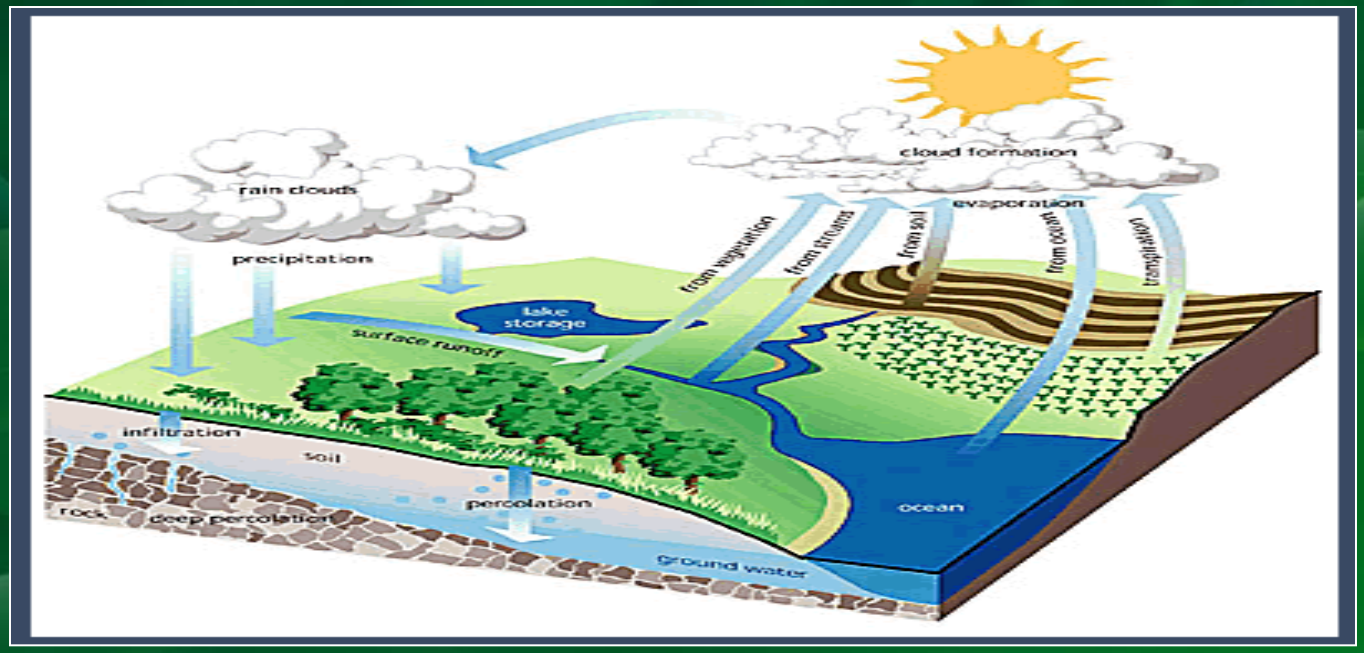
Hydrology

Jeremy Maul, Senior Wetland Specialist
Board of Water and Soil Resources

Hydrology

The science of water - its properties, distribution and circulation - both on the surface and underground.



Hydrology

- The most important of the 3 parameters.
  - Duh! It's the science of water, without water there's no "wet"land
- Without it you would not have either of the other two parameters

"Hydrology is probably the single most important determinant of the establishment and maintenance of … wetlands and wetland processes".

- Mitsch & Goslink, 2007. *Wetlands*

Criteria for Wetland Hydrology

87 Manual Supplement Hydrology Standard:

14 or more consecutive days of flooding, ponding, or water table within 12 inches of the surface during the growing season at a minimum frequency of 5 out of 10 years (50%)

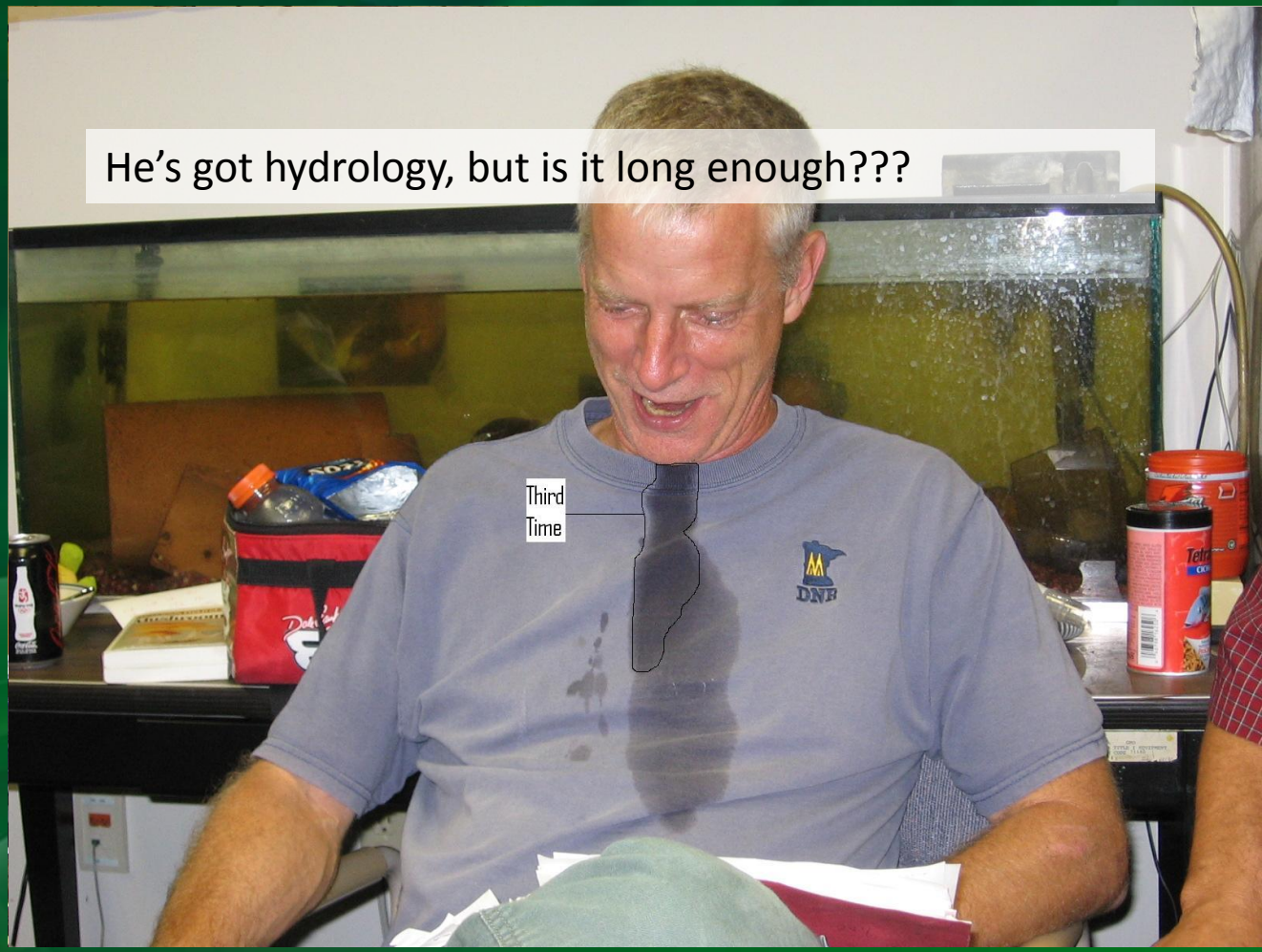
Definition of a Wetland

Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Doesn’t say anything about 12 inches or 14 days

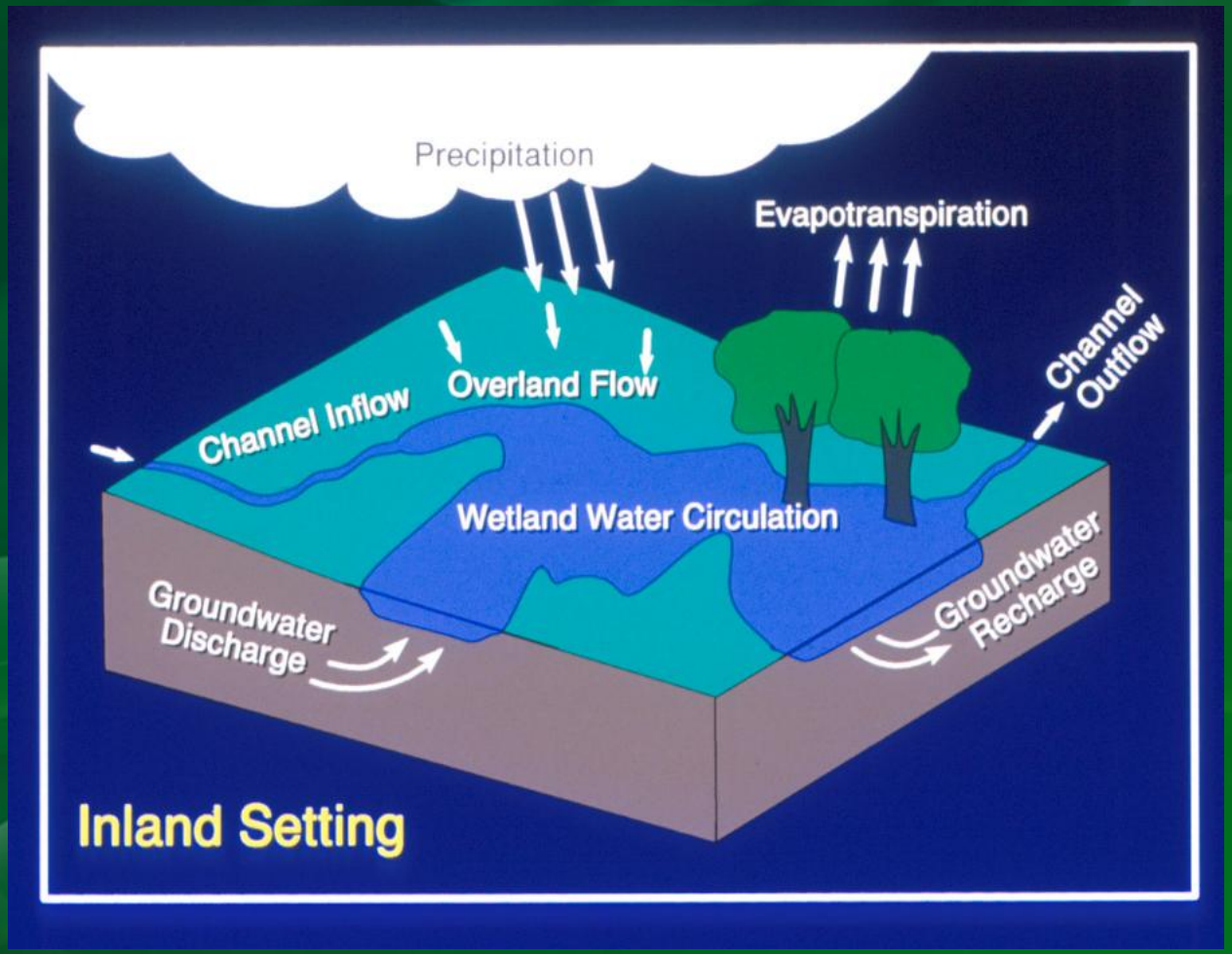
Hydrology is highly variable

- It's dependant on outside sources
- It might be there one day and gone the next
- Only needs to be there for 14 consecutive days sometime in the growing season, in most years(to meet standard)



Wetland Hydrology

Wetlands gain and lose water constantly through a variety of pathways.



Water Budgets

Inputs = **Outputs** + **Storage**

- Precipitation
- Groundwater discharge
- Surface inflow

- Evapo-transpiration
- Groundwater recharge
- Surface outflow

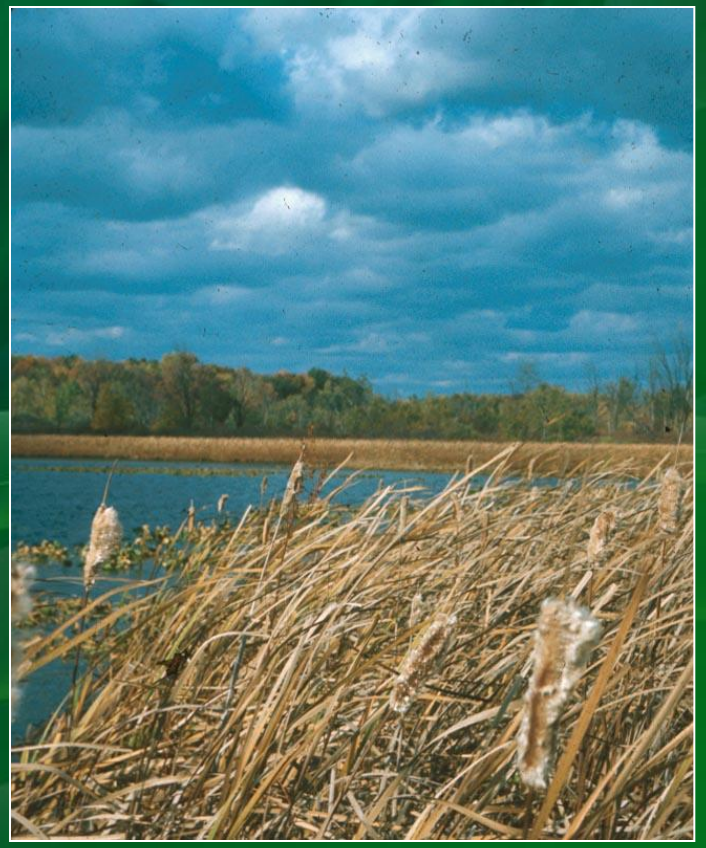
- Above Ground
- Below Ground

Factors that Influence Hydrology

- Geomorphic setting (landscape position)
- Stratigraphy (rock & soil layers)
- Soil texture and drainage (porosity & permeability).
- Plant cover (composition / amount %)
- Precipitation

Geomorphic setting (landscape position)

Fringes of lakes and rivers.



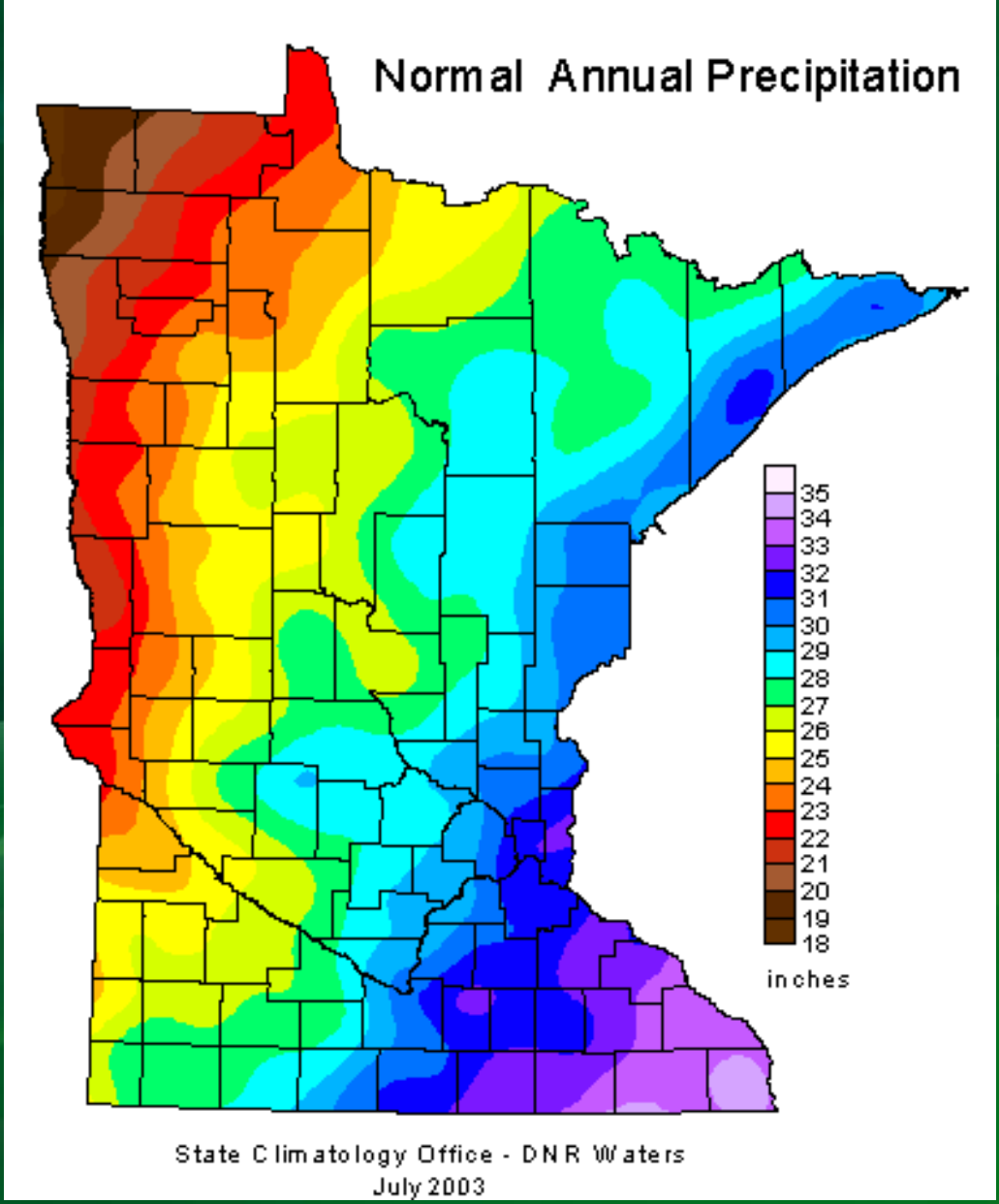
Wetlands in depressions

Riverine (floodplain) wetlands

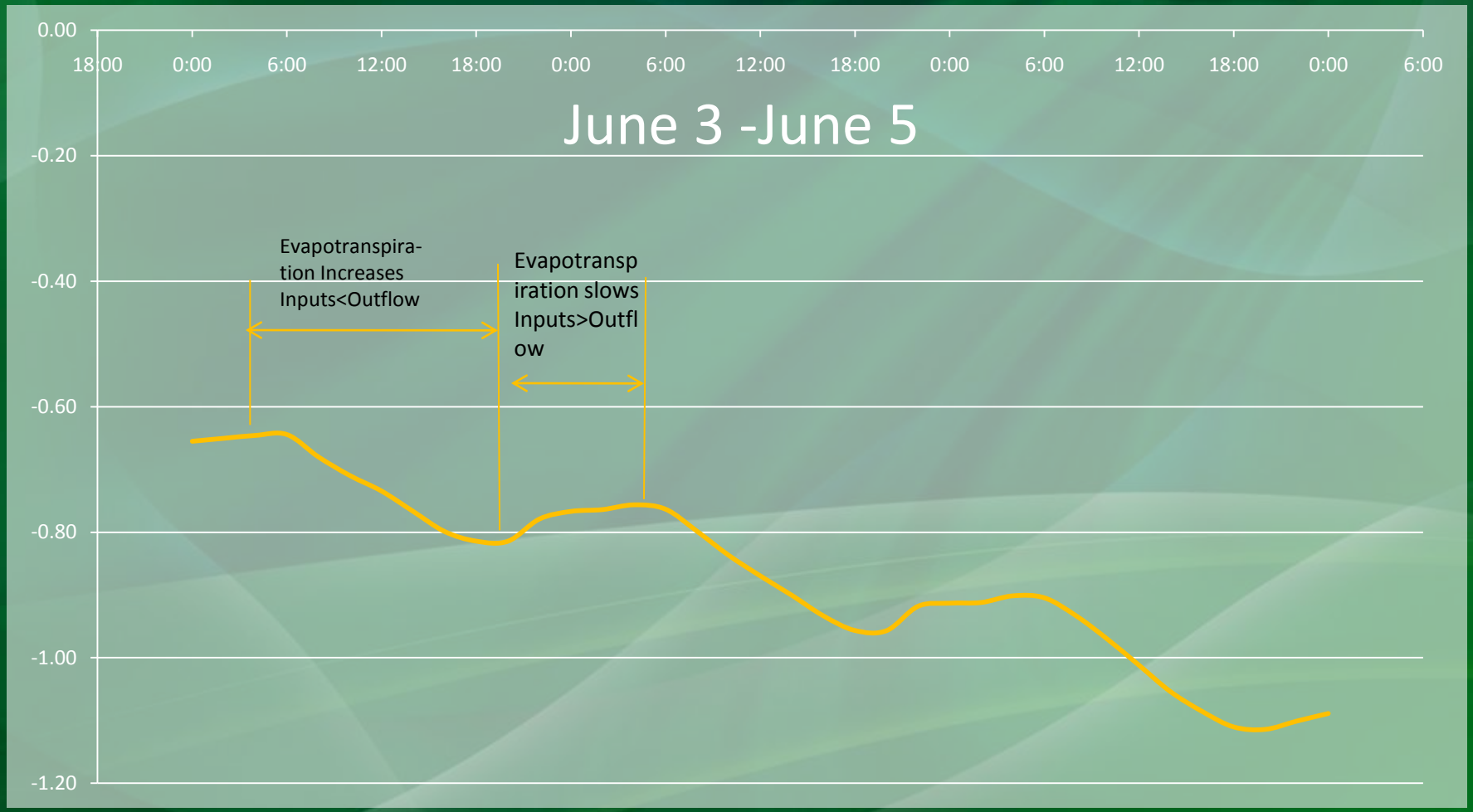
Wetlands on slopes

Precipitation

- Average Annual precipitation varies significantly from one side of the state to the other
- A difference of 14 inches from Houston to Kittson counties



Hydrology-Daily Variations



Some Terminology

Inundation

A condition in which water from any source temporarily or permanently covers a land surface.

Ponding

A condition in which water stands in a closed depression. The water is removed only by percolation, evaporation, or transpiration.

Flooding

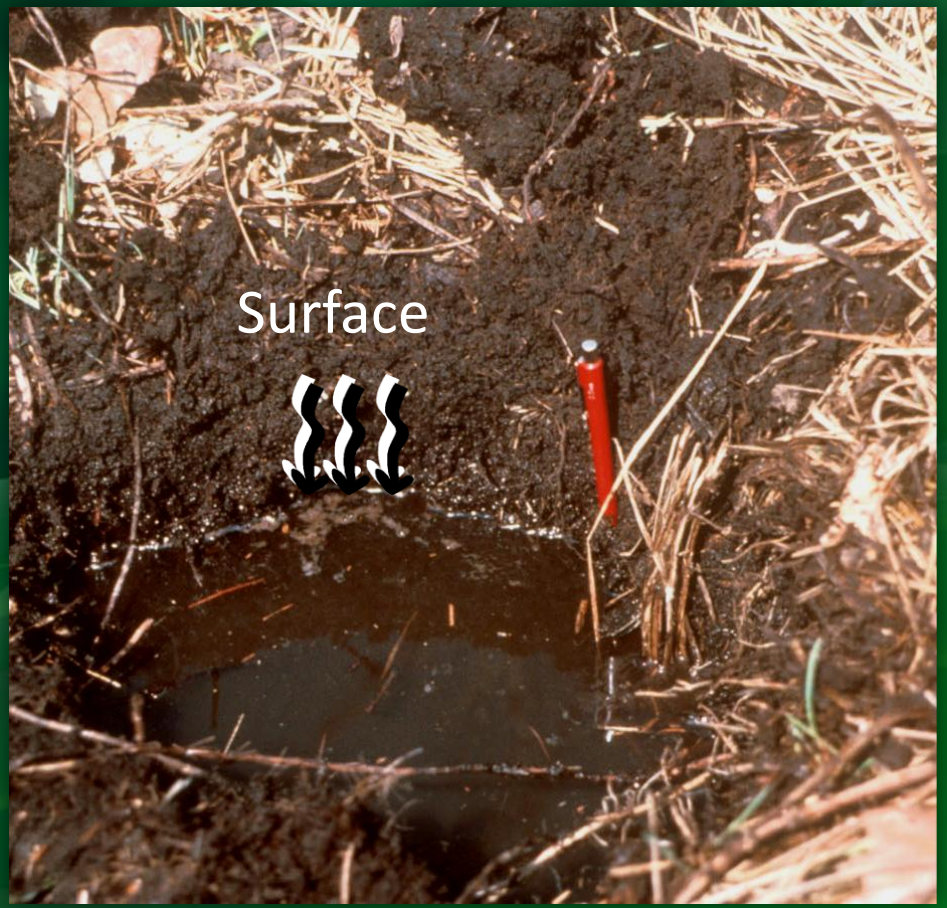
The soil surface is temporarily covered with flowing water from any source, such as overflowing streams or rivers, and runoff from adjacent slopes.

Saturation

Condition in which all easily drained pores between soil particles are temporarily or permanently filled with water.

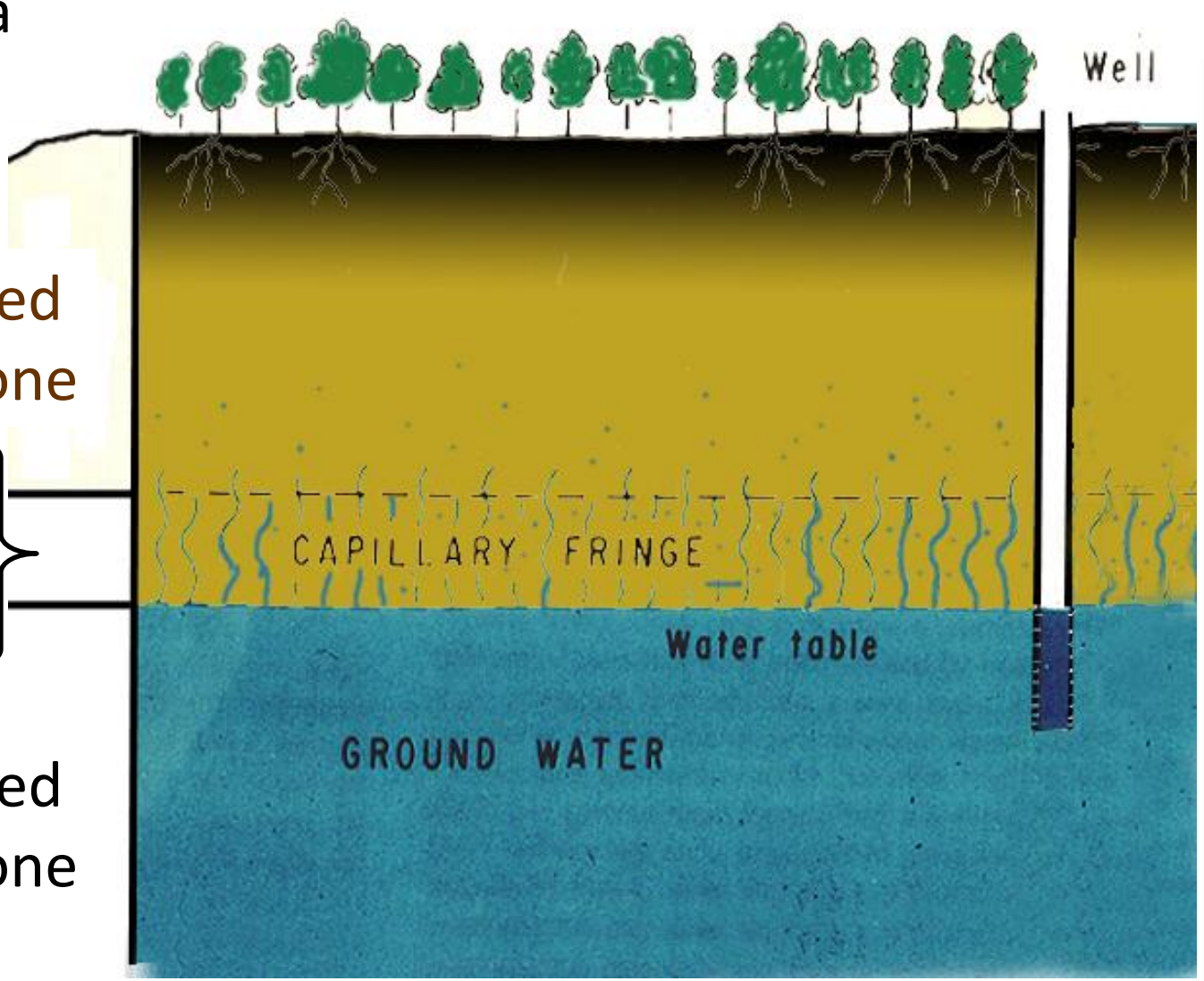
Water Table

The upper surface of groundwater, or the level at which water stands in an unlined borehole.



Capillary Fringe

A zone immediately above the water table in which water is dra



Unsaturated Zone

Zone of tension saturation

Saturated Zone

Anaerobic

- A situation in which molecular oxygen is virtually absent from the environment.

- The rate of diffusion of oxygen through water is 1/10,000th that of the rate of diffusion through air

Reduction

- Any chemical reaction in which the atoms in a soil take on electrons.
- Reduction is the opposite of oxidation.

Reduction in Soils

Factors that can delay the onset of reduced conditions in wet soils.

- Inputs of oxygenated water
- Cool temperatures
- Limited supply of organic matter

Evaluating Antecedent Precipitation Conditions

Antecedent Moisture Conditions

- Refers to the hydrologic conditions leading up to an observation
- Observations include photographs and site visits
- Uses climate data to determine normal ranges of precip for given area
- Creates thresholds for above and below normal

Methods

- Monthly weighted totals
- 30 day rolling average
- Others

ERDC/EL TR-WRAP-00-1

US Army Corps of Engineers®
Engineer Research and Development Center

Wetlands Regulatory Assistance Program

Accessing and Using Meteorological Data to Evaluate Wetland Hydrology

Steven W. Sprecher and Andrew G. Warne

April 2000

http://el.erdc.usace.army.mil/elpubs/pdf/wrap00-1/wrap00-1.pdf

http://www.bwsr.state.mn.us/wetlands/wca/antecedent-precip.pdf

Evaluating Antecedent Precipitation Conditions at a Site Using Climate Data Available in Minnesota

Introduction

The publications ***Accessing and Using Meteorological Data to Evaluate Wetland Hydrology*** (Sprecher and Warne, 2000), and ***NRCS Engineering Field Handbook – Chapter 19 – Hydrology Tools for Wetland Determination*** (NRCS, 1997), are important resources for nationwide application. They describe procedures for evaluating whether precipitation prior to a particular date was within the range of normal.

In Minnesota, we have the additional benefit of one of the best state climatology offices in the nation. The climate data and tools readily available via the web from the State Climatology Office (at http://climate.umn.edu/) greatly enhance the application of these procedures. Together with the capabilities of spreadsheets (such as Microsoft Excel), the State Climatology Office data and tools make the procedures accessible and straightforward.

In this guidance we'll present the procedures and some suggestions for using them together with the State Climatology Office data and tools. The first method uses monthly precipitation data and the WETS Tables (or their Minnesota-enhanced equivalents) and is derived from the method presented in *Hydrology Tools for Wetland Determination* (NRCS, 1997). The State Climatology Office web site has a built-in tool for applying this method. The second method evaluates daily precipitation data on the basis of 30-day rolling sums. These methods can also be combined.

Contents

Evaluating Normal Rainfall

"Old way"

WETS tables

- USDA National Water and Climate Center
- Analyze monthly precipitation data from >8,000 National Weather Service stations
- Based on a standard 30 years of rainfall data
- Provide monthly and annual thresholds for:
  - Below normal rainfall (lowest 3 years in 10)
  - Above normal rainfall (highest 3 years in 10)

Evaluating Normal Rainfall

"New Way"

Wetland Delineation Precipitation Data Retrieval from a Gridded Database

-Use this to determine the normal precipitation ranges and historic rainfall data (usually lags a couple months behind)

http://climate.umn.edu/

-Has other data sources of precipitation that can give more recent data that can be compiled and used in with the normal precip ranges

-

Precipitation data for target wetland location:

county: **Stearns**
township name: **Rockville**
nearest community: **Rockville**
township number: **123N**
range number: **29W**
section number: **8**

To create a **precipitation documentation worksheet** using USDA-NRCS methodology, select the date of the site visit or aerial photograph and click on "create worksheet".

2008 July 29 **create worksheet**

precipitation totals are in inches

color key:
total is in lowest 30th percentile of the period-of-record distribution
total is => 30th and <= 70th percentile
total is in highest 30th percentile of the period-of-record distribution

multi-month totals:
WARM = warm season (May thru September)
ANN = calendar year (January thru December)
WAT = water year (Oct. previous year thru Sep. present year)

Period-of-Record Summary Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WARM	ANN	WAT
30%	0.43	0.32	0.80	1.45	2.25	3.03	2.27	2.38	1.81	1.08	0.57	0.33	13.77	22.85	22.69
70%	0.96	0.95	1.59	2.61	4.02	5.26	3.97	4.33	3.81	2.60	1.49	0.93	20.21	28.90	29.73
mean	0.76	0.73	1.35	2.22	3.30	4.25	3.40	3.49	2.93	1.95	1.25	0.72	17.37	26.36	26.37

1971-2000 Summary Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WARM	ANN	WAT
30%	0.50	0.24	1.09	1.29	2.36	3.27	2.79	2.97	2.08	1.13	0.85	0.37	15.33	24.91	23.92
70%	1.16	0.89	2.01	2.87	4.02	5.62	4.33	4.62	3.27	3.00	2.08	0.94	21.04	32.01	33.37
mean	0.84	0.69	1.67	2.13	3.31	4.71	3.77	3.83	3.06	2.32	1.57	0.72	18.68	28.63	28.72

Year-to-Year Data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WARM	ANN	WAT
2008	0.02	0.55													
2007	0.17	1.60	3.27	2.11	1.57	1.50	1.49	4.67	3.84	4.74	0.02	1.05	13.07	26.03	22.90
2006	0.17	0.33	1.00	4.25	1.47	3.40	1.58	4.15	5.04	0.71	0.40	1.57	15.64	24.07	29.92
2005	1.85	0.83	0.98	2.54	4.05	6.46	2.56	2.30	6.91	4.11	3.24	1.18	22.28	37.01	32.55
2004	0.53	0.98	1.22	1.12	7.12	3.59	3.98	1.94	6.60	3.07	0.69	0.31	23.23	31.15	29.54
2003	0.28	0.47	0.69	3.72	3.34	5.81	4.24	0.18	3.97	1.28	0.82	0.36	17.54	25.16	26.46
2002	0.15	1.50	1.94	3.32	2.36	4.85	7.60	7.77	2.87	3.48	0.08	0.20	25.45	36.12	38.11
2001	0.99	1.25	0.75	8.01	3.37	2.98	2.05	1.69	2.33	1.36	3.99	0.40	12.42	29.17	29.43
2000	0.71	1.35	1.39	0.76	3.29	2.38	4.69	1.42	0.68	1.58	3.28	1.15	12.46	22.68	18.16
1999	0.82	0.09	1.16	2.51	5.26	4.46	3.10	2.58	2.43	0.96	0.15	0.38	17.83	23.90	27.18
1998	1.16	0.75	3.42	1.12	5.31	5.18	3.92	4.37	1.39	2.66	1.46	0.65	20.17	31.39	28.80
1997	2.10	0.53	1.24	0.73	1.77	3.04	6.83	4.88	2.05	1.14	0.85	0.19	18.57	25.35	31.14
1996	1.48	0.21	0.71	0.73	3.58	2.52	2.93	1.54	1.71	3.27	3.64	1.06	12.28	23.38	19.78

Minnesota Climatology Working Group

State Climatology Office - DNR Waters University of Minnesota

Precipitation Worksheet Using Gridded Database

Precipitation data for target wetland location:

county: **Stearns** township number: **123N**
township name: **Rockville** range number: **29W**
nearest community: **Rockville** section number: **8**

Aerial photograph or site visit date:
Sunday, July 29, 2007

(values are in inches)	first prior month: June 2007	second prior month: May 2007	third prior month: April 2007
estimated precipitation total for this location:	1.50	1.57	2.11
there is a 30% chance this location will have less than: *	3.07	2.44	1.15
there is a 30% chance this location will have more than: *	5.67	3.88	2.60
type of month: dry normal wet	dry	dry	normal
monthly score	3 * 1 = 3	2 * 1 = 2	1 * 2 = 2
multi-month score: 6 to 9 (dry) 10 to 14 (normal) 15 to 18 (wet)	7 (Dry)		

view USDA-NRCS WETS data for Stearns County

Evaluating Antecedent Moisture Conditions

NRCS method - Rainfall Documentation Worksheet
Hydrology Tools for Wetland Determination EFH Chapter 19

Date 6/22/2010
Weather Station New Ulm
County Nicollet
Soil Name
Photo/obs Date

Landowner/ Project Hydro Training
State MN
Growing Season 4/20 to 10/15 - 179days

Long-term Rainfall Records

	Month	WETS 3 years in 10 less than	Normal	WETS 3 years in 10 more than	Rainfall	Condition Dry, Wet, Normal	Condition Value	Month Weight Value	Product of Previous 2 Columns
1st Prior Month*	May	2.47	3.37	4.18	1.74	Dry	1	3	3
2nd Prior Month*	April	1.36	2.45	3.10	1.97	Normal	2	2	4
3rd Prior Month*	March	1.10	1.85	2.30	1.53	Normal	2	1	2
								Sum	9

*compared to photo/obs date

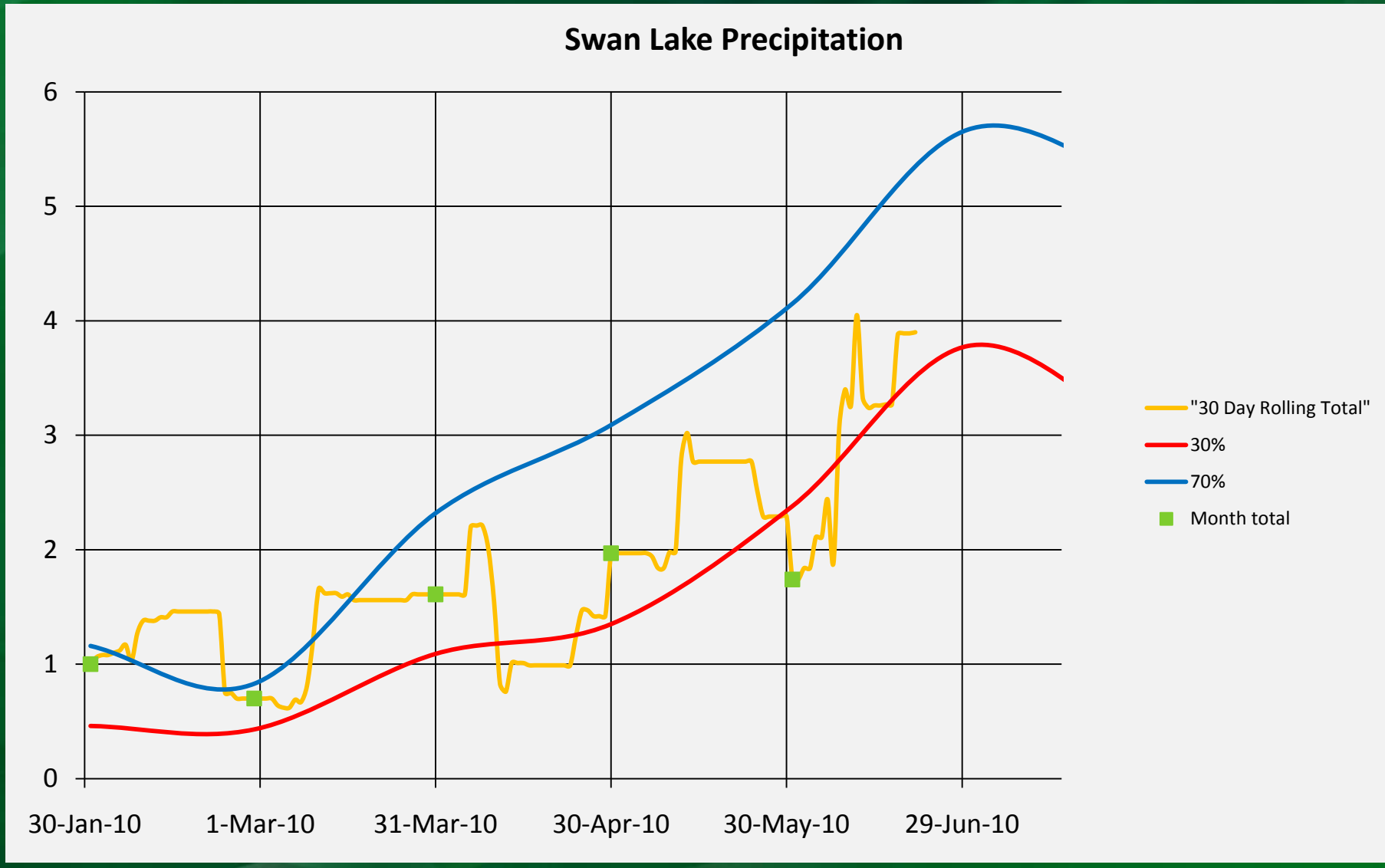
Note: If sum is
6 - 9 prior period has been drier than normal
10 - 14 prior period has been normal
15 - 18 prior period has been wetter than normal

Condition value:
Dry =1
Normal =2
Wet =3

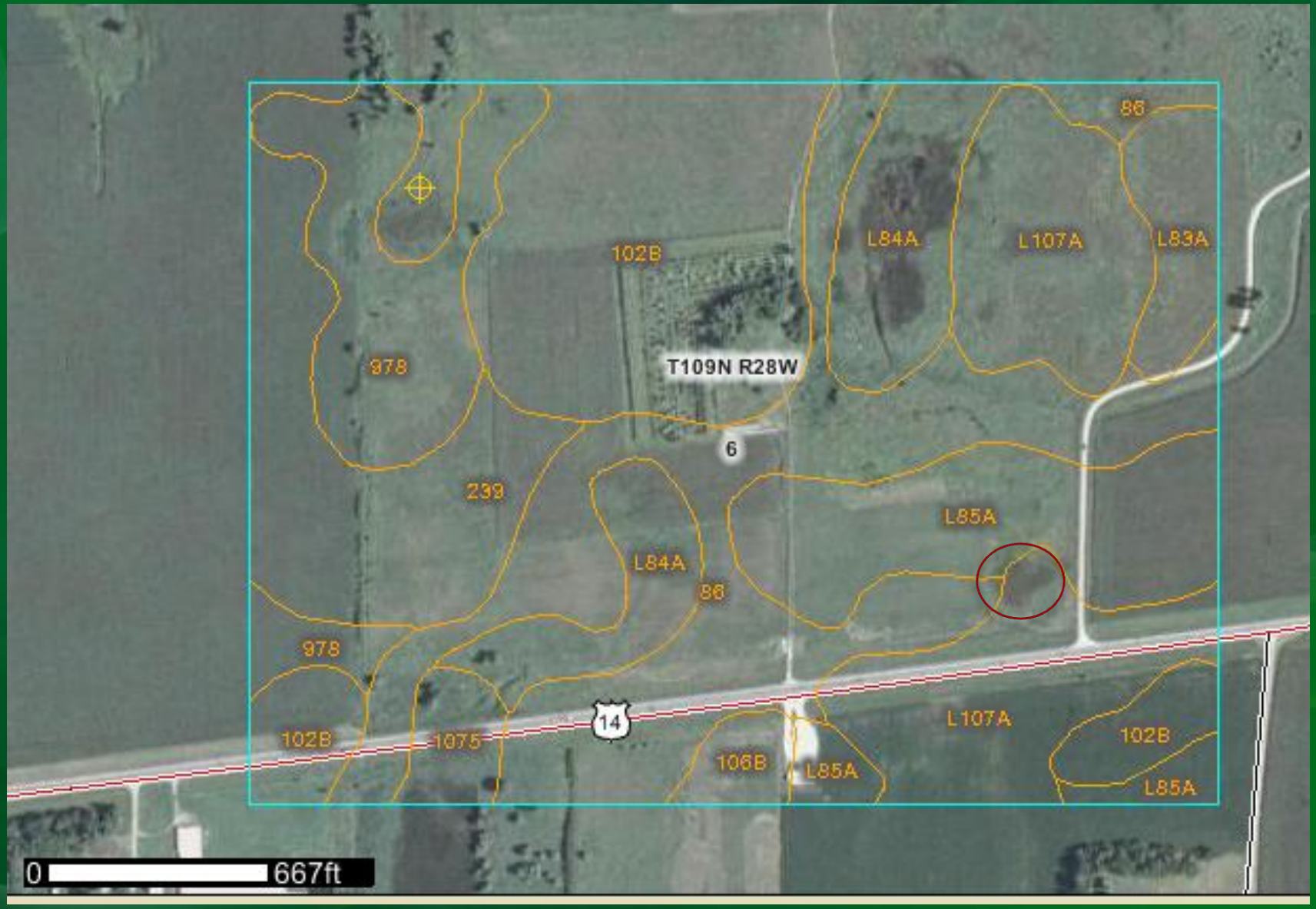
Evaluating Antecedent Moisture Conditions

- What's that mean?
- S
- It
- A

30 Day Rolling Average



Soils Info for Hydrology



Soils Info

Nicollet County, Minnesota

L107A—Canisteo-Glencoe, depressional complex, 0 to 2 percent slopes

Map Unit Setting

Elevation: 700 to 1,900 feet
Mean annual precipitation: 23 to 35 inches
Mean annual air temperature: 43 to 50 degrees F
Frost-free period: 124 to 200 days

Map Unit Composition

Canisteo and similar soils: 50 percent
Glencoe, depressional, and similar soils: 35 percer
Minor components: 15 percent

Description of Canisteo

Setting

Landform: Rims on moraines
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Till

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inch
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit
Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 perc
Gypsum, maximum content: 1 percent
Available water capacity: High (about 10.3 inch

Interpretive groups

Land capability (nonirrigated): 2w

Typical profile

Description of Glencoe, Depressional

Setting

Landform: Depressions on moraines
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Till

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat):
Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 20 percent
Gypsum, maximum content: 1 percent
Available water capacity: High (about 11.2 inches)

Interpretive groups

Land capability (nonirrigated): 3w

Typical profile

0 to 10 inches: Clay loam
10 to 35 inches: Clay loam
35 to 48 inches: Loam
48 to 60 inches: Loam

Pre-Site Visit Summary

- Try to get an idea of where you wetlands are and where the hydrology is coming from
- Know the antecedent moisture conditions so you can put observations into context
- Document! Document! Document!

Minnesota Mapping Conventions

Slide Review Hydrology

Series of aerial images showing changes in wetland hydrology signatures over time:

Background

- In 1994, BWSR, Corps, and NRCS collaborated on the development of wetland mapping protocols.
- Purpose was to aid in the implementation of the Federal Farm Bill and promote consistency between wetland determinations made under the National Food Security Act Manual and 87 Manual.
- BWSR modified for WCA use
- Is now incorporated into the 87 Manual supplements

Applicability

- Most useful for interpreting wetland hydrology in agricultural areas.
- Can be useful in other situations (with appropriate caution) where hydrology is in question.
- Generally more accurate in agricultural fields that are/were planted with annually seeded row crops such as soybeans and corn. These fields will often show signs of crop stress, standing water, or drowned out crops in summer aerial imagery when wetland hydrology is present.

Applicability

- Not as reliable for fields planted in perennial forage crops compared to those planted to row crops.
- Some situations where it is useful in areas that are not cropped or hayed such as pastures and naturally vegetated seasonally flooded/saturated wetlands. However, greater emphasis should be placed on other data sources in these situations.

Basics

- Minnesota mapping conventions use a percentage of the slides with normal precipitation to indicate the likelihood of wetland hydrology being present

- UM Climatology website tools are used for precipitation data in most cases.

Basics

- Must have a minimum of 5 normal precipitation years for the procedure; may add equal number of wet and dry years

- In years where precipitation is extreme, (wet or dry) disregard slide for counting hydrology "hits"

Items Needed to Do Analyses

- Blank photo

- Slides of tract

- Form for recording slide review
- Precipitation data

Interpreting Images

Crop Stress (CS)– differences in crop color due to stress from wetness

Interpreting Images

Drowned Out (DO) – Cropped areas that have been plowed through or planted and then drowned out

Interpreting Images

NC – not cropped. Area appears to have natural vegetative cover rather than annual crops or is bare due to herbicide application. Adjacent cropped area is often "squared-up" or otherwise planted in a pattern so as to avoid the area.

Interpreting Images

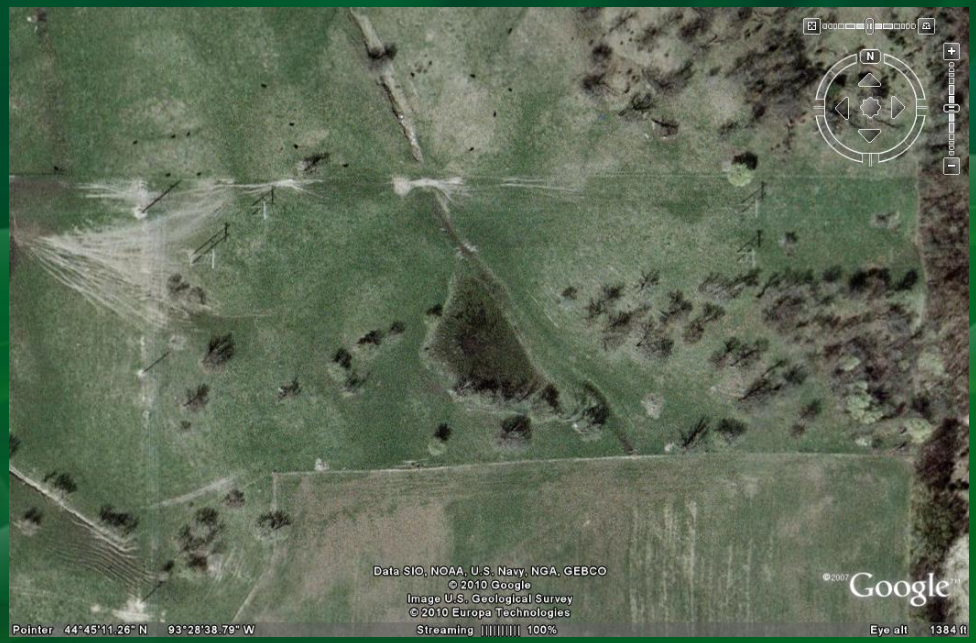
Standing Water (SW) – surface water visible on photo.

Interpreting Images

AP – altered pattern. Detectable differences in vegetation or cropping patterns resulting from delayed planting dates or other alterations to standard farming practices as a result of wetness.

Interpreting Images

WS – wetland signature. General term that can be used in non-cropped areas when the observer is familiar with the vegetative cover associated with a particular signature on an aerial image. Can also be applied to areas that have greener vegetation during dry conditions.



Interpreting Images

Normal Vegetative Cover (NV) - The outline of the area in question cannot be readily distinguished from the surrounding upland area or the signatures on the image are not due to wetness.

Interpreting Images

Wetland signatures may appear for reasons other than wetness:

- iron chlorosis (alkaline soils, lack of iron availability)
- severe winter weather - freeze out.
- peat depth (shallower peat may show a lighter photo tone)

- farmers can make decisions on cropping based on business considerations that may have nothing to do with wetness in a particular field.

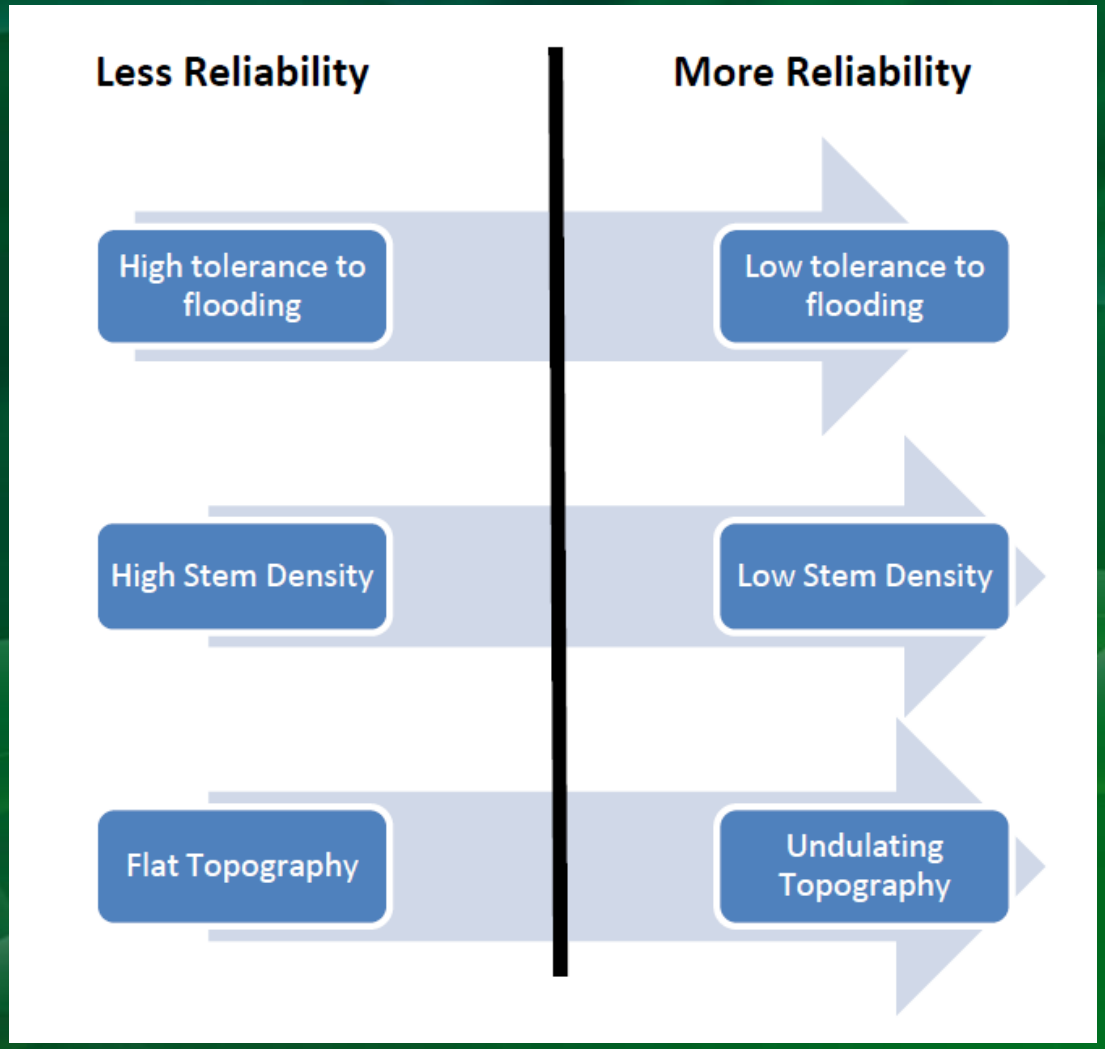
Interpreting Images

Wetland signatures may appear for reasons other than wetness:

- iron chlorosis (alkaline soils, lack of iron availability)
- severe winter weather - freeze out.
- peat depth (shallower peat may show a lighter photo tone)

- farmers can make decisions on cropping based on business considerations that may have nothing to do with wetness in a particular field.

Factors Affecting Interpretation Reliability



Reference Areas

Reference areas of known wetland and upland can provide important information and context to signatures and interpretations in other areas. Comparing areas of known wetland and upland during different antecedent precipitation conditions can strengthen interpretations in questionable areas.

Evaluation Steps

1. Review soils data for presence of hydric soils, NWI map, aerial imagery from wet and dry periods, and any other wetland mapping resources to identify potential wetland areas for further evaluation.

2. Conduct a quick review of aerial imagery to determine the frequency of wetland signatures in a particular area.

3. Determine which areas exhibit enough wetland signatures to warrant a comprehensive review.

4. Label evaluation areas on base air photo and observation recording form.

Evaluation Steps

5. Review each image carefully and note observations in accordance with terminology.

6. Tally the number of years of imagery with normal antecedent precipitation conditions that exhibited wetland signatures (hits).

7. For areas with 30% or more hits in normal years, review each image again and sketch the approximate size and location of potential wetland areas.

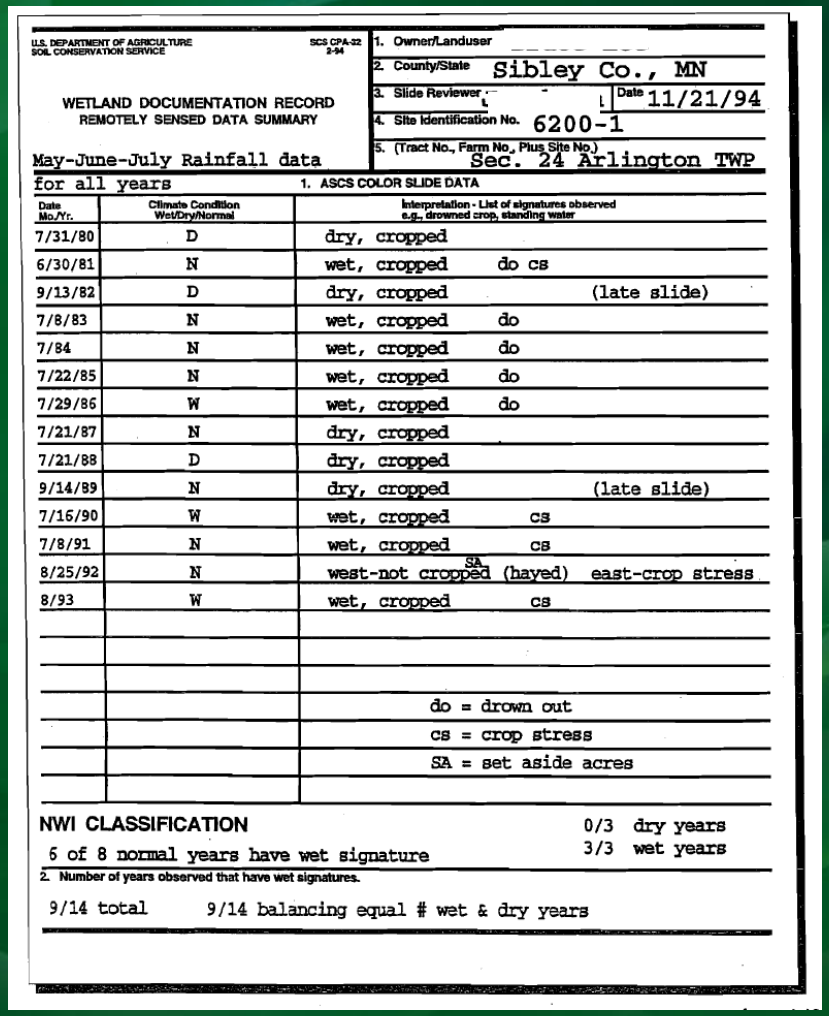
8. Conduct a field review in accordance with 87 Manual procedures and examine any other available information regarding the hydrology of the area in question.

9. If necessary, conduct a second review of imagery in consideration of field observations and other data obtained since the first review. Modify observations accordingly.

Example print-out of WETS table for a July 2006 FSA slide. This print-out indicates that the slide was taken following a normal precipitation period.

(values are in inches)	first prior month: **June 2006**	second prior month: **May 2006**	third prior month: **April 2006**
estimated precipitation total for this location:	**3.72**	**1.90**	**3.42**
there is a 30% chance this location will have less than: *	2.79	2.51	1.30
there is a 30% chance this location will have more than: *	5.12	3.95	2.75
type of month: dry normal wet	**normal**	**dry**	**wet**
monthly score	**3 * 2 = 6**	**2 * 1 = 2**	**1 * 3 = 3**
multi-month score: 6 to 9 (dry) 10 to 14 (normal) 15 to 18 (wet)	**11 (Normal)**		

Fill out a Slide Review Data Form



U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS CPA-32
2-94

WETLAND DOCUMENTATION RECORD
REMOTELY SENSED DATA SUMMARY

May-June-July Rainfall data for all years

1. Owner/Landuser
2. County/State: Sibley Co., MN
3. Slide Reviewer: Date: 11/21/94
4. Site Identification No.: 6200-1
5. (Tract No., Farm No., Plus Site No.): Sec. 24 Arlington TWP

1. ASCS COLOR SLIDE DATA

Date Mo./Yr.	Climate Condition Wet/Dry/Normal	Interpretation - List of signatures observed e.g., drowned crop, standing water
7/31/80	D	dry, cropped
6/30/81	N	wet, cropped do cs
9/13/82	D	dry, cropped (late slide)
7/8/83	N	wet, cropped do
7/84	N	wet, cropped do
7/22/85	N	wet, cropped do
7/29/86	W	wet, cropped do
7/21/87	N	dry, cropped
7/21/88	D	dry, cropped
9/14/89	N	dry, cropped (late slide)
7/16/90	W	wet, cropped cs
7/8/91	N	wet, cropped cs
8/25/92	N	west-not cropped SA (hayed) east-crop stress
8/93	W	wet, cropped cs

do = drown out
cs = crop stress
SA = set aside acres

NWI CLASSIFICATION

6 of 8 normal years have wet signature

0/3 dry years
3/3 wet years

2. Number of years observed that have wet signatures.

9/14 total 9/14 balancing equal # wet & dry years

Can be any form that you want as long as it has the following information:

- Slide year
- Climatic condition (wet, dry, normal)
- Wetland signature interpretation
- Reviewer name and date

Other data can be incorporated into the form such as NWI classification, soil unit, etc., but the above items are the documentation requirements for the slide review. **They should be in the delineation report!**

Wetland Mapping Conventions Review Record

Project Name_____ Date_____ County_____

Investigator_____ Legal Description (Sec, T, R)_____

Year	Climate Condition (wet, dry, normal)[1]	Interpretation (list hydrology indicators observed, e.g. crop stress, drowned out, standing water, etc.)[2]				
		Area_____	Area_____	Area_____	Area_____	Area_____
1979						
1980						
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
2003						
2004						
2005						
2006						
2007						
2008						
2009						

Summary Table

	Area_____	Area_____	Area_____	Area_____	Area_____
# Normal Yrs.					
# Normal Yrs with wet signatures					
% Normal Yrs with wet signatures					

[1]Use MN State Climatology website to determine USDA/NRCS climate condition for legal description of parcel being investigated.

[2]In the space below, provide legend for interpretation symbols used.

Example data form for recording mapping conventions review. Can record data for up to 5 different areas on this form.

Making a Decision

1. Utilize relevant procedure from MN Mapping Conventions.

2. Further scrutinize slides in borderline situations.

3. Determine if slide review shows a wetland hydrology indicator.

Making a Decision (cont.)

4. Look at other information (see 87 Manual and Supplement) including field observations.

5. Determine if hydrology is present during some portion of the growing season.

6. Follow problem area procedures to determine if area is a wetland (has indicators of all 3 parameters).

Important Final Points

- Slide review is one piece of information to be considered with others in determining if wetland hydrology is present.
- Consider other sources of information as described in the 87 Manual and Supplements. Consider what is appropriate and available for the site in question.
- Weigh all evidence in making a determination. If there is not enough evidence to make a reasonable decision, then ask for more information.

And Most Importantly…..

Document and explain the basis for the determination in the file (LGU) and report (applicant/consultant).

Problems with this Method

Non – Cropped Areas

- Aerial Photos are not as helpful in non-cropped areas. Ex. pastures, building sites
- Color variations from wetlands to uplands are sometimes not very distinct
- Maps that are still useful in non-cropped areas:
  - NWI
  - Soils
  - Topo

Non – Cropped Areas cont...

Field visits are a must for these areas!

- Vegetation will give the biggest clues
  - Even if veg. is grazed or mowed, usually changes in type of vegetation is noticeable.
- Soils should be reviewed by digging a couple of holes
- Hydrology might be absent.
  - Use clues and indicators to determine hydrology.

Important Final Points

- Slide review is one piece of information to be considered with others in determining if wetland hydrology is present.
- Consider other sources of information as described in the 87 Manual and Supplements. Consider what is appropriate and available for the site in question.
- Weigh all evidence in making a determination. If there is not enough evidence to make a reasonable decision, then ask for more information. As always it's up to the applicant to provide the information.

Hydrologic Monitoring

- If all else fails, i.e. last resort, monitor
- What's the most important question you need to ask before starting monitoring?
- Answer-Why

Monitoring

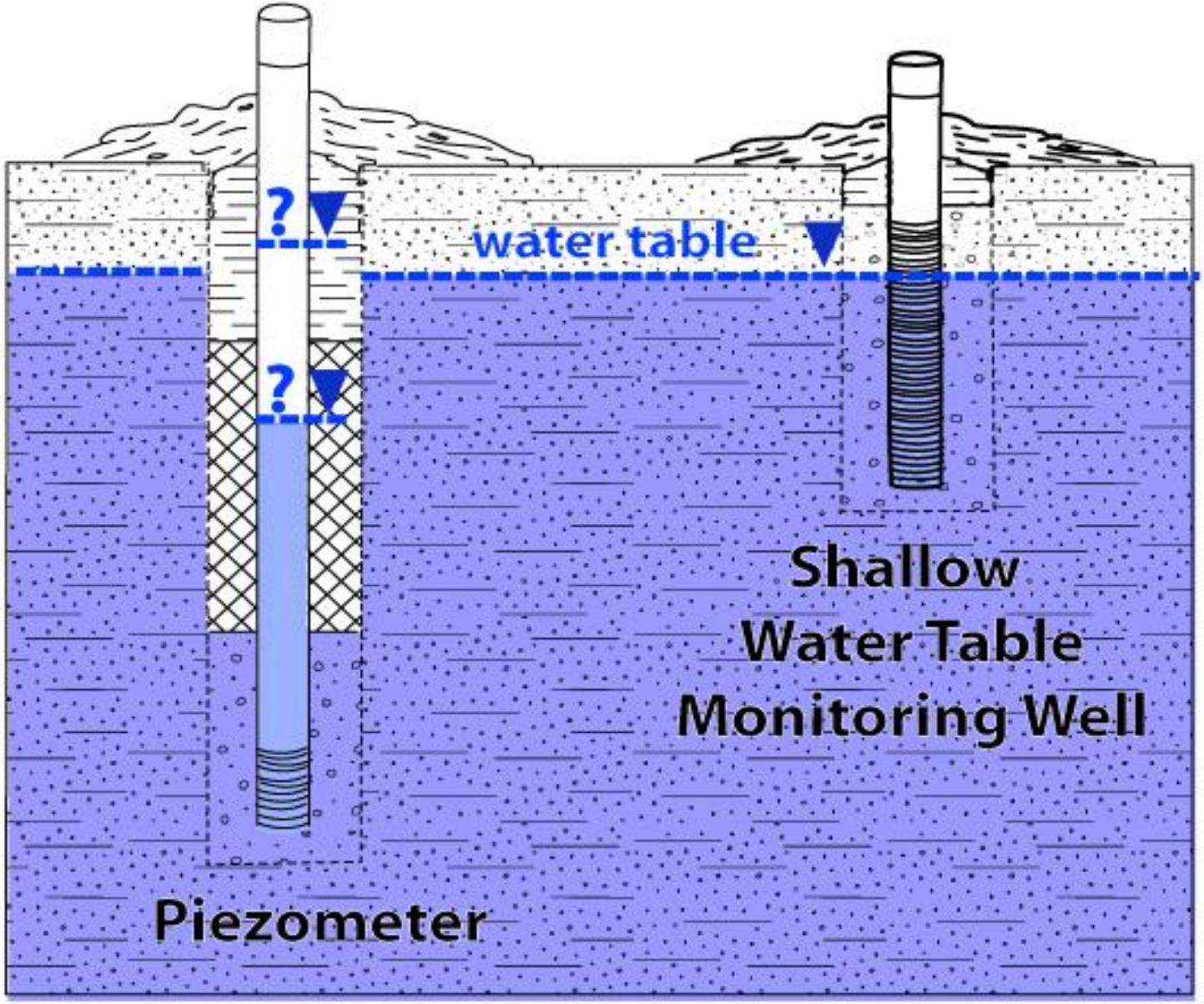
- Alone, monitoring data < 3 years are not enough to demonstrate the presence or absence of wetland hydrology.
- Remember technical standard “5 years in 10”
- Where will you be in 10 years?
- Not intended to replace or make irrelevant the field indicators!

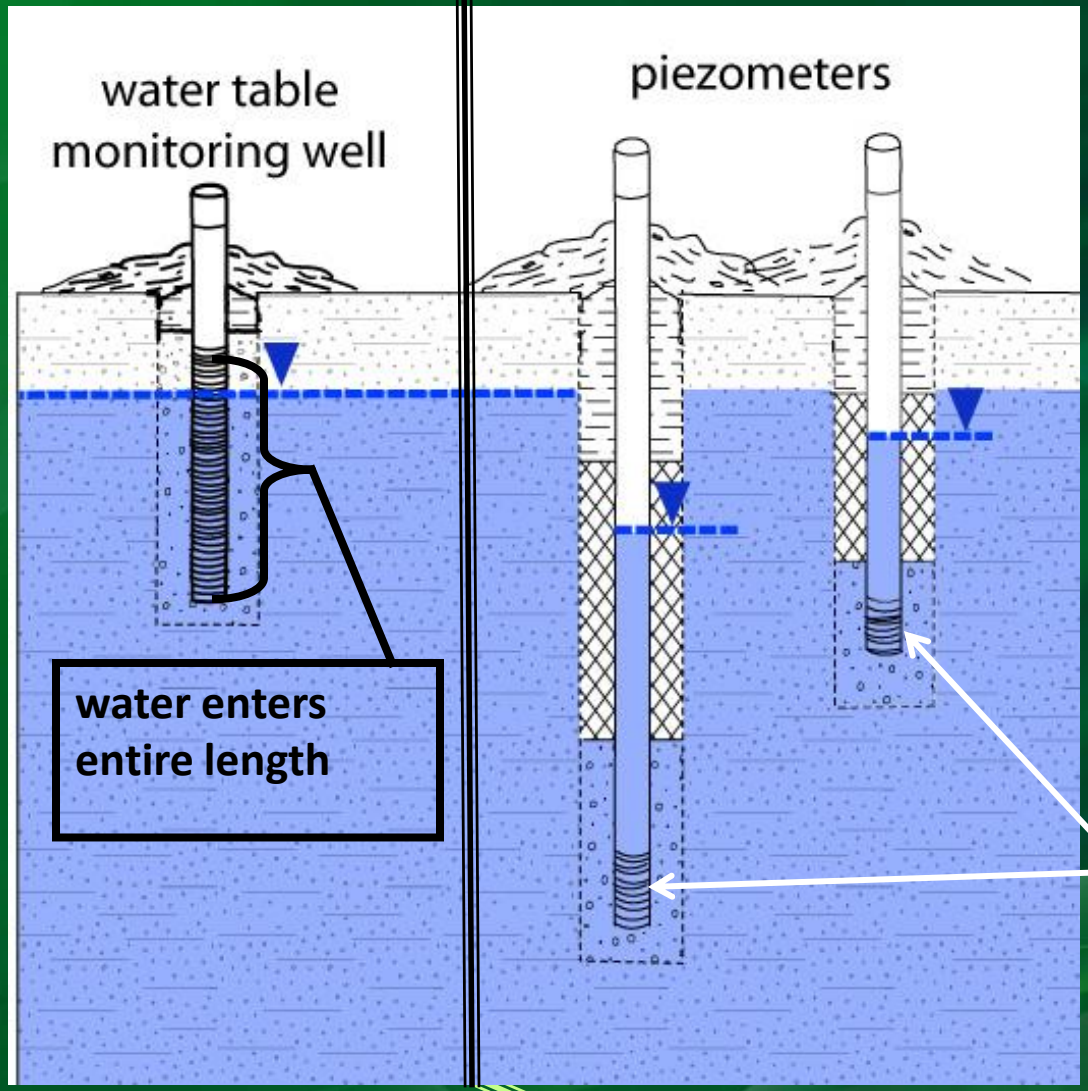
Why Hydrologic Monitoring?

- Verify site wetness (depth, duration)
- Verify delineations, resolve disputes
- Determine water movement (flow-through, discharge or recharge conditions)
- Restoration/replacement success
- Wetland creation potential
- Functional assessments
- Calcareous fen determination
- “Beyond delineation”

Hydrologic Monitoring

- Important to agree on the question before setting out to answer it with monitoring.


?
?
water table
Shallow
Water Table
Monitoring Well
Piezometer



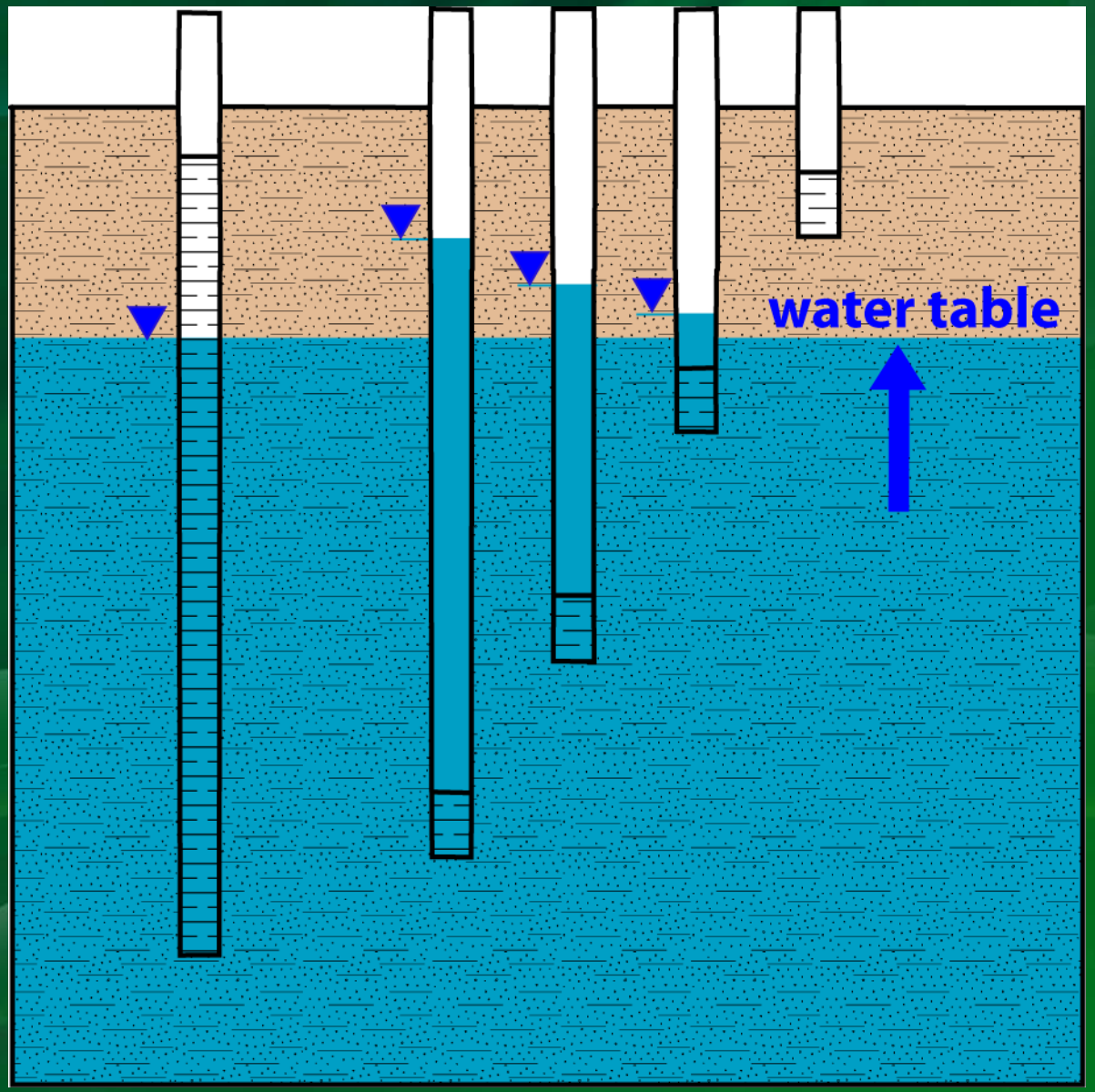
Piezometers:

- do not (necessarily) measure saturation levels
- monitor head (pressure) differences
- water movement

Water table monitoring wells:

- measure saturation

Rising Water Level - Discharge



The End

Wetland Hydrology Indicators

Hydrology Indicators

Table 9. Wetland hydrology indicators for the Midwest Region.

Indicator	Category	
	Primary	Secondary
Group A – Observation of Surface Water or Saturated Soils		
A1 – Surface water	X	
A2 – High water table	X	
A3 – Saturation	X	
Group B – Evidence of Recent Inundation		
B1 – Water marks	X	
B2 – Sediment deposits	X	
B3 – Drift deposits	X	
B4 – Algal mat or crust	X	
B5 – Iron deposits	X	
B7 – Inundation visible on aerial imagery	X	
B8 – Sparsely vegetated concave surface	X	
B9 – Water-stained leaves	X	
B13 – Aquatic fauna	X	
B14 – True aquatic plants	X	
B6 – Surface soil cracks		X
B10 – Drainage patterns		X
Group C – Evidence of Current or Recent Soil Saturation		
C1 – Hydrogen sulfide odor	X	
C3 – Oxidized rhizospheres along living roots	X	
C4 – Presence of reduced iron	X	
C6 – Recent iron reduction in tilled soils	X	
C7 – Thin muck surface	X	
C2 – Dry-season water table		X
C8 – Crayfish burrows		X
C9 – Saturation visible on aerial imagery		X
Group D – Evidence from Other Site Conditions or Data		
D9 – Gauge or well data	X	
D1 – Stunted or stressed plants		X
D2 – Geomorphic position		X
D5 – FAC-neutral test		X

- Previous 87 Manual indicators are gone (10 indicators).
- Replaced by Chapter 4 of regional supplements (25 to 29 indicators).

Wetland Hydrology Indicators

- Wetland hydrology elements inferred by the wetland definition include:
  - Timing *(during growing season)*;
  - Frequency *(in most years)*; and
  - Duration *(long enough to influence soil and vegetation)*.

Wetland Hydrology Indicators

- Wetland hydrology elements inferred by the wetland definition include:
  - Timing *(during growing season)*;
  - Frequency *(in most years)*; and
  - Duration *(long enough to influence soil and vegetation)*.

Wetland Hydrology Indicators

- Wetland hydrology indicators are not intended to confirm timing, frequency and duration of a hydrologic event.
- Wetland hydrology indicators simply confirm that a hydrologic event occurred recently.

Hydrology Indicators

- Wetland hydrology indicators are still divided into two categories:
  - Primary – provide stand-alone evidence of a current or recent hydrologic event; and
  - Secondary – provide evidence of recent hydrology when supported by one or more other hydrology indicators.

Wetland Hydrology Indicators

- A primary hydrology indicator should address at least two elements
- Presence of a hydrology indicator in association with hydrophytic vegetation and hydric soil confirm that wetland hydrology occurs during the growing season, in most years, and long enough to meet wetland conditions.

Wetland Hydrology Indicators

- Lack of hydrology indicator does not confirm lack of wetland hydrology; many Midwest wetlands lack indicators during dry periods.
- Understanding normal seasonal and annual variations in rainfall, temperature, and other climatic conditions is essential in interpreting hydrology indicators.

Wetland Hydrology Indicators

- If no hydrology indicators are present in an area with wetland vegetation and hydric soil, use the procedures in Chapter 5 to determine if wetland hydrology is present.

Wetland Hydrology Indicators

- Hydrology indicators are presented in four groups:

Wetland Hydrology Indicators

- Group A: Direct observation of surface water or saturated soils.
- Group B: Evidence of recent inundation.
- Group C: Evidence of recent soil saturation.
- Group D: Evidence from other site conditions or data

Wetland Hydrology Indicators

- Very important: read entire indicator description as well as cautions and user notes
- List of indicators is not absolute or all-encompassing
- Other evidence of wetland hydrology may be used with appropriate documentation provided

Wetland Hydrology Indicators

- Format for hydrology indicators is more user friendly:
  - An indicator reference number;
  - An indicator category (Primary or Secondary);
  - A general description of the indicator;
  - Cautions and user notes to further clarify indicator use; and
  - A photo, when available, to visually represent the indicator.

Indicator B1: Water marks

Category: Primary

General Description: Water marks are discolorations or stains on the bark of woody vegetation, rocks, bridge supports, buildings, fences, or other fixed objects as a result of inundation (Figure 26).

Figure 26. Water marks (dark stains) on trees in a seasonally flooded wetland.

Cautions and User Notes: When several water marks are present, the highest reflects the maximum extent of inundation. Water marks indicate a water-level elevation and can be extrapolated from nearby objects across lower elevation areas. Use caution with water marks that may have been caused by extreme, infrequent, or very brief flooding events. In regulated systems, such as reservoirs, water-level records can be used to distinguish unusually high pools from normal operating levels.

Wetland Hydrology Indicators

A1: Surface water

Category: Primary

General Description: This indicator consists of the direct, visual observation of surface water during a site visit.

- Surface water may be present in non-wetland areas immediately after an event
- Surface water observed during the non-growing season may be an acceptable indicator if BPJ suggest
- May be absent from a wetland during the normal dry season or during extended periods of drought.

Wetland Hydrology Indicators

A2 – High water table

Category: Primary

Water table 12 in. (30 cm) or less below the surface in a soil pit, auger hole, or shallow monitoring well. +

Wetland Hydrology Indicators

A3 – Saturation

Category: Primary

Visual observation of saturated soil conditions 12 in. or less from the soil surface as indicated by water **glistening** on the surfaces and broken interior faces of soil samples.

Wetland Hydrology Indicators

B1 – Water Marks

Category: Primary

Water marks are discolorations or stains on the bark of woody vegetation, rocks, bridge supports, buildings, fences, or other fixed objects as a result of inundation.

Wetland Hydrology Indicators

B2 – Sediment Deposits

Category: Primary

Sediment deposits are thin layers or coatings of fine-grained mineral material or organic matter remaining on tree bark, plant stems or leaves, rocks, and other objects after surface water recedes

Wetland Hydrology Indicators

B3 – Drift Deposits

Category: Primary

General Description: Drift deposits consist of rafted debris that has been deposited on the ground surface or entangled in vegetation or other fixed objects.

Wetland Hydrology Indicators

B4 – Algal mat or crust;

Category: Primary

General Description: This indicator consists of a mat or dried crust of algae, perhaps mixed with other detritus, left on or near the soil surface after dewatering.

Wetland Hydrology Indicators

B5 – Iron deposits;

Category: Primary

General Description: This indicator consists of a thin orange or yellow crust or gel of oxidized iron on the soil surface or on objects near the surface.

Wetland Hydrology Indicators

B6 – Surface soil cracks;

Category: Secondary

Surface soil cracks consist of shallow cracks that form when fine-grained mineral or organic sediments dry and shrink

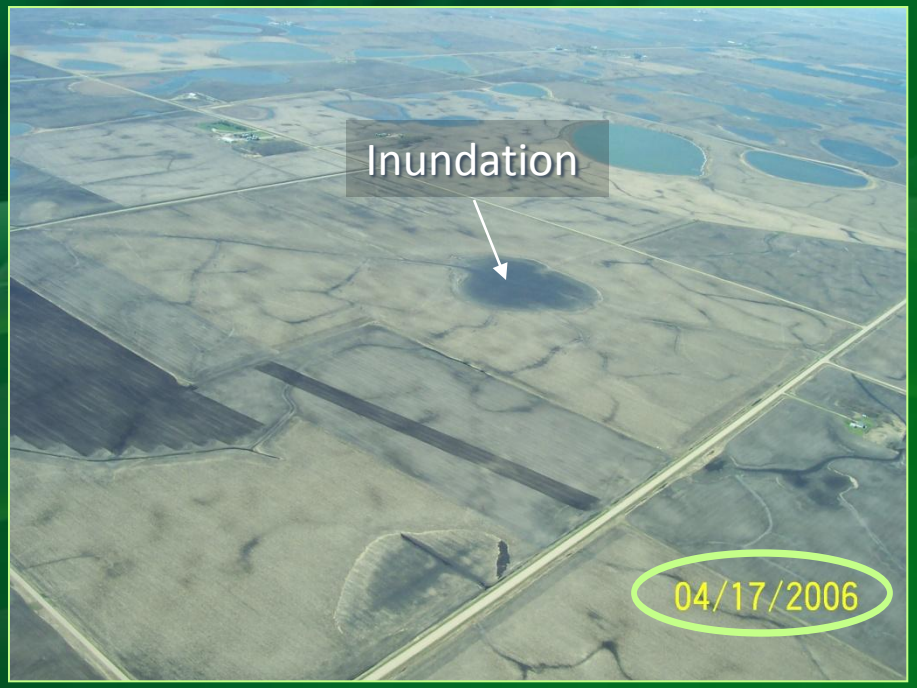
- Surface soil cracks may also occur in temporary ponds and puddles that are not wetlands.
- Verify the presence of hydrophytic vegetation and/or hydric soils.
- This indicator does not include deep cracks due to shrink-swell action in clay soils (e.g. Vertisols).

Wetland Hydrology Indicators

B7 – Inundation on aerial imagery;

Category: Primary

General Description: One or more recent aerial photographs or satellite images that show the site to be inundated.



Wetland Hydrology Indicators

B7 – Inundation on aerial imagery

Cautions and User Notes:

- Surface water may be present on non-wetland sites immediately after a heavy rain or during periods of unusually high precipitation, runoff, or river stages.
- Use Chapter 5 to evaluate normality of precipitation prior to photo.
- Surface water observed during non-growing season may be an acceptable indicator if BPJ suggests that wet conditions normally extend into the growing season for sufficient duration in most years.
- Evaluate multiple years of photos whenever possible.

Wetland Hydrology Indicators

B8 – Sparsely vegetated concave surface;

Category: Primary.

General Description: On concave land surfaces, the ground surface is either unvegetated or sparsely vegetated due to long-duration ponding during the growing season.

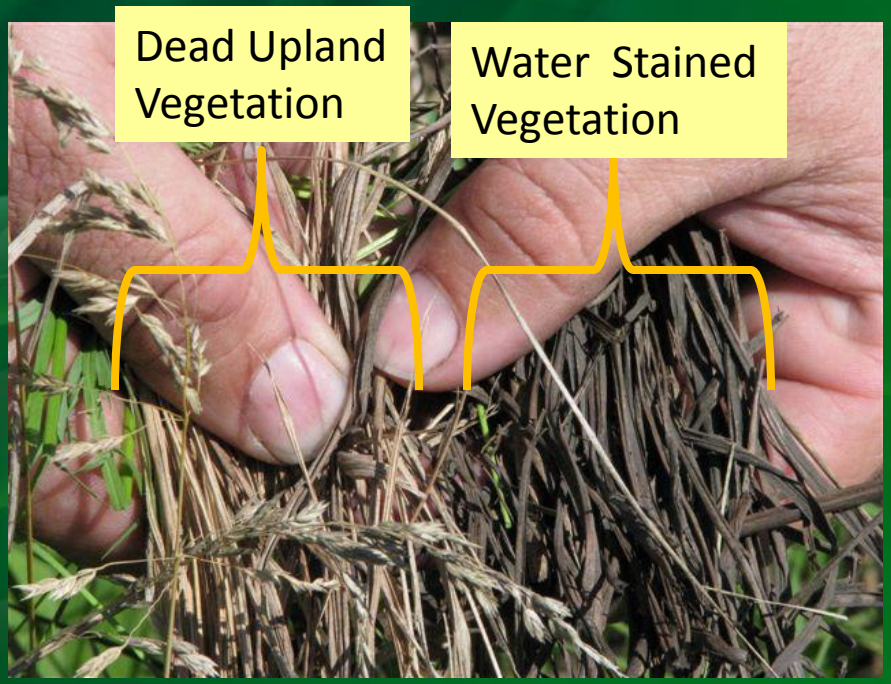
Sparsely vegetated concave surfaces should contrast with vegetated slopes and convex surfaces in the same area.

Wetland Hydrology Indicators

B9 – Water-stained leaves

Category: Primary

General Description: Water-stained leaves are fallen or recumbent dead leaves that have turned grayish or blackish in color due to inundation for long periods.



Wetland Hydrology Indicators

Indicator B10: Drainage patterns

Category: Secondary

This indicator consists of flow patterns visible on the soil surface or eroded into the soil, low vegetation bent over in the direction of flow, absence of leaf litter or small woody debris due to flowing water, and similar evidence that water flowed across the ground surface.

Usually seen in areas where water flows broadly over the surface such as in areas adjacent to streams in seeps, and swales that convey surface water.

Wetland Hydrology Indicators

B13 – Aquatic fauna;

Category: Primary.

- Presence of live individuals, diapausing insect eggs or crustacean cysts, or dead remains of aquatic fauna,
- Either on the soil surface or clinging to plants or other emergent objects.
- Sparsely vegetated concave surfaces should contrast with vegetated slopes and convex surfaces in the same area.

Wetland Hydrology Indicators

B14 – True aquatic plants;

Category: Primary.

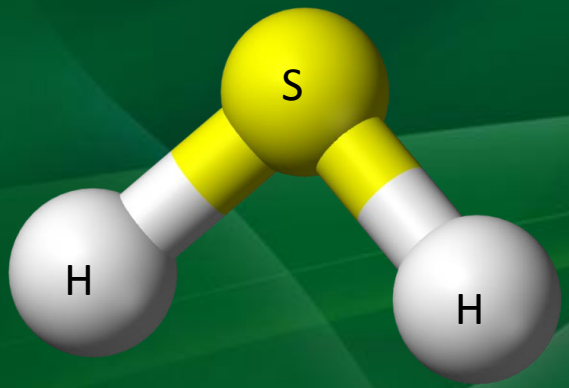
- This indicator consists of the presence of live individuals or dead remains of true aquatic plants.
- Require water for support, or desiccate in the absence of standing water

Wetland Hydrology Indicators

C1 – Hydrogen sulfide odor;

Category: Primary.

General Description: A hydrogen sulfide (rotten egg) odor within 12 in. of the soil surface.



Wetland Hydrology Indicators

C2 – Dry season water table;

Category: Secondary.

General Description: Visual observation of the water table between 12 and 24 in. (30 and 60 cm) below the surface during the normal dry season or during a drier-than-normal year.

•**Notes:** Allow sufficient time for water to drain into a newly dug hole and to stabilize at the water table level.

•Sampling techniques must not penetrate restrictive layers that may be present.

•We need the water table, not the zone of saturation.

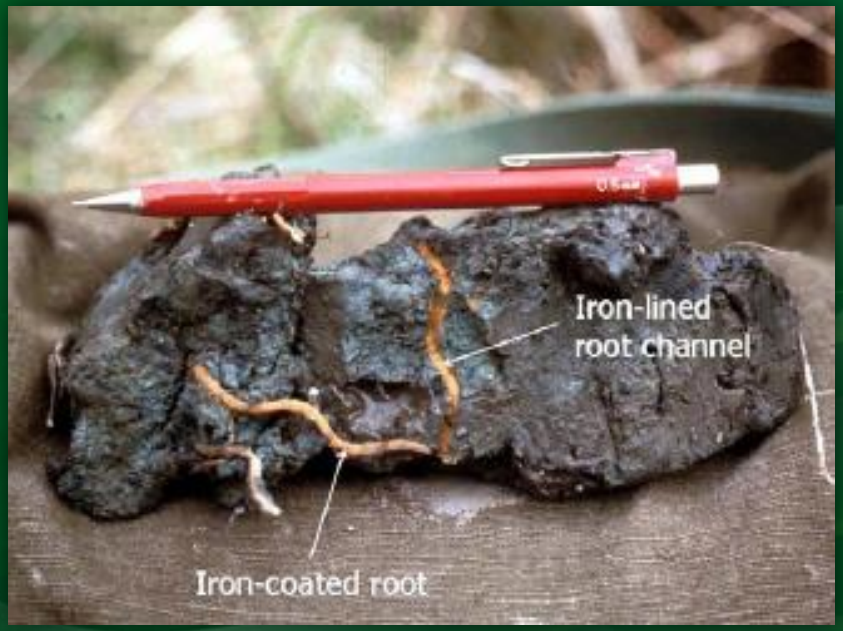
•This indicator is not for use in areas that have controlled drainage for subsurface irrigation. This isn't real common in MN, but with the Increased emphasis on controlled drainage it will be more prevalent.

Wetland Hydrology Indicators

C3 – Oxidized rhizospheres along living roots;

Category: Primary.

General Description: Presence of a layer containing iron-oxide coatings or plaques on the surfaces of living roots and/or iron-oxide coatings or linings on soil pores immediately surrounding living roots within 12 inches of the soil surface.



Wetland Hydrology Indicators

C3 – Oxidized rhizospheres along living roots

Cautions and User Notes:

- Oxidized iron must be associated with living roots to indicate contemporary wet conditions and distinguish these features from other pore linings.
- Care must be take to distinguish iron-oxide coatings from organic matter associated with plant roots, use hand lens when necessary.
- Oxidized rhizospheres must occupy at least 2% of the volume of the layer.

Wetland Hydrology Indicators

C4 – Presence of reduced iron;

Category: Primary.

Presence of a layer containing reduced (ferrous) iron in the upper 12 in. of the soil profile, as indicated by a ferrous iron test or by the presence of a soil that changes color upon exposure to the air.

Avoid testing soil that may have come into contact with iron digging tools

Wetland Hydrology Indicators

C6 – Recent iron reduction in tilled soils;

Category: Primary.

Redox concentrations as pore linings or soft masses in the tilled surface layer of soils cultivated within the last two years.

- The presence of redox features that are continuous and unbroken indicates that the soil was saturated and reduced since the last episode of cultivation.
- Use caution with older features that may be broken up but not destroyed by tillage.
- The indicator is most reliable in areas that are cultivated regularly, so that soil aggregates and older redox features are more likely to be broken up.
- There is no minimum thickness requirement for the layer containing redox concentrations, must occur within 12 in.

Wetland Hydrology Indicators

C7 – Thin muck surface;

Category: Primary.

General Description: This indicator consists of a layer of muck 1 in. (2.5 cm) or less thick on the soil surface.

Cautions and User Notes:

- Thin muck surfaces disappear quickly or become incorporated into mineral horizons when wetland hydrology is withdrawn and therefore indicate an active wetland hydrologic regime.
- A muck layer greater than 1 inch thick does not qualify for this indicator.

Sorry, couldn't find a photo.
Use your imagination.
If you have one please send it to me.

Wetland Hydrology Indicators

C8 – Crayfish burrows;

Category: Secondary.

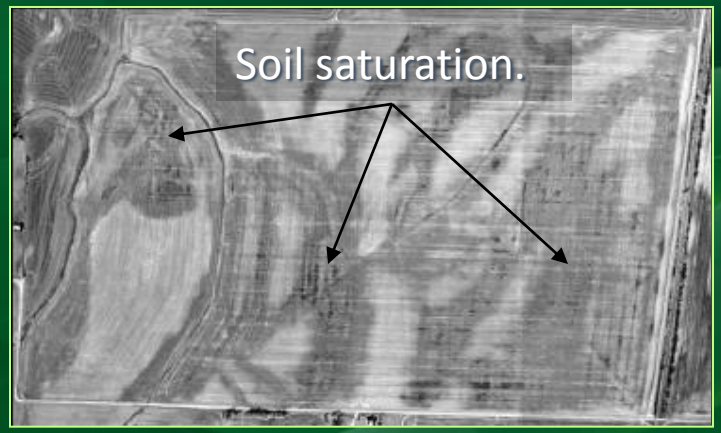
General Description: Presence of crayfish burrows, as indicated by openings in soft ground up to 2 in. (5 cm) in diameter, often surrounded by chimney-like mounds of excavated mud.

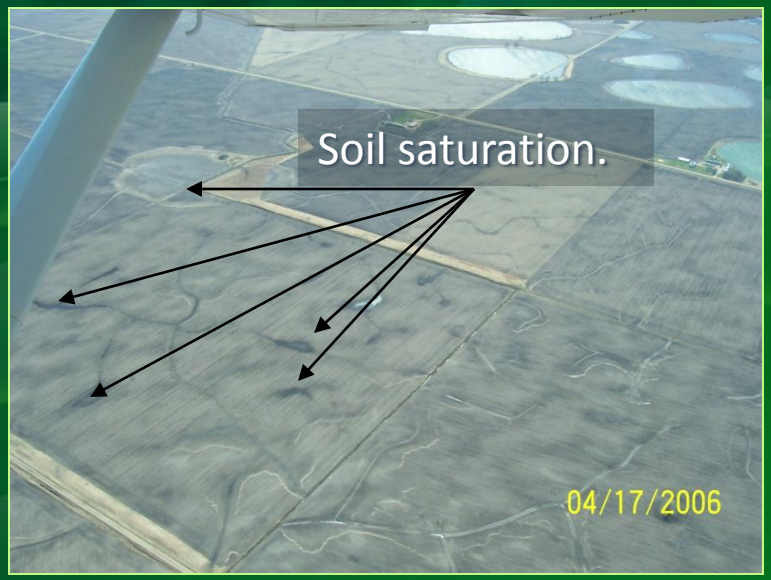
Wetland Hydrology Indicators

C9 – Saturation visible on aerial imagery;

Category: Secondary.

General Description: One or more recent aerial photographs or satellite images indicate soil saturation. Saturated soil signatures must correspond to field-verified hydric soils, depressions or drainage patterns, differential crop management, or other evidence of a seasonal high water table.





Wetland Hydrology Indicators

C9 – Saturation visible on aerial imagery

Cautions and User Notes:

- This indicator requires on-site verification that saturation signatures seen on photos correspond to hydric soils or other evidence of a seasonal high water table.
- Saturation may be present on non-wetland sites immediately after heavy rains or during periods of unusually high precipitation, runoff, or river stages.
- Use the state climatology website (http://climate.umn.edu/wetland/) to evaluate normality of precipitation prior to photo.
- Saturation observed during non-growing season may be an acceptable indicator if BPJ suggests that wet conditions normally extend into the growing season for sufficient duration in most years.
- Evaluate multiple years of photos whenever possible.

Wetland Hydrology Indicators

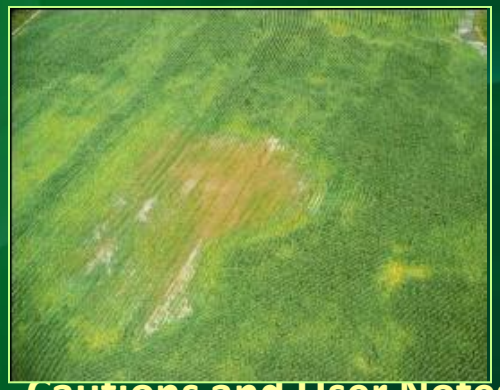
D1 – Stunted or stressed plants;

Category: Secondary.

- **General Description:** In agricultural or planted vegetation located in a depression, swale, or other topographically low area, this indicator is present if individuals of the same species growing in the potential wetland are clearly of smaller stature, less vigorous, or stressed compared with individuals growing in nearby drier landscape situations.

Crop Stress

Wetland Hydrology Indicators



D1 – Stunted or stressed plants

Cautions and User Notes:

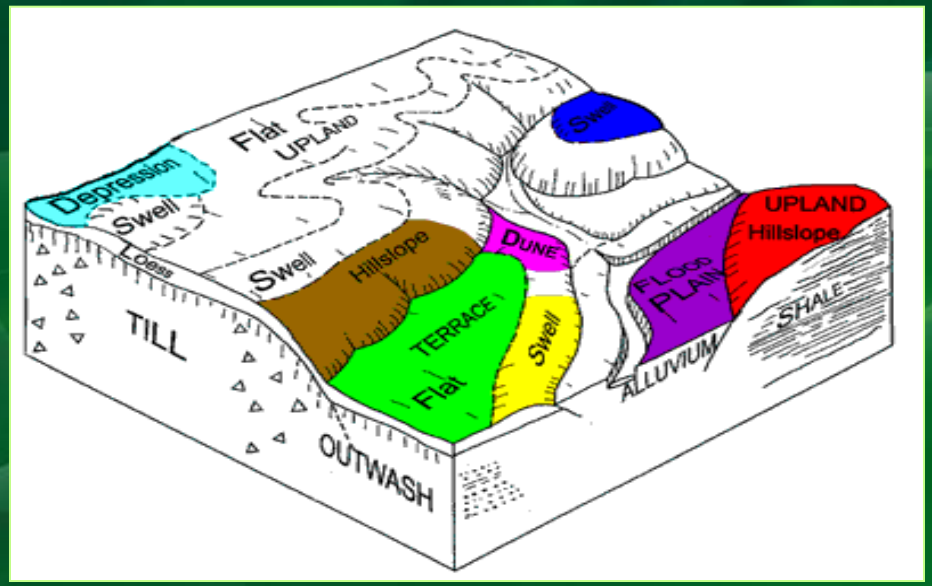
- Use caution in areas where stunting of plants on non-wetland sites may be caused by low soil fertility, excessively drained soils, salinity, cold temperatures, uneven application of agricultural chemicals, or other factors not related to wetness.
- For this indicator to be present, a majority of individuals in the potential wetland area must be stunted or stressed.
- In this region, this indicator is restricted to agricultural or planted vegetation.

Wetland Hydrology Indicators

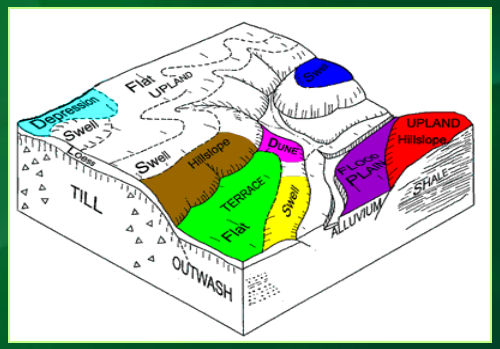
D2 – Geomorphic position; and

Category: Secondary.

General Description: This indicator is present if the area in question is located in a localized depression, linear drainageway, concave position within a floodplain, at the toe of a slope, on the low-elevation fringe of a pond or other water body, or in an area where groundwater discharges.



Wetland Hydrology Indicators



D2 – Geomorphic position

Cautions and User Notes:

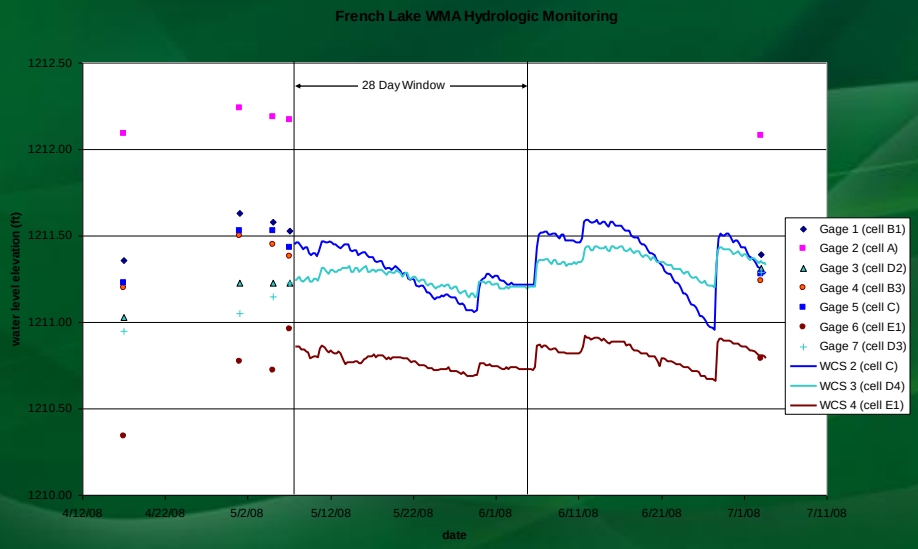
- This indicator does not include concave positions on rapidly permeable soils that do not have wetland hydrology unless the water table is near the surface.
- This indicator is not applicable in areas with functioning drainage systems.

Wetland Hydrology Indicators

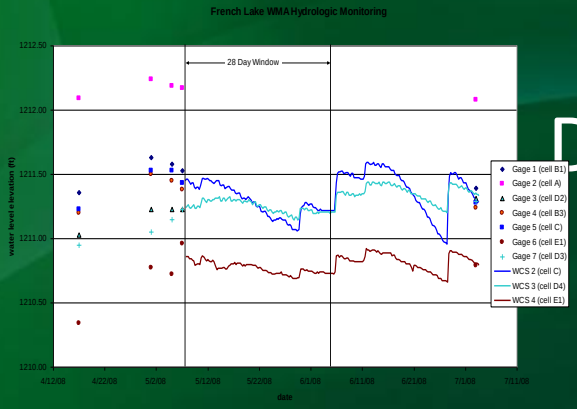
D9 – Gauge or well data.

Category: Primary.

General Description: Stream or lake gauge data, or groundwater well data, indicate that the site is inundated or has a water table 12 in. (30 cm) or less below the surface for 14 or more consecutive days during the growing season in most years (at least 5 years in 10, or 50 percent or higher probability), or meets an alternative wetland hydrology standard established for a particular geographic area or wetland type.



Wetland Hydrology Indicators



D9 – Gauge or well data

Cautions and User Notes:

- This indicator may be used in any area that is subject to flooding, ponding, or shallow water tables, and is not limited to highly disturbed or problematic wetland situations (U. S. Army Corps of Engineers 2005).
- Any combination of inundation or soil saturation is sufficient to meet the 14-day requirement.
- An evaluation of the normality of water levels or precipitation during the monitoring period is required if fewer than 10 years of recent gauge or well data are available.
- Alternative standards for specific geographic areas or wetland types are also acceptable, if supported by appropriate scientific literature, field studies, or professional opinion and approved by the appropriate Corps District.

Chapter 5: Difficult Wetland Situations in the Midwest

Lack of hydrology indicator does not confirm lack of wetland hydrology; many Midwest wetlands lack indicators during dry periods.

Understanding normal seasonal and annual variations in rainfall, temperature, and other climatic conditions is essential in interpreting hydrology indicators.

Wetlands Lacking Hydrology Indicators

- Much of the Midwest region is characterized by long summer dry seasons where surface water recedes from wetland margins, water tables drop, and many wetlands dry out completely.
- Long-term patterns or multi-year droughts may result in wetlands not being inundated or saturated in a given year, or for several years in a row.

Wetlands Lacking Hydrology Indicators

- When evaluating wetland hydrology, delineators must consider timing of the site visit and antecedent moisture conditions.
- Special care must be taken on sites where hydrophytic vegetation and hydric soils are present but hydrology indicators appear to be absent.

Wetlands Lacking Hydrology Indicators

- Procedure

  Step 1 – Verify indicators of hydrophytic vegetation and hydric soil are present;

  Step 2 – Verify site is in a geomorphic position where wetlands are likely to occur; then

  Step 3 – Use one or more following approaches to determine if wetland hydrology is present.

Wetlands Lacking Hydrology Indicators

Step 3a – Site visits during the dry season:

For site visits during normal "dry season" on a site with hydric soils and hydrophytic vegetation and no evidence of hydrologic manipulation (e.g., no drainage ditches, dams, levees, water diversions, etc.), consider hydrology criterion to be met and the site a wetland.

Dry season –when evapotranspiration exceeds precipitation, resulting in drawdown of soil moisture storage and/or a moisture deficit.

Wetlands Lacking Hydrology Indicators

Step 3b – Periods with below normal rainfall:

Determine if rainfall in preceding 2-3 months was normal, above, or below normal (use WETS tables or Wetland Delineation Precipitation Data Retrieval from a Gridded Database). If precipitation was below normal, hydric soils and hydrophytic vegetation are present, and there is no evidence of hydrologic manipulation; then consider hydrology criterion to be met.

Agricultural Lands

- Should be considered Atypical
  - Typically lack a natural plant community
  - Soils are often altered due to tillage
  - Drainage Activities often remove hydrology, either partially or completely

There are a number of tools to help determine if wetlands are present, we'll focus on hydrology for now

Tools for assessing Hydrology on Ag Areas

- Look for the indicators before, discount ones that would have been present before alteration
- Mapping Conventions

- Lateral Effect Estimates and drainage guides produced by NRCS (training available through WDCP at http://www.mnwetlands.umn.edu/)
- Hydrologic models
- Monitoring