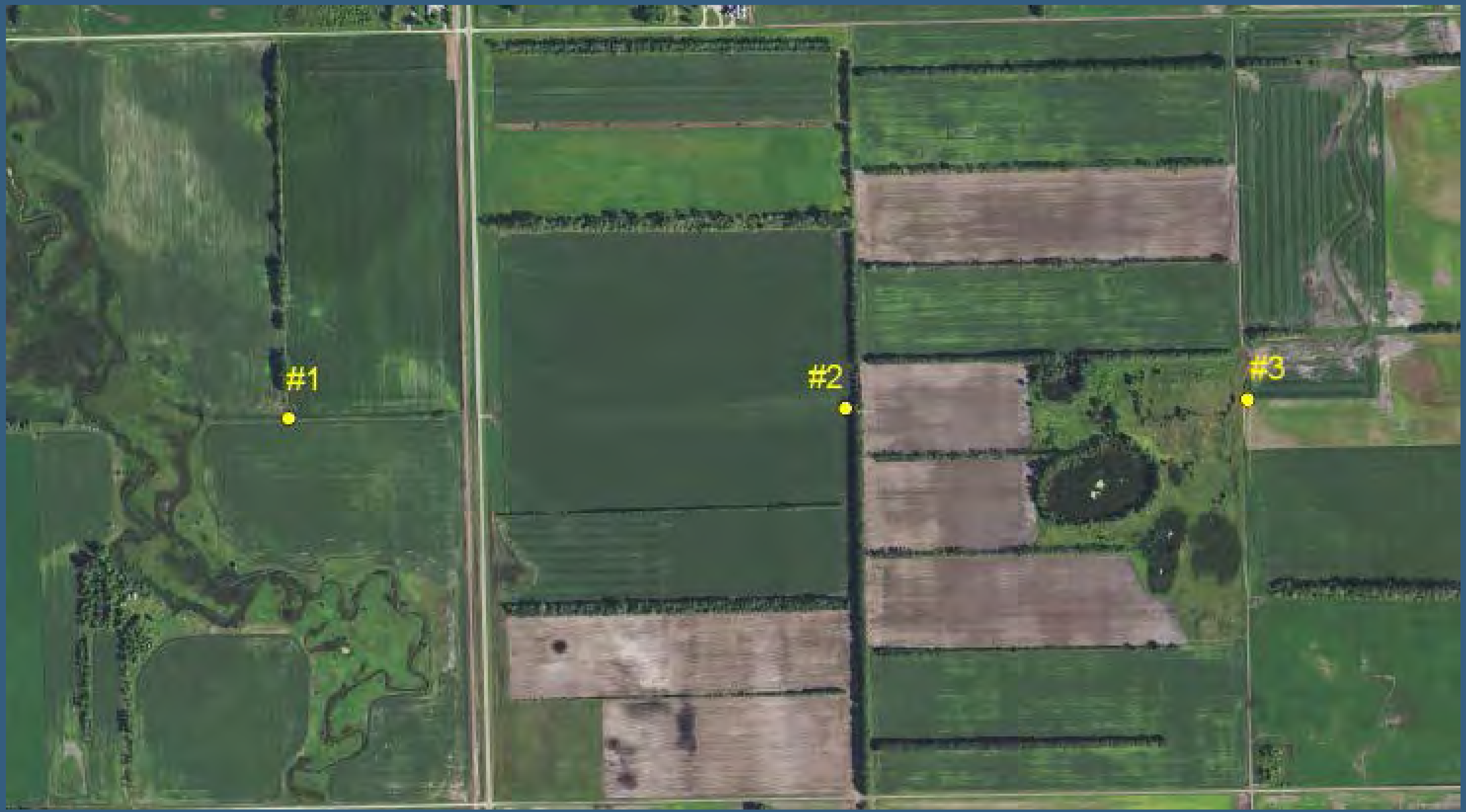
LARGE PERCENTAGE OF SURFACE DA TO BE DRAINED:

* GROUNDWATER INFLOW ESTIMATED AT 27 CFS

* TILE DRAIN CAPACITY ESTIMATED AT 1 CFS

WETLANDS AT THE SURFACE INTERSECTION OF A SWC STUDIED GROUND ACQUIFER:





WILL THE DRAINAGE SYSTEM HAVE ANY IMPACT ON WETLANDS?

WILL THE DRAINAGE SYSTEM HAVE ANY IMPACT ON GROUNDWATER IN THE CROP FIELDS?

GOALS FOR THESE “NON-VS” WETLAND TYPE SITUATIONS”:

- <14 DAY RESPONSE TIME TO REQUESTS
- MAKE THE BEST TECHNICAL RECOMMENDATION WE CAN WITH AVAILABLE DATA
- CONTINUE TO LEARN & COLLECT INFORMATION, AND SHARE WITH THOSE WORKING ON DRAINAGE IN ND