A Presentation of the 2013 Drainage Research Forum

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

IOWA STATE UNIVERSITY
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Subirrigation Research in North Dakota

NDSU NORTH DAKOTA STATE UNIVERSITY

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Department of Agricultural and Biosystems Engineering

IA-MN-SD Drainage Forum, Sioux Falls, SD
November 14, 2013

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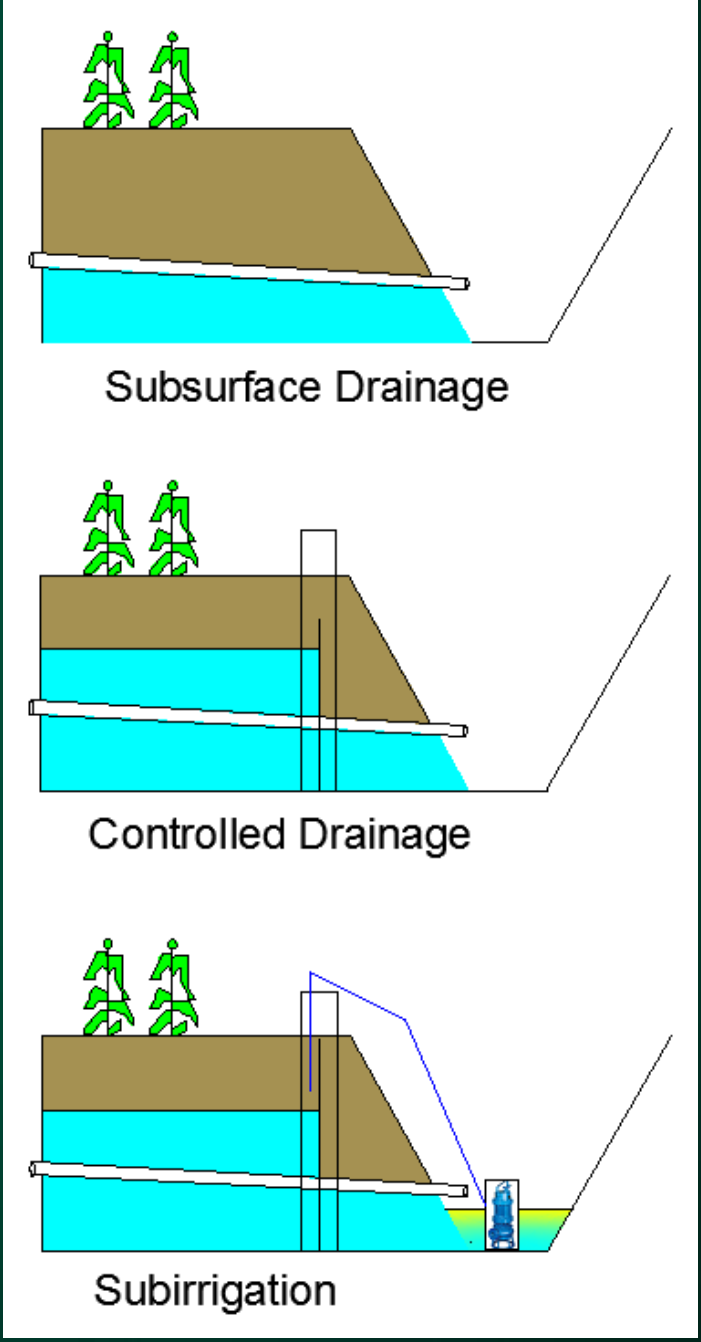
Subsurface drainage (SD) uses subsurface conduits to remove water from a depth below soil surface.

Controlled drainage (CD) uses weirs or structures to manage the water level in the field so that it is drained only when it is necessary.

Subirrigation (SI) is application of irrigation water below the ground surface by raising the water table to within or near the root zone.

(ASABE, 2005)



Problems?

Land owner:

- Will controlled drainage and subirrigation increase crop yield?
- When do I turn on and off the drainage?
- How much water should I apply for SI?
- Why should I care about saving water?

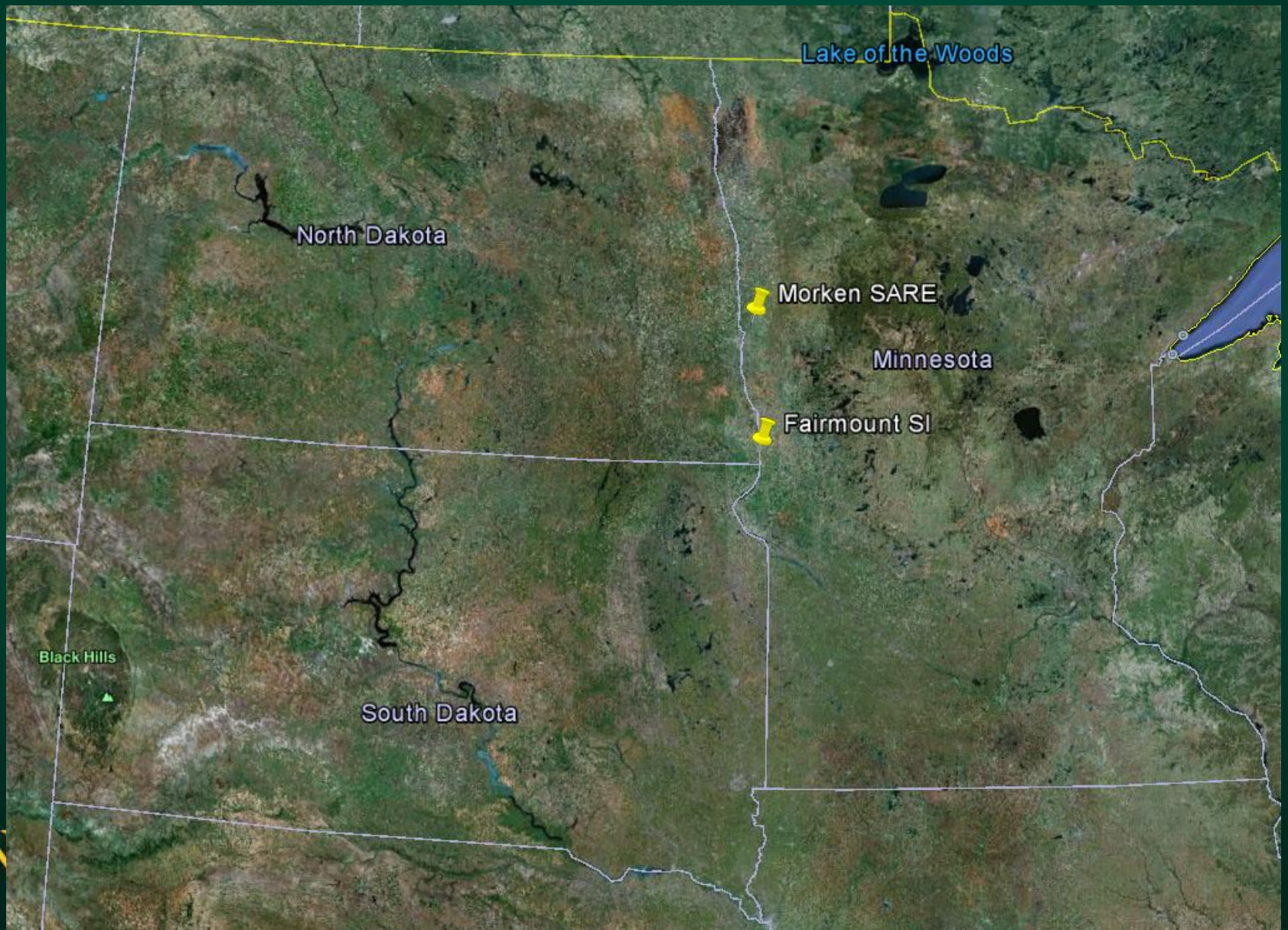
State agencies:

- What about the hydrological and environmental impact if applying the controlled drainage and subirrigation practices?

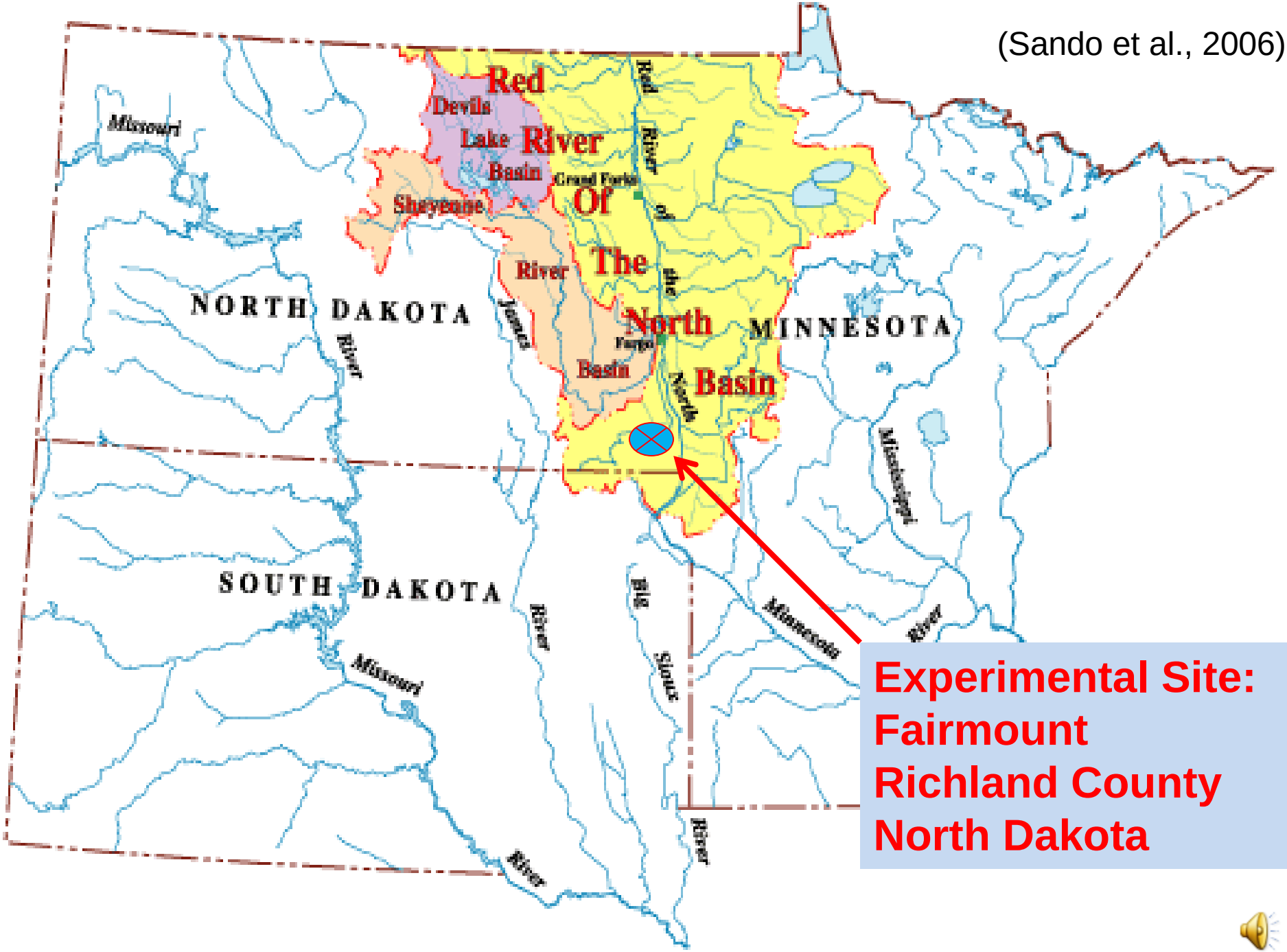
Research engineers/scientists:

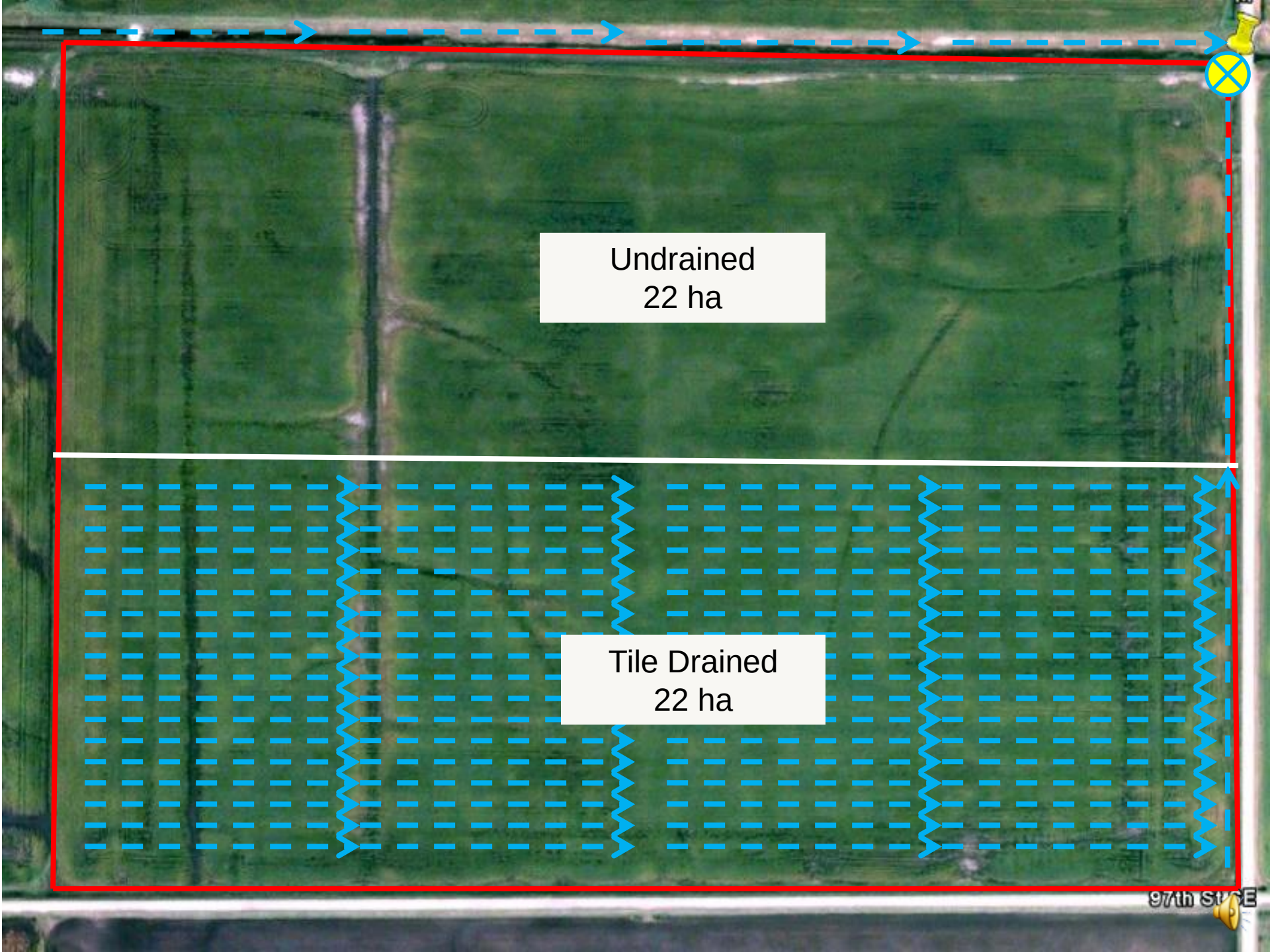
- Where does the water/nutrients/salts go?
- What would be the water and nutrient balance with this new technology?
- Who will use it?

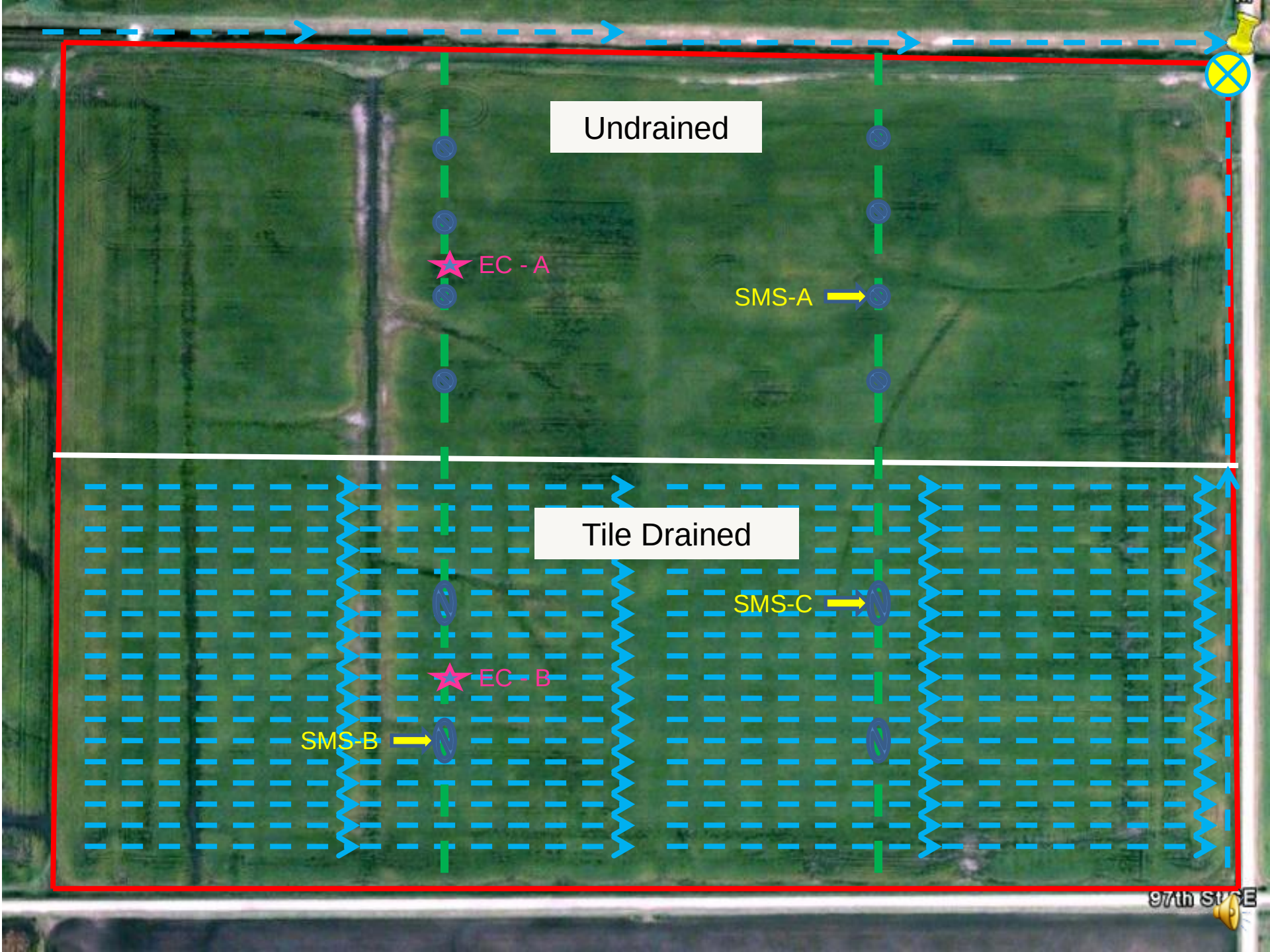
Subirrigation Experiments



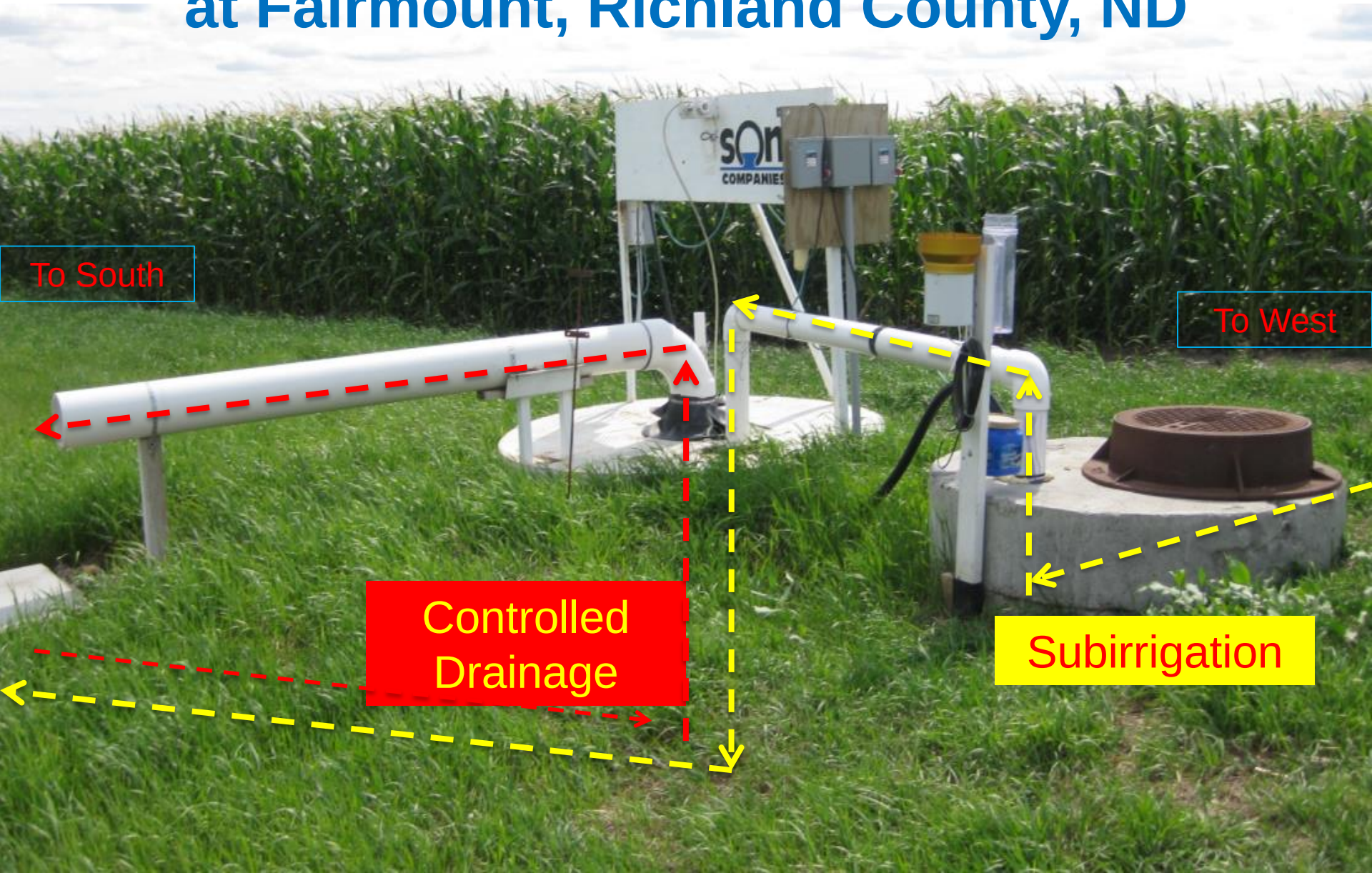
(Sando et al., 2006)



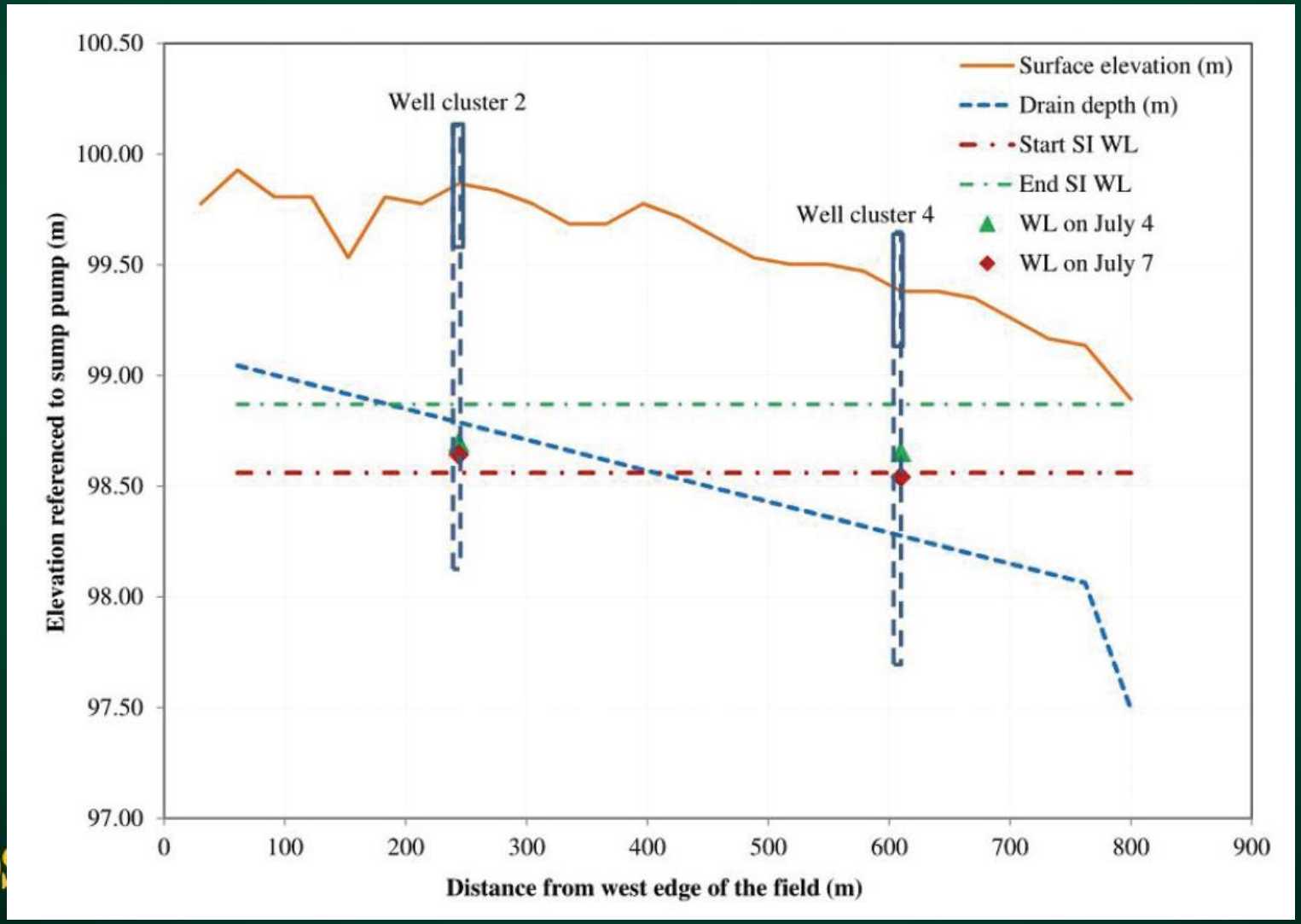

Undrained
22 ha
Tile Drained
22 ha
97th St E


Undrained
EC - A
SMS-A
Tile Drained
SMS-C
EC - B
SMS-B
97th St E

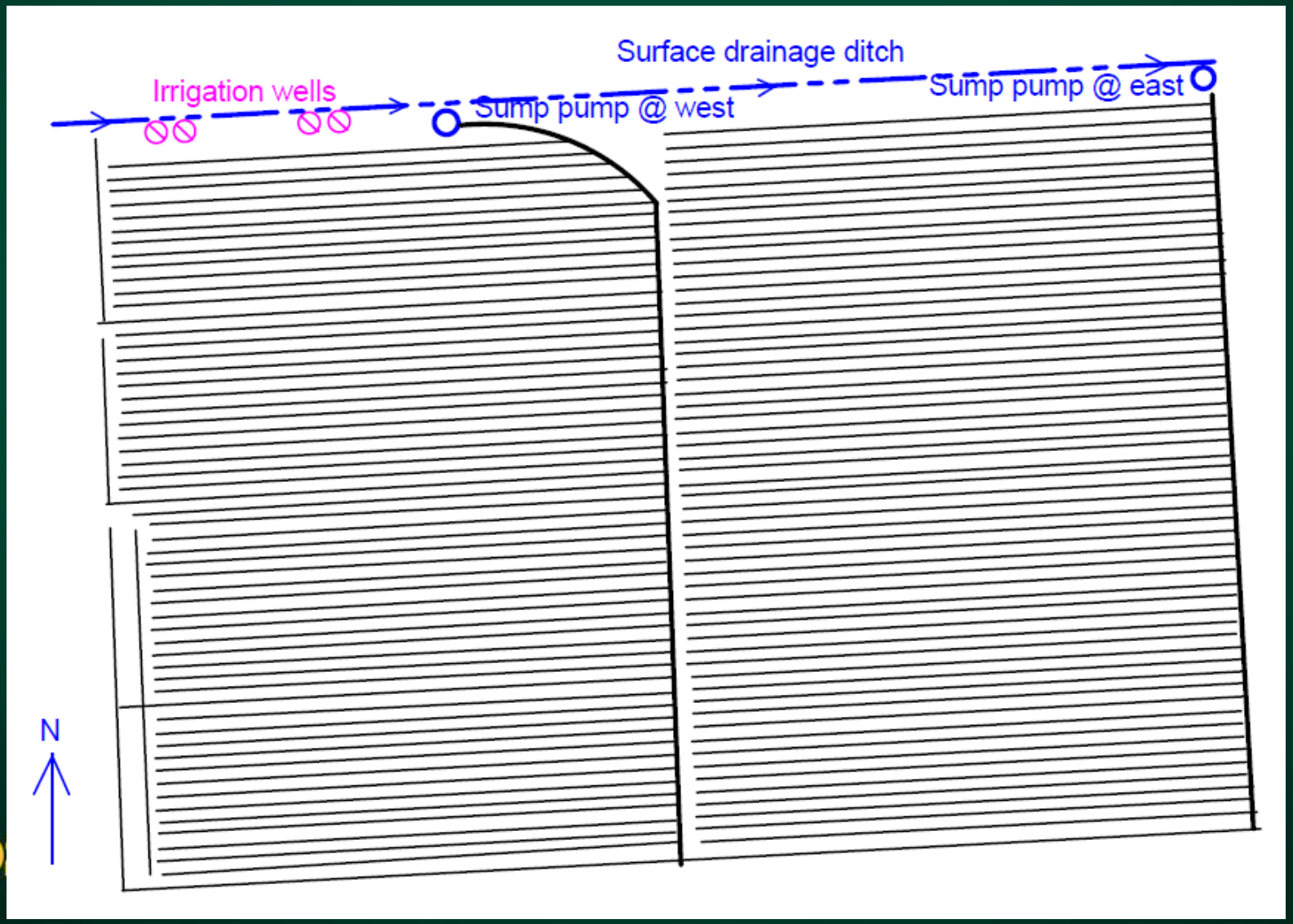
Controlled Drainage and Subirrigation at Fairmount, Richland County, ND



Field profile layout from the west to the east sides of the field during a subirrigation (SI) process on July 4-7, 2010 (from Jia et al., 2012).



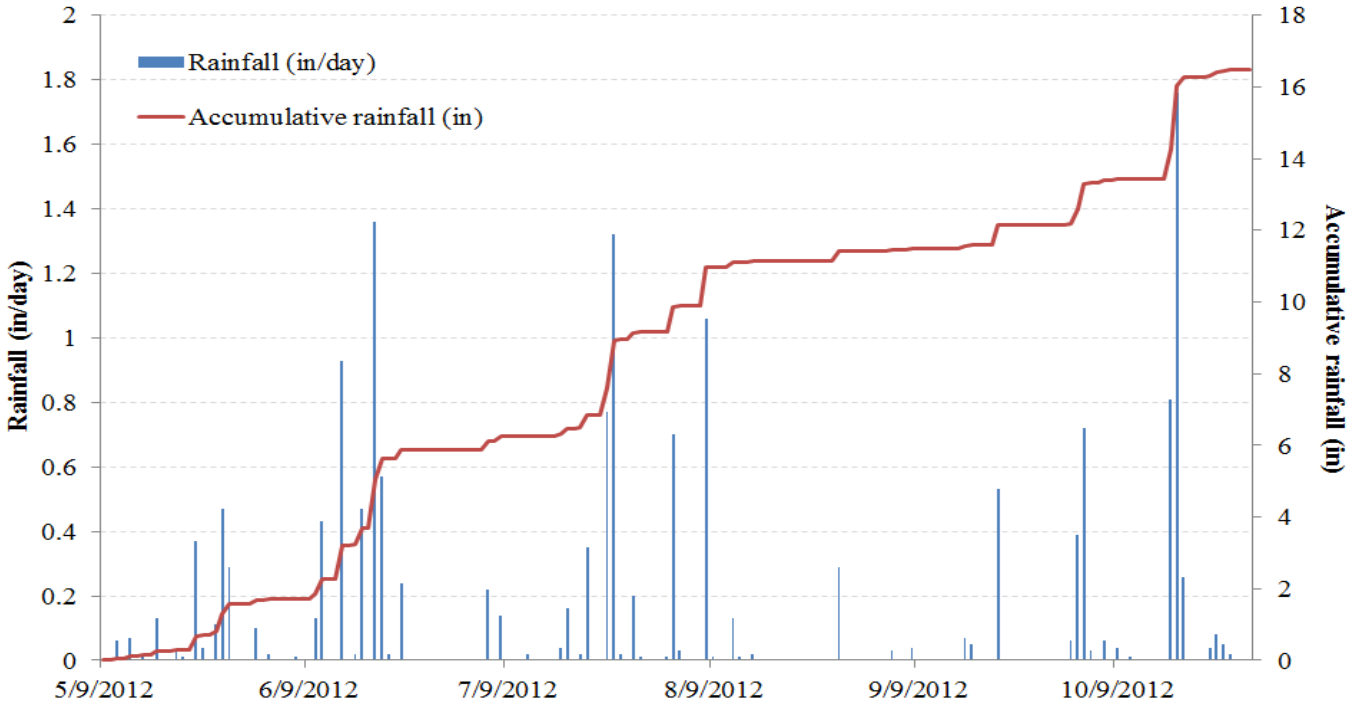
Tile drainage system layout: 30 ft spacing, 3.2-4 ft depth, and 1% grade. Subirrigate with groundwater from the down stream using the same mains.



East sump

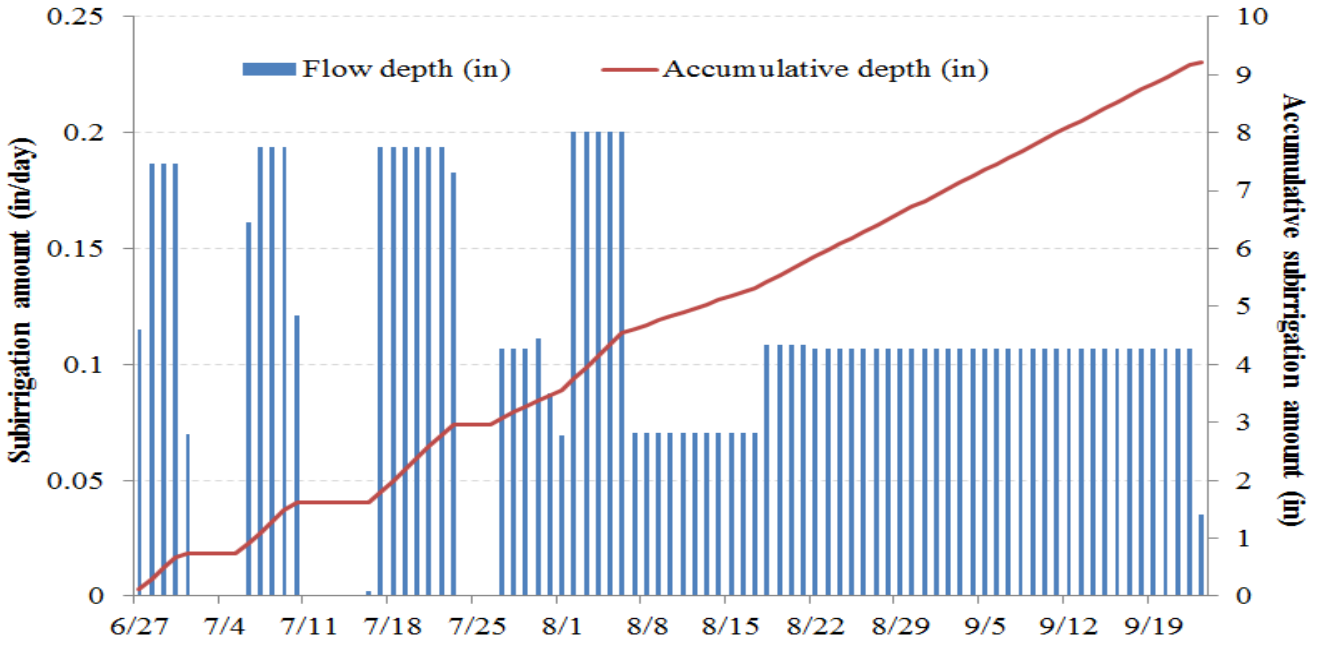
Rainfall :

16.5 in



Subirrigation:

9.2 in



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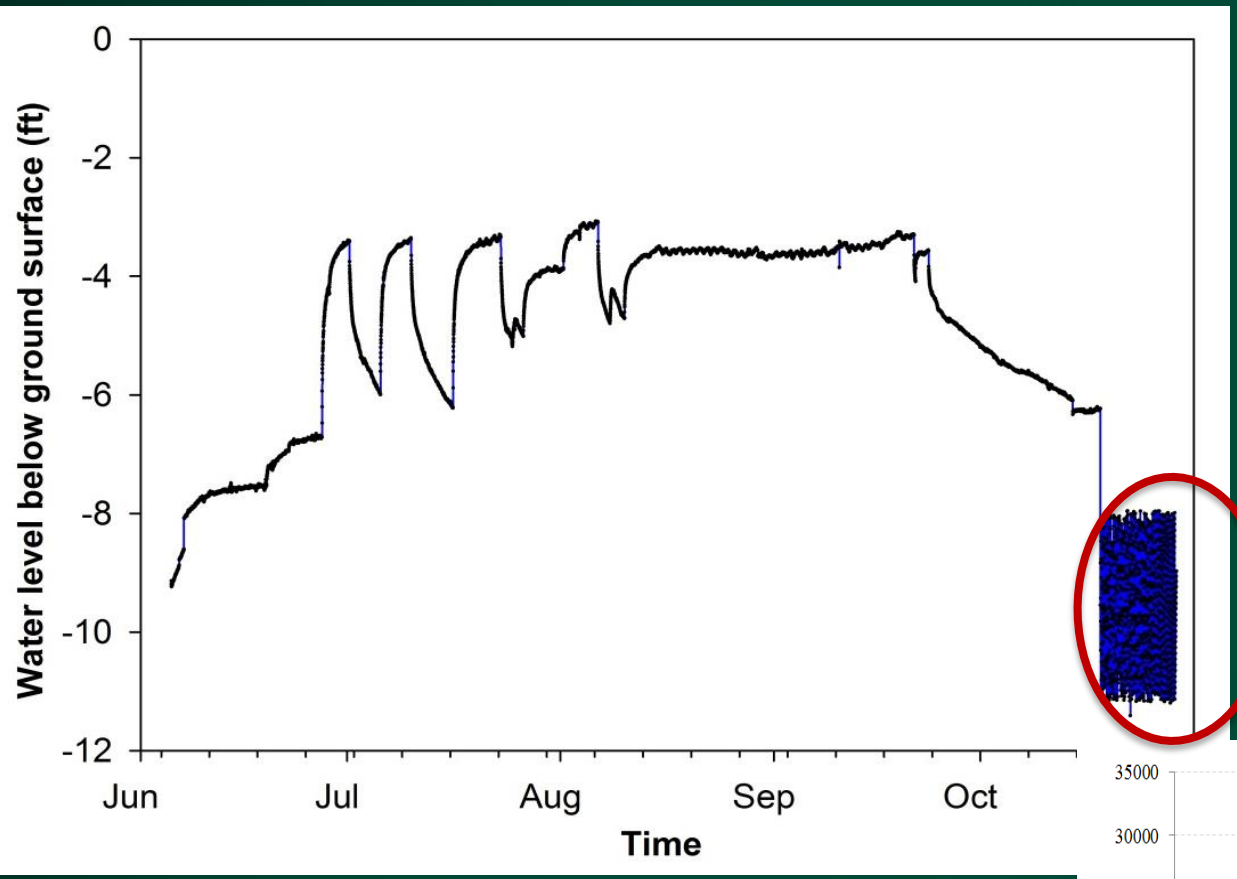
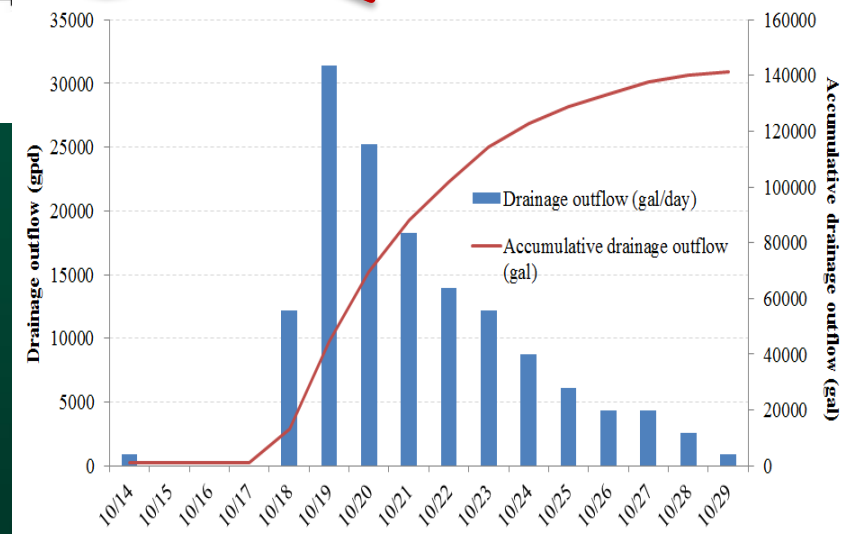
Water level and drainage outflow at the east sump pump in 2012





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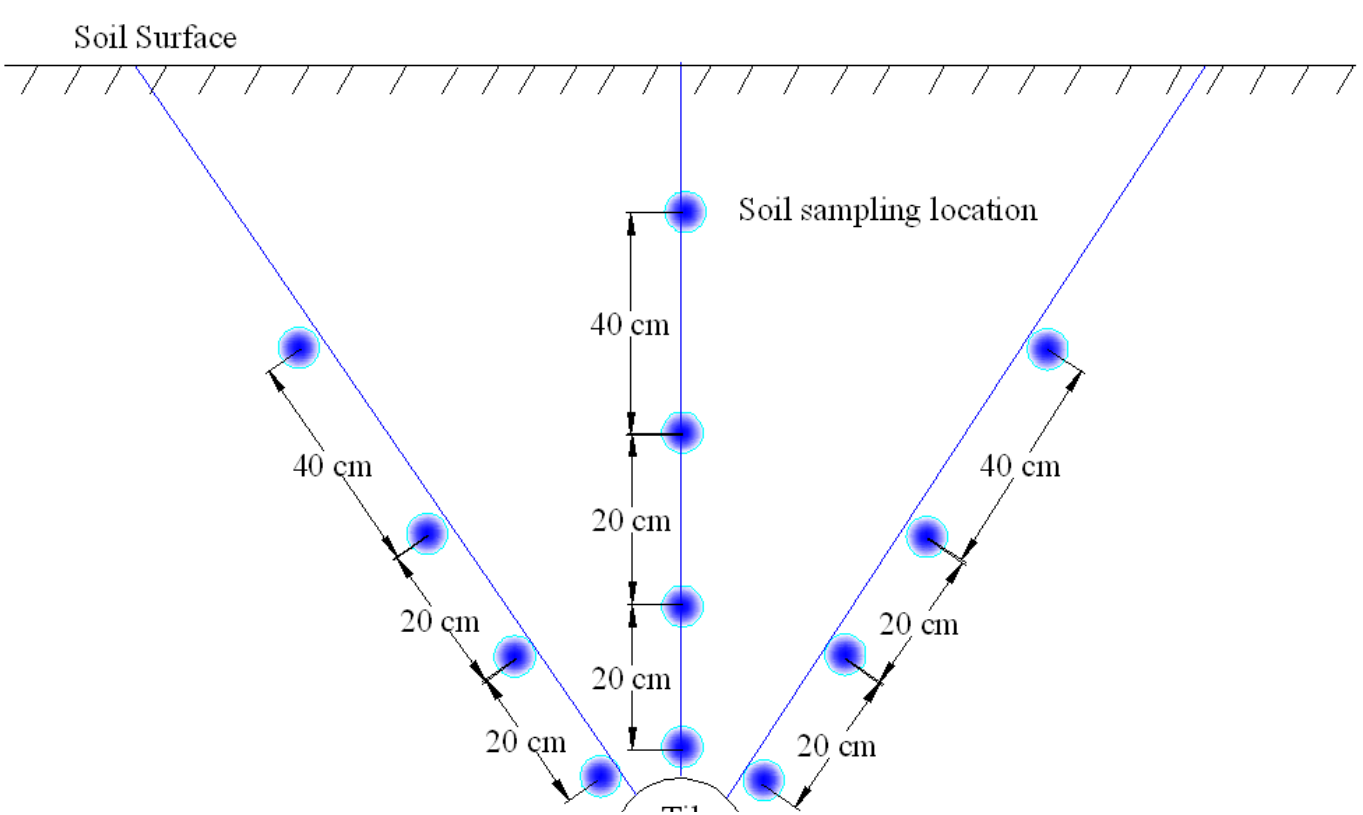
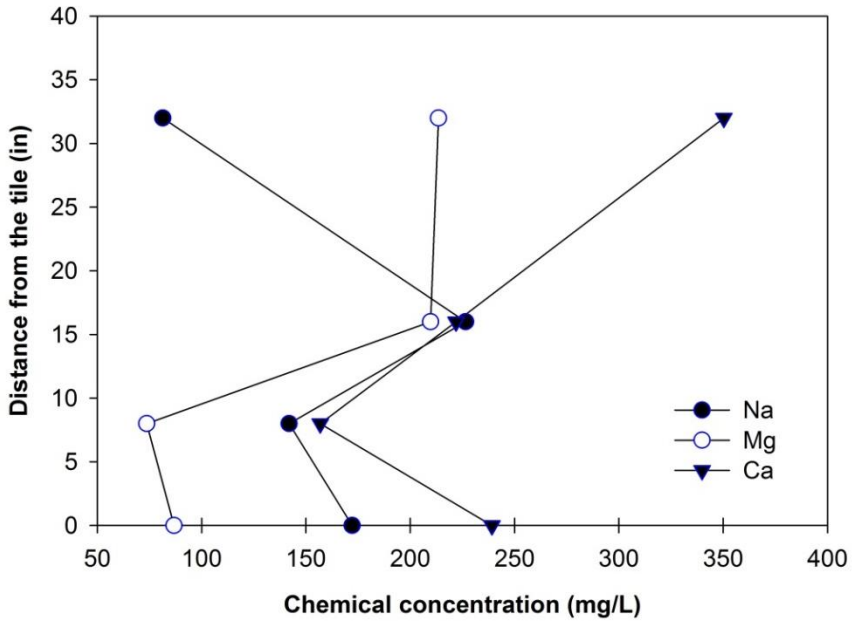
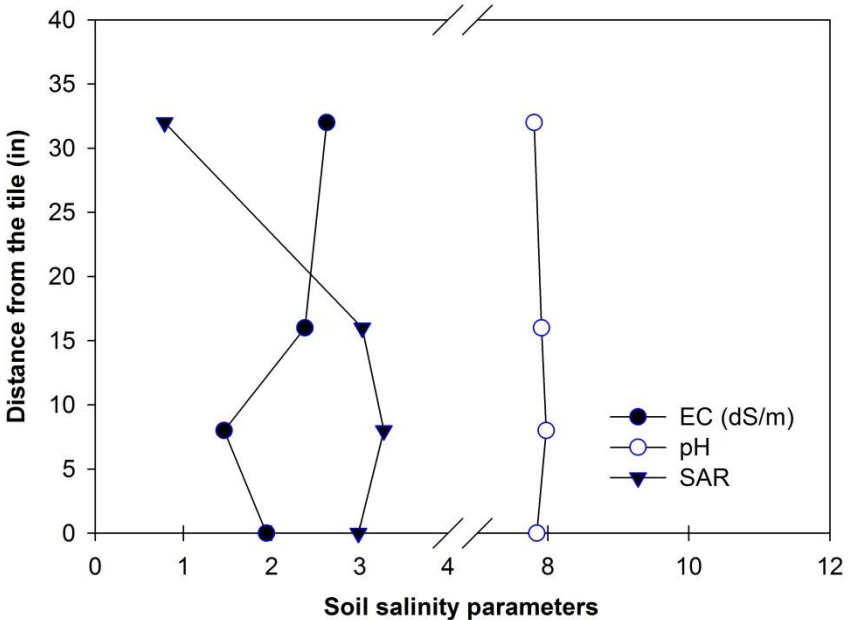
Crop Yield for undrained (UD), controlled drained (CD), and subirrigated (SI) at Fairmount, Richland County, ND

Year	UD (bu/ac)	CD (bu/ac)	% Dif	CD+SI (bu/ac)	% Dif
2008 (corn)	162	167	3.2	173	6.6
2009 (corn)	130	128	-1.5	141	8.1
2010 (soybean)	44	48	6.6	48	8.4
2012 (sugarbeets)	27.8			34.8 (tons/ac)	25
2013 (Corn)	140			198	41

Soil sodicity effect



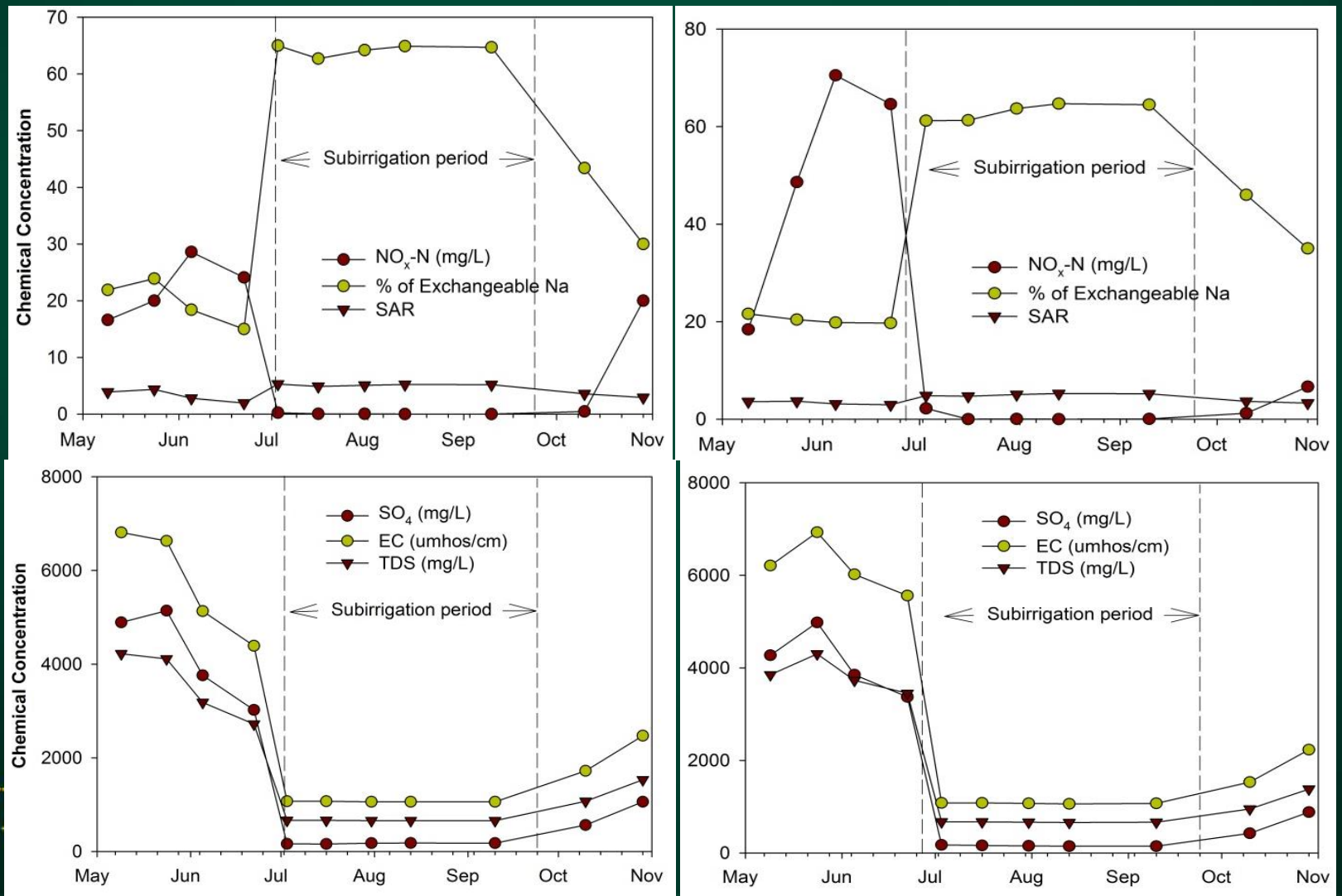




Water quality at east sump pump structure

West sump

East sump



Effect of optimal water management for sustainable and profitable crop production and improvement of water quality in Red River Valley

Xinhua Jia, Thomas Scherer, Dean Steele, and Thomas DeSutter

- Optimize water management via a controlled drainage (CD) and subirrigation (SI) system;
- Monitor water quality changes;
- Estimate water balance; and
- Develop CD and SI scheduling using crop, soil and climate information.

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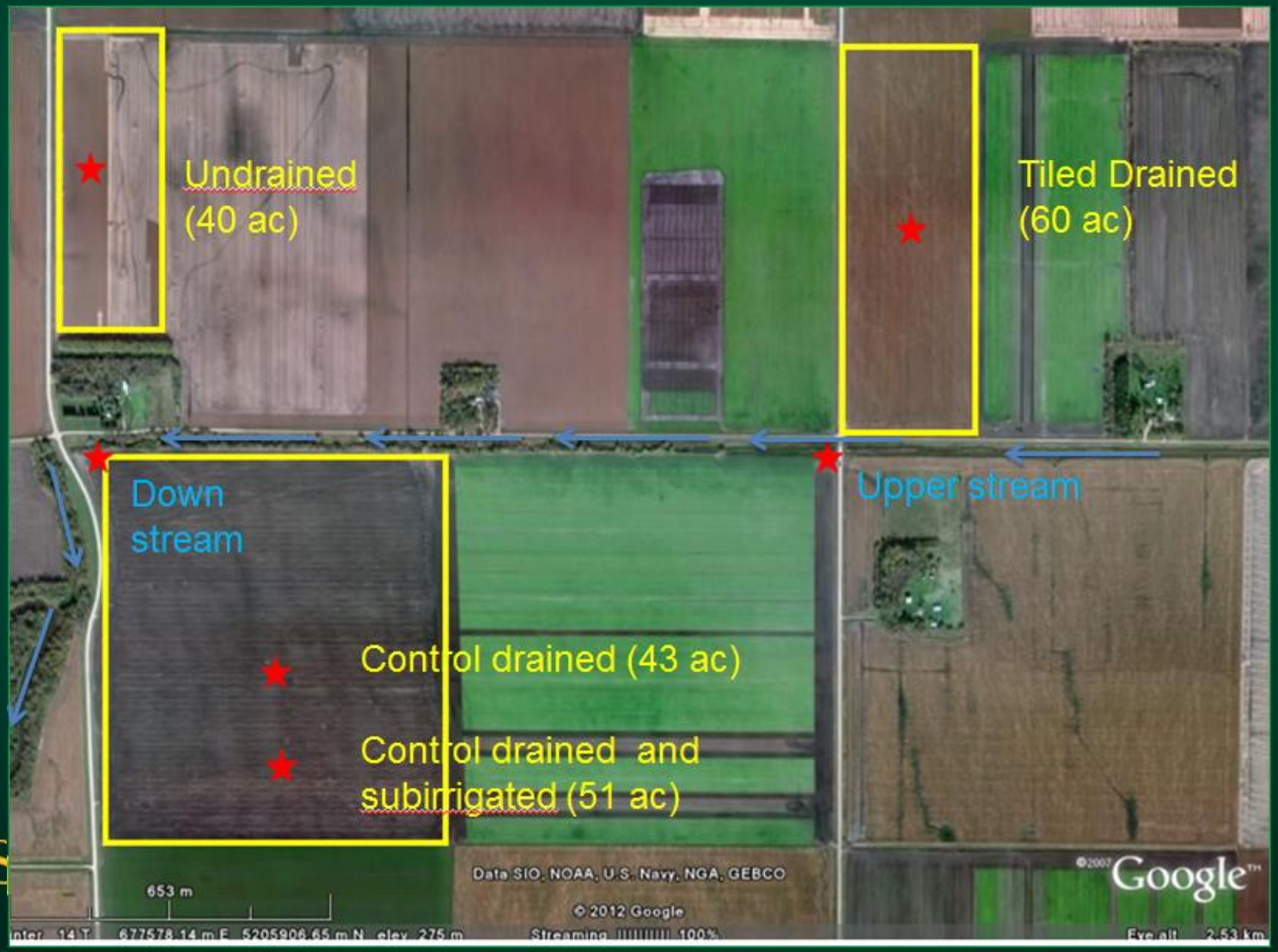
Experimental fields



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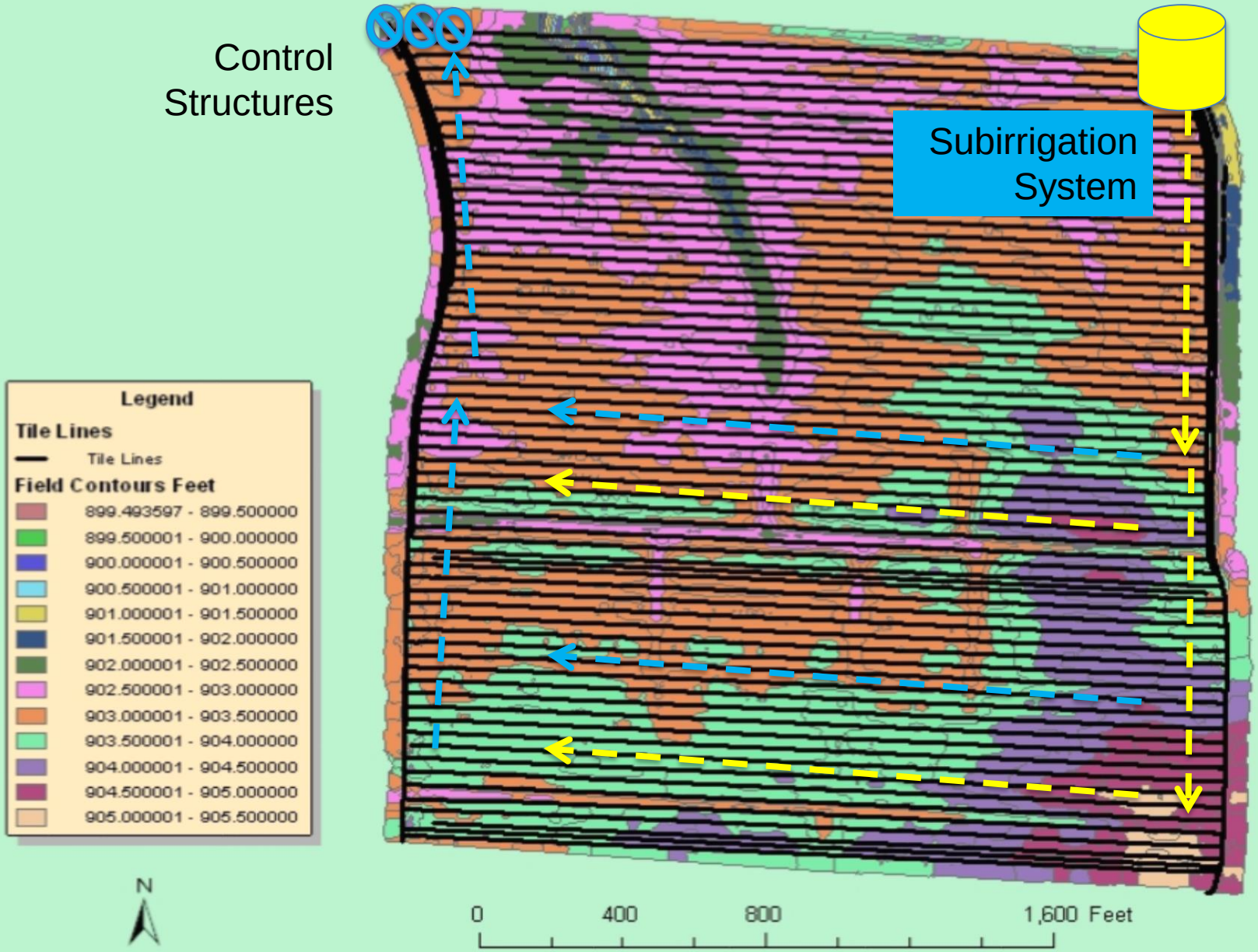
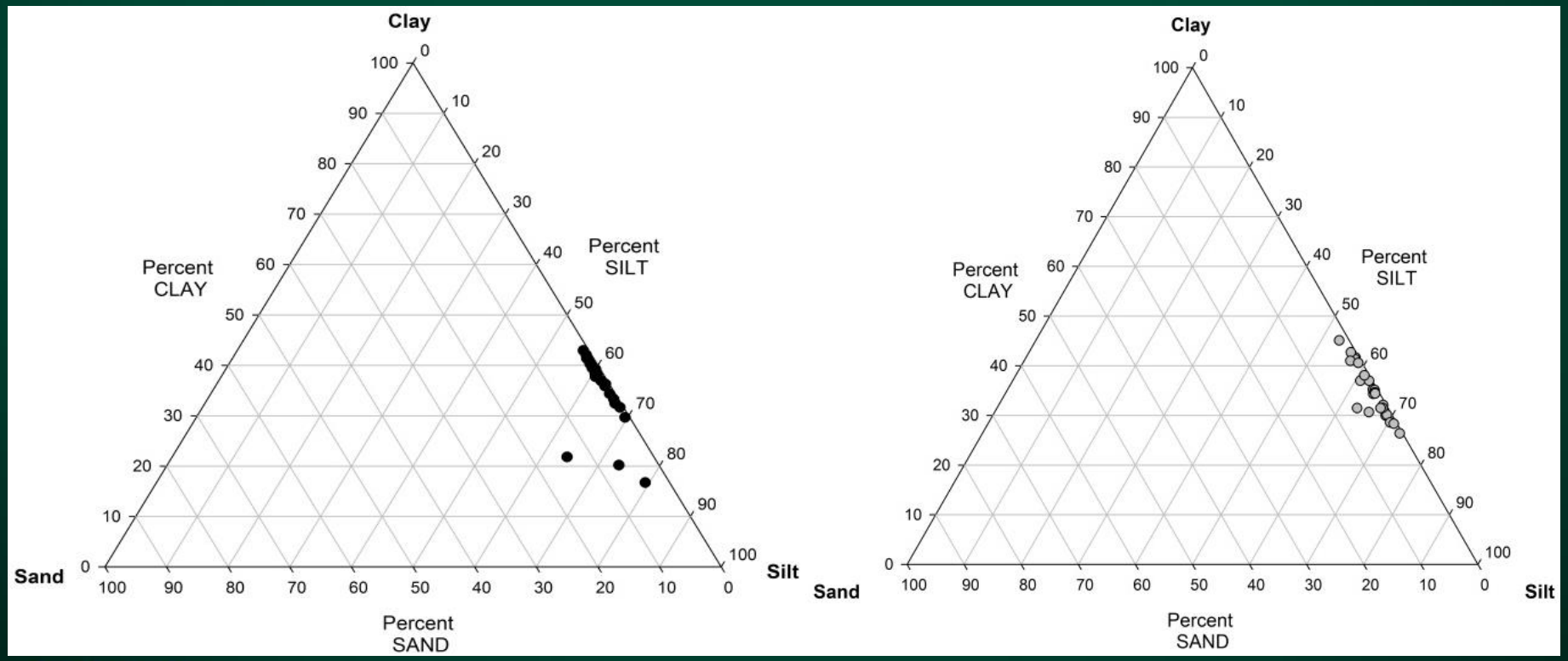
Zimmerman Tile & Contour Lines - Feet



Particle size distribution for top 1 m (left) and bottom 1 m (right) soils from four experimental plots.



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Controlled Drainage Structures

Subirrigation system

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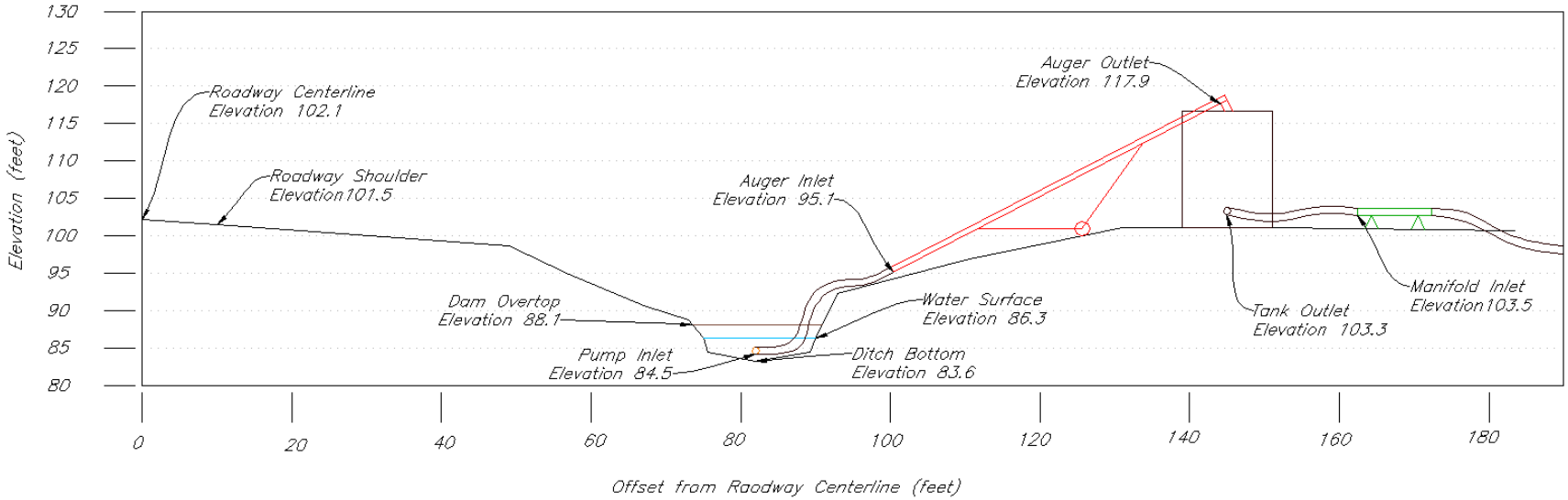

Elevation (feet)
130
125
120
115
110
105
100
95
90
85
80
Roadway Centerline
Elevation 102.1
Roadway Shoulder
Elevation 101.5
Auger Outlet
Elevation 117.9
Auger Inlet
Elevation 95.1
Dam Overtop
Elevation 88.1
Water Surface
Elevation 86.3
Pump Inlet
Elevation 84.5
Ditch Bottom
Elevation 83.6
Tank Outlet
Elevation 103.3
Manifold Inlet
Elevation 103.5
0
20
40
60
80
100
120
140
160
180
Offset from Roadway Centerline (feet)

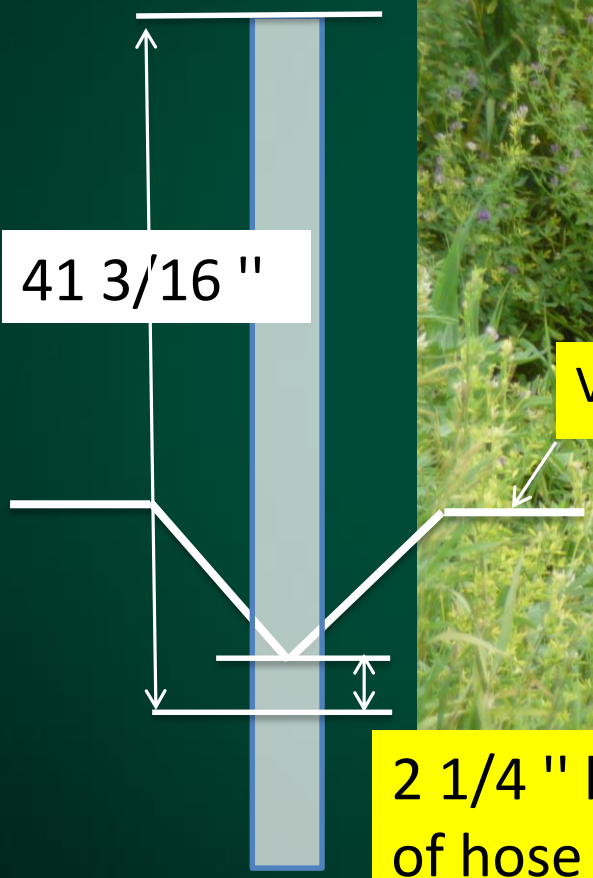
Evapotranspiration Measurement

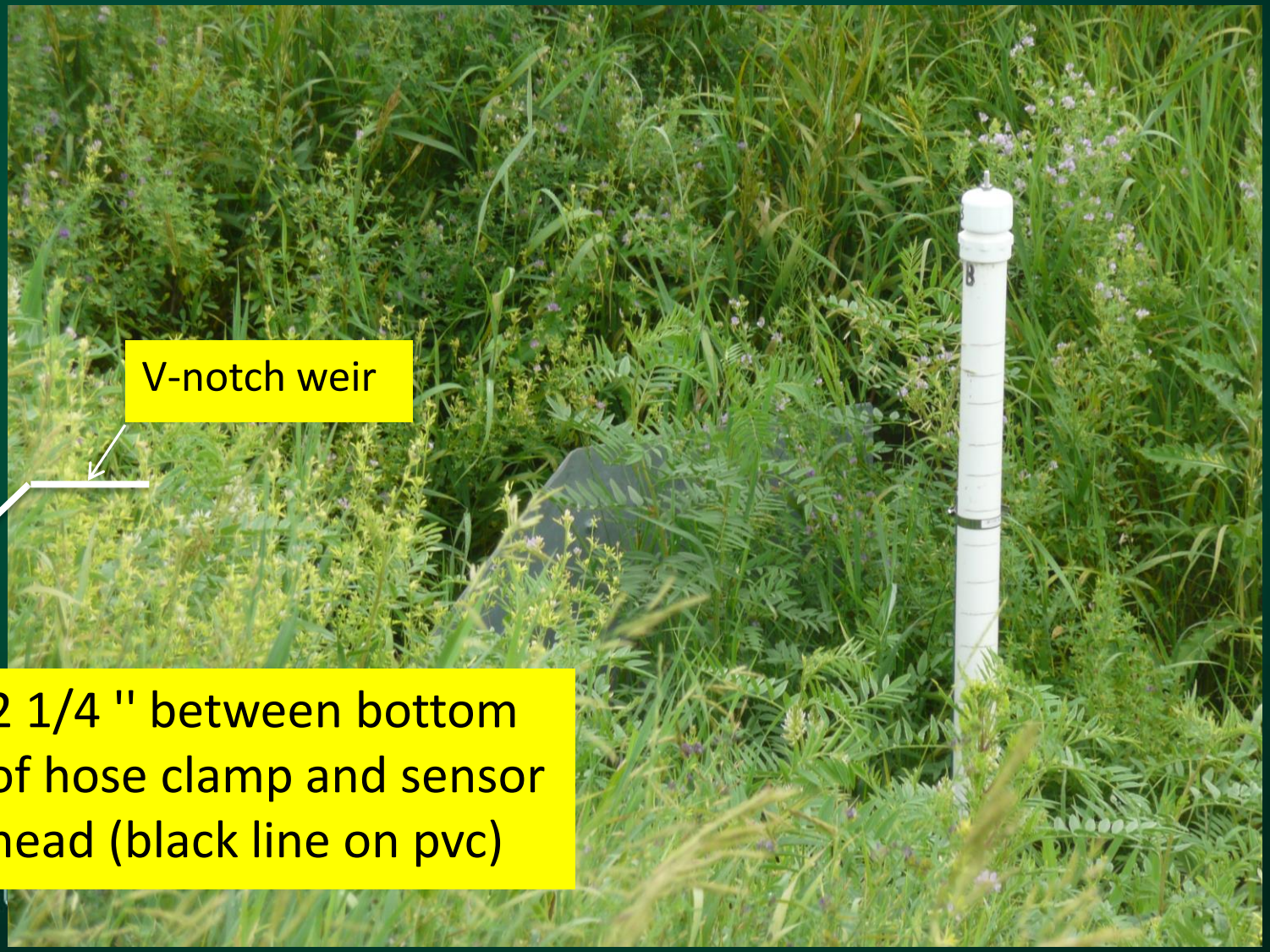
Drainage Outflow Measurement using Ultrasonic Flow Meter

Bury the well during planting

Raise the well after planting

Surface Runoff Measurement





2 1/4 " between bottom of hose clamp and sensor head (black line on pvc)

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Water quality monitoring in ditch 39

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Preliminary Results –
Water Quality Analysis on May 21, 2013

	Up Stream	Down Stream	CD #1	CD #2	CD #3	Undrained	Free Drainage
EC (umhos/cm)	731	759	752	607	800	379	735
NO_3 (mg/L)	1.27	1.15	0.69	6.68	6.09	0.69	4.53
PO_4 (mg/L)	0.02	0.01	0.02	0.05	0	0.91	0.05
pH	8.2	8.1	7.9	7.9	7.7	7.6	7.8
NH_4 (mg/L)	0.02	0.02	0.03	0.25	0.02	0.03	0.02

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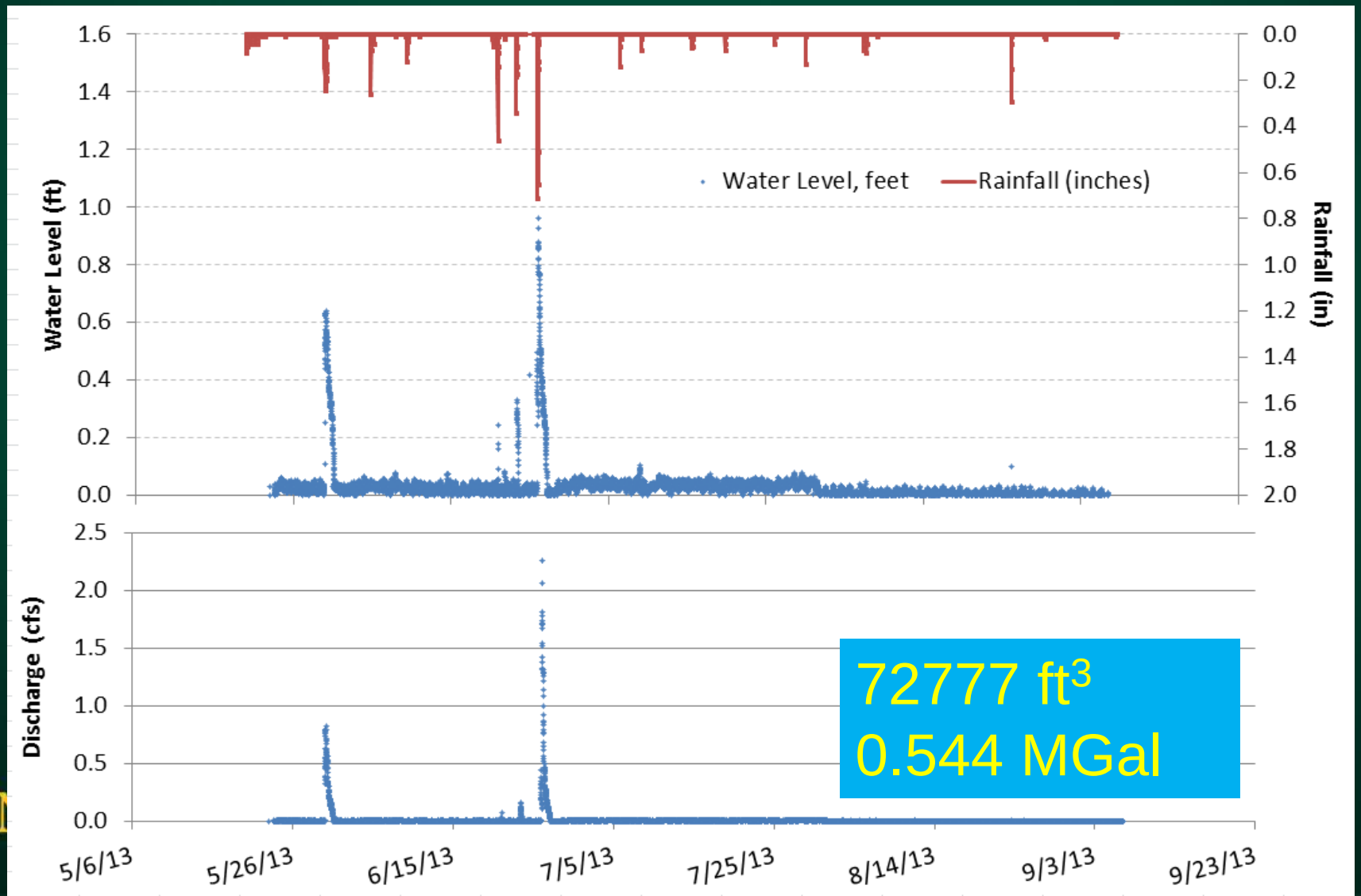
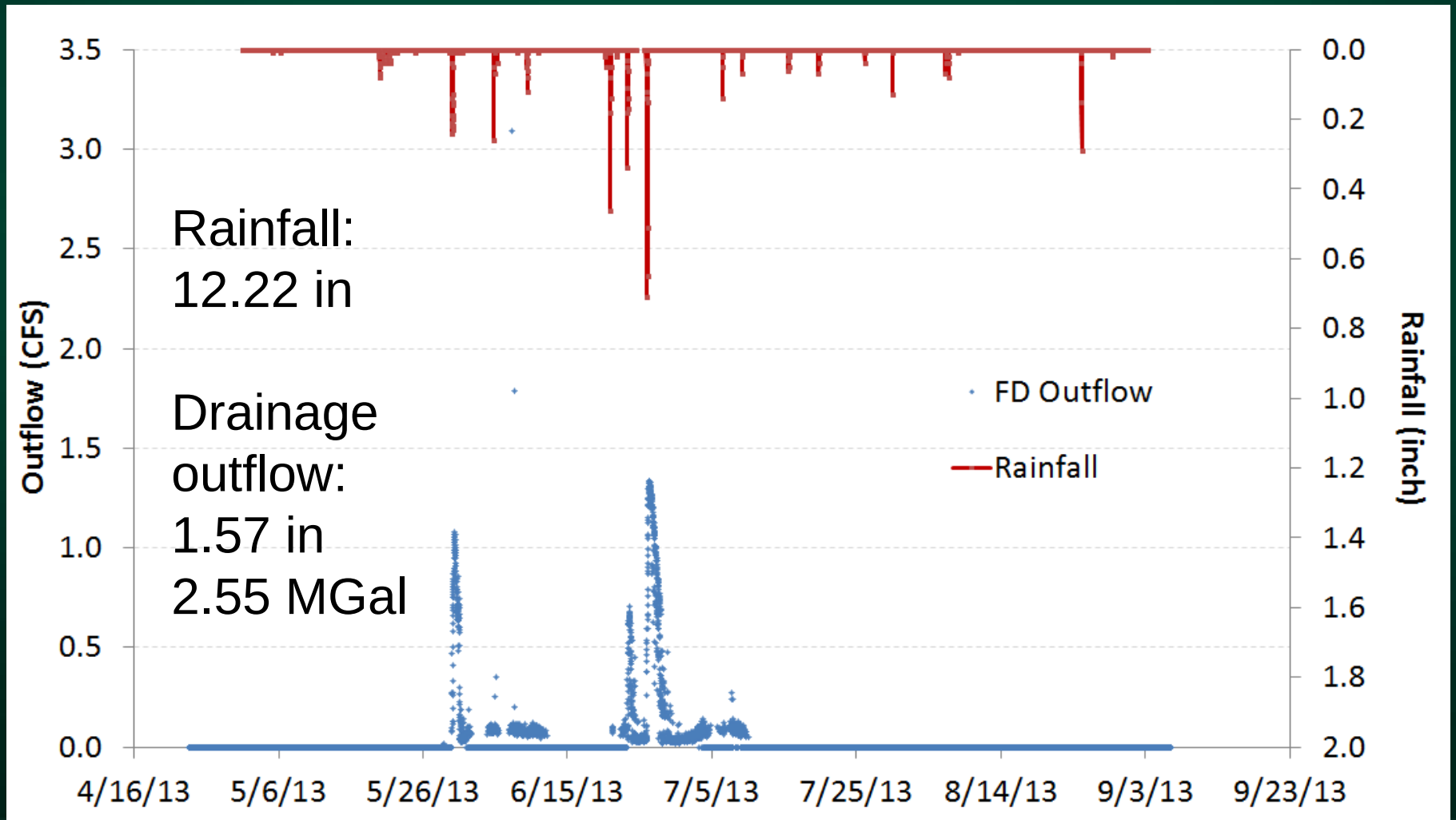
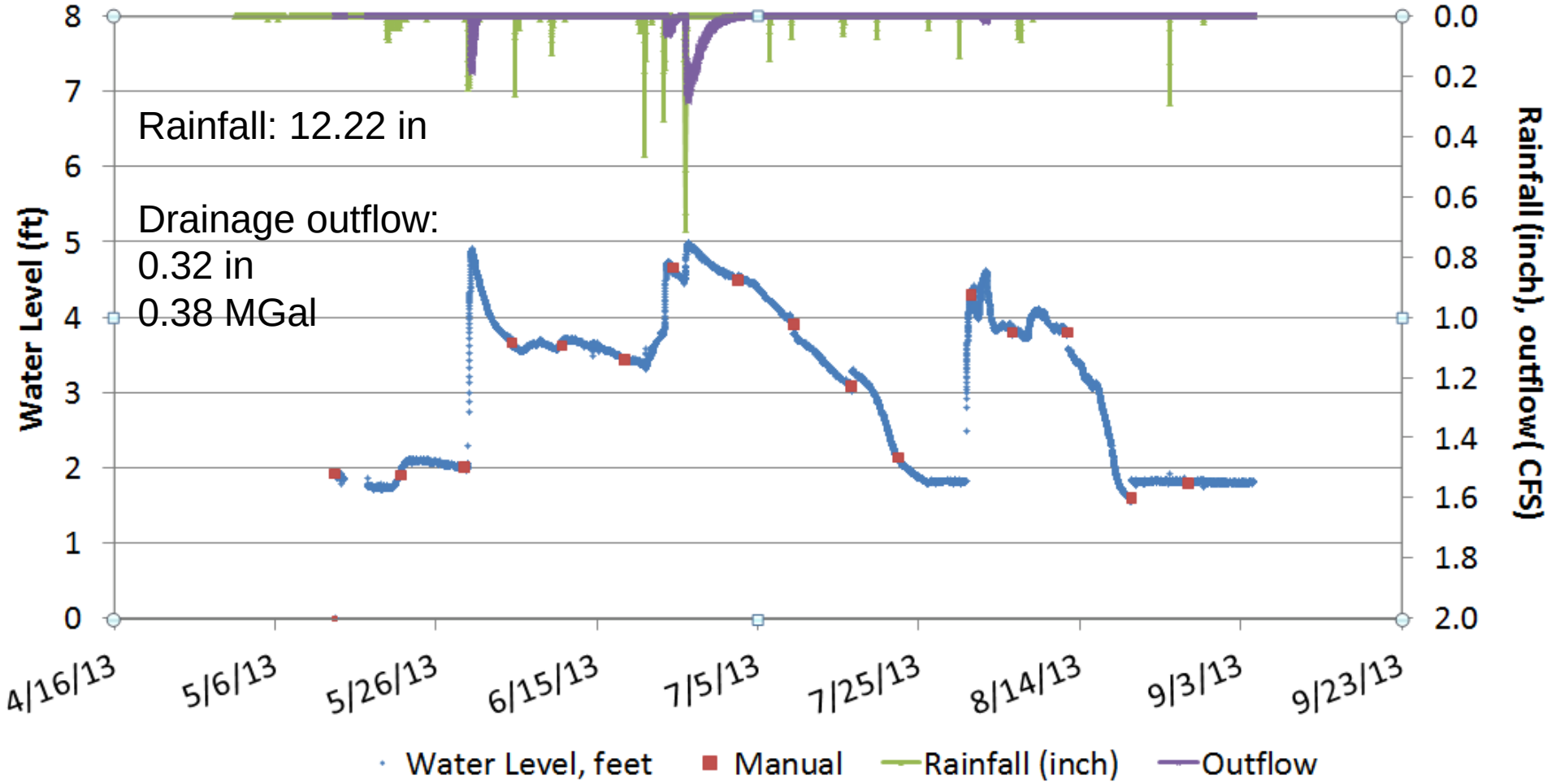
Surface Runoff Measurement



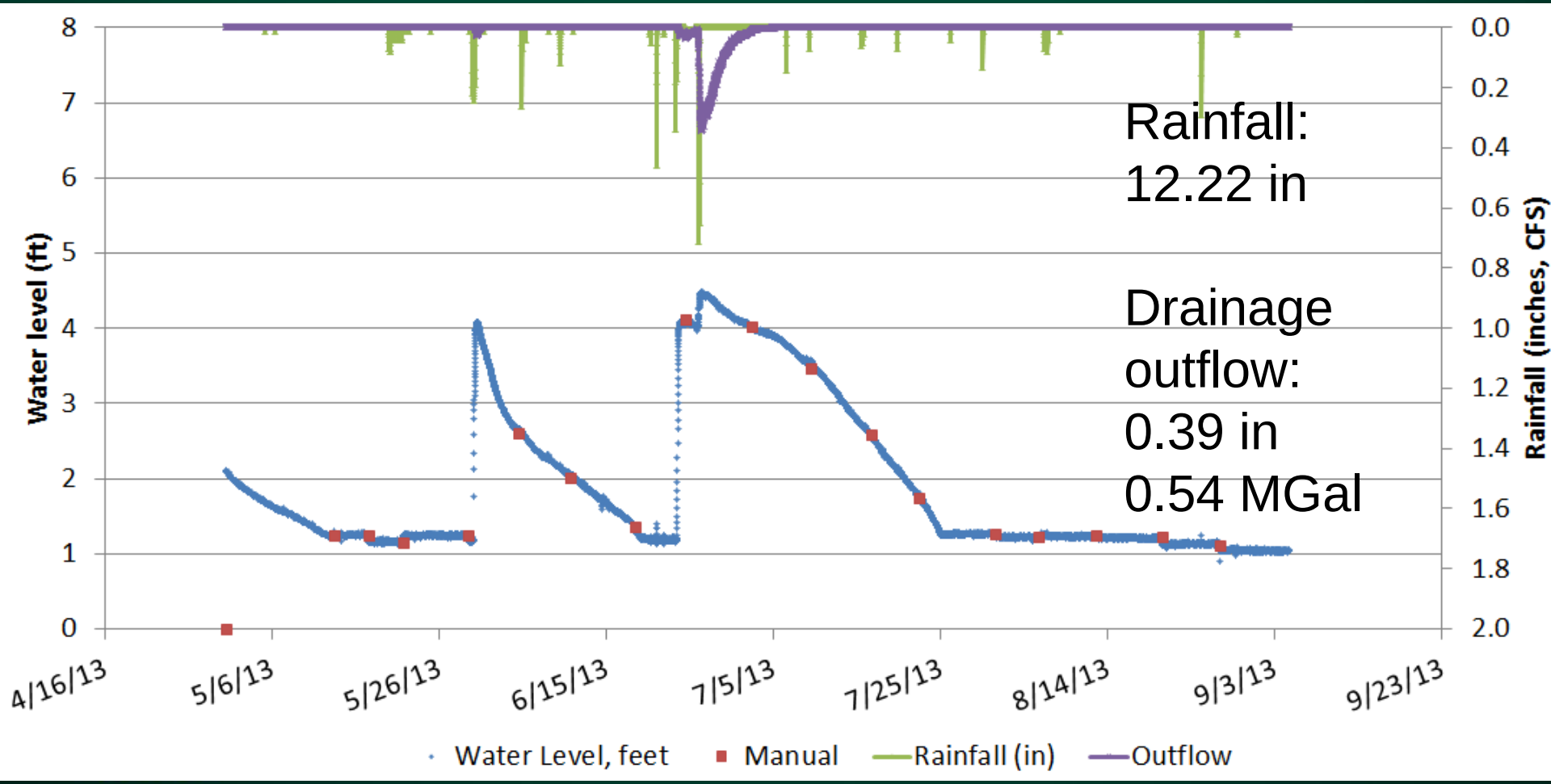
Drainage Outflow from Free Drainage Field



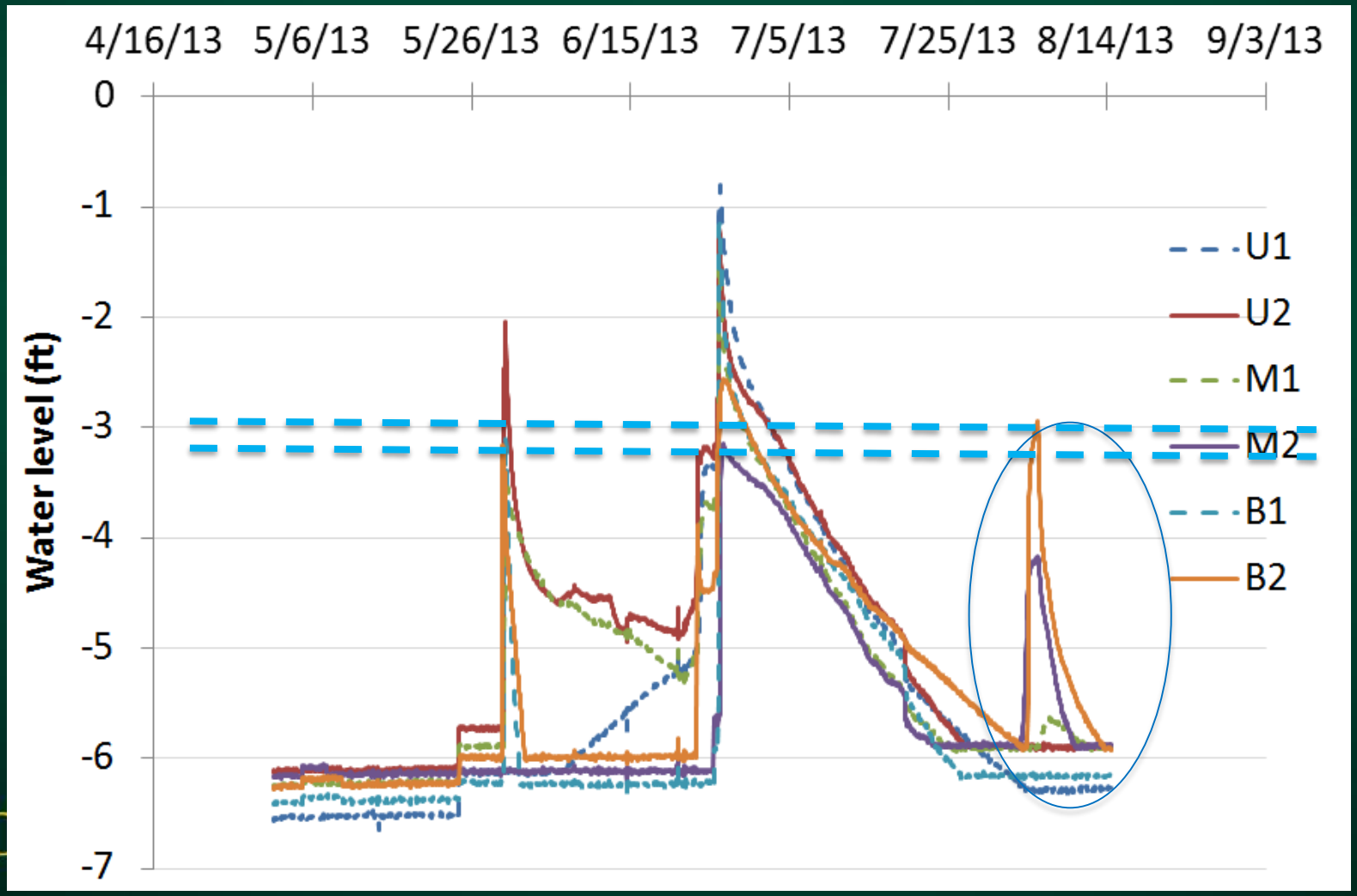
Controlled Drainage Measurement (East control structure)



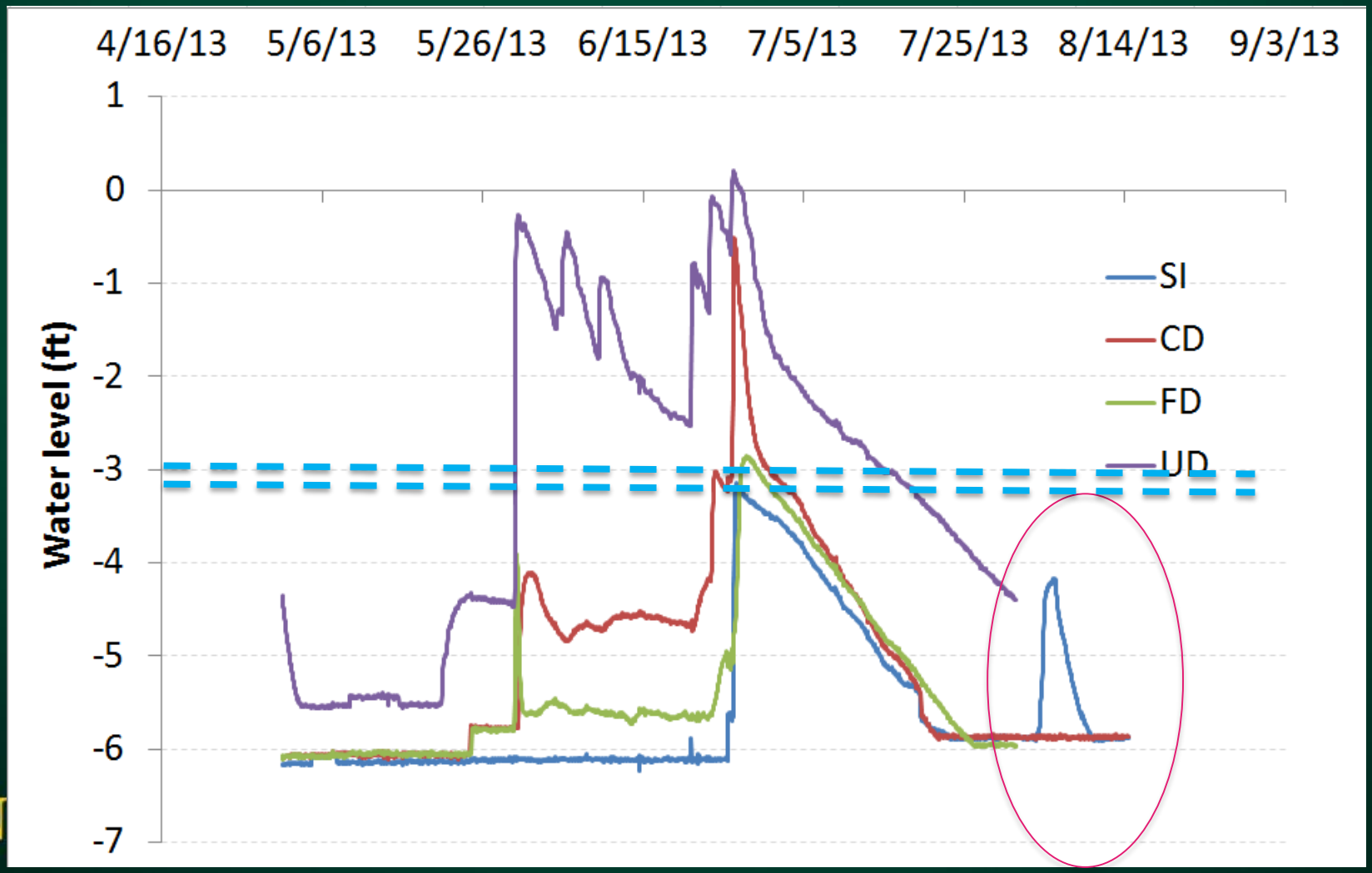
Controlled Drainage Measurement (West control structure)



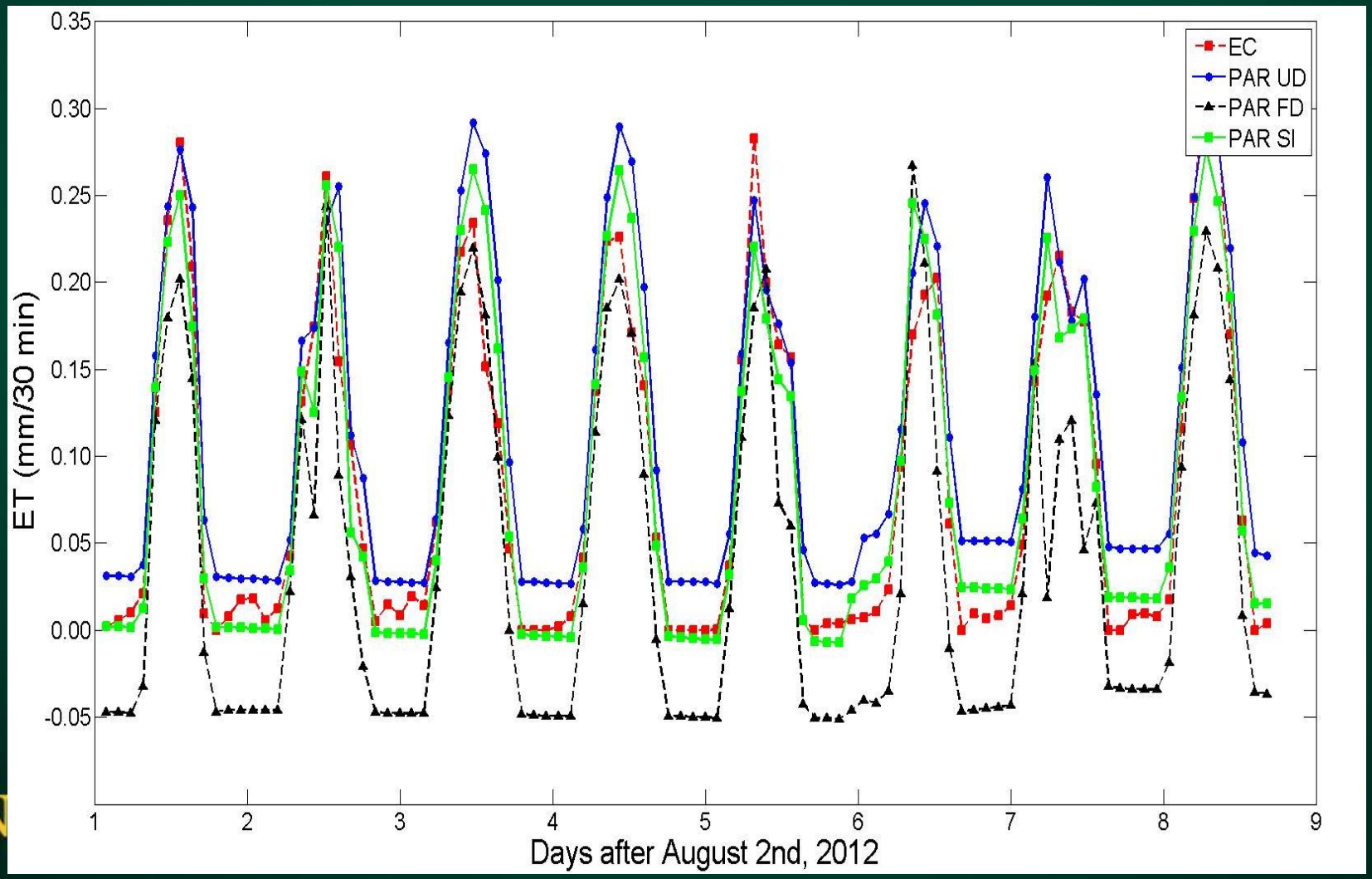
Water level change at up (U), middle (M), and bottom (B), in the middle between two tiles (1) and near the tile line (2) of the subirrigation field



Water level change in the subirrigated (SI), control drained (CD), free drained (FD), and undrained (UD) fields in 2013



Comparison of evapotranspiration (ET) estimates for the undrained (UD), free drained (FD), and subirrigated (SI) plots using the PAR method and eddy covariance (EC) (Kolars et al., 2013)



Subirrigation

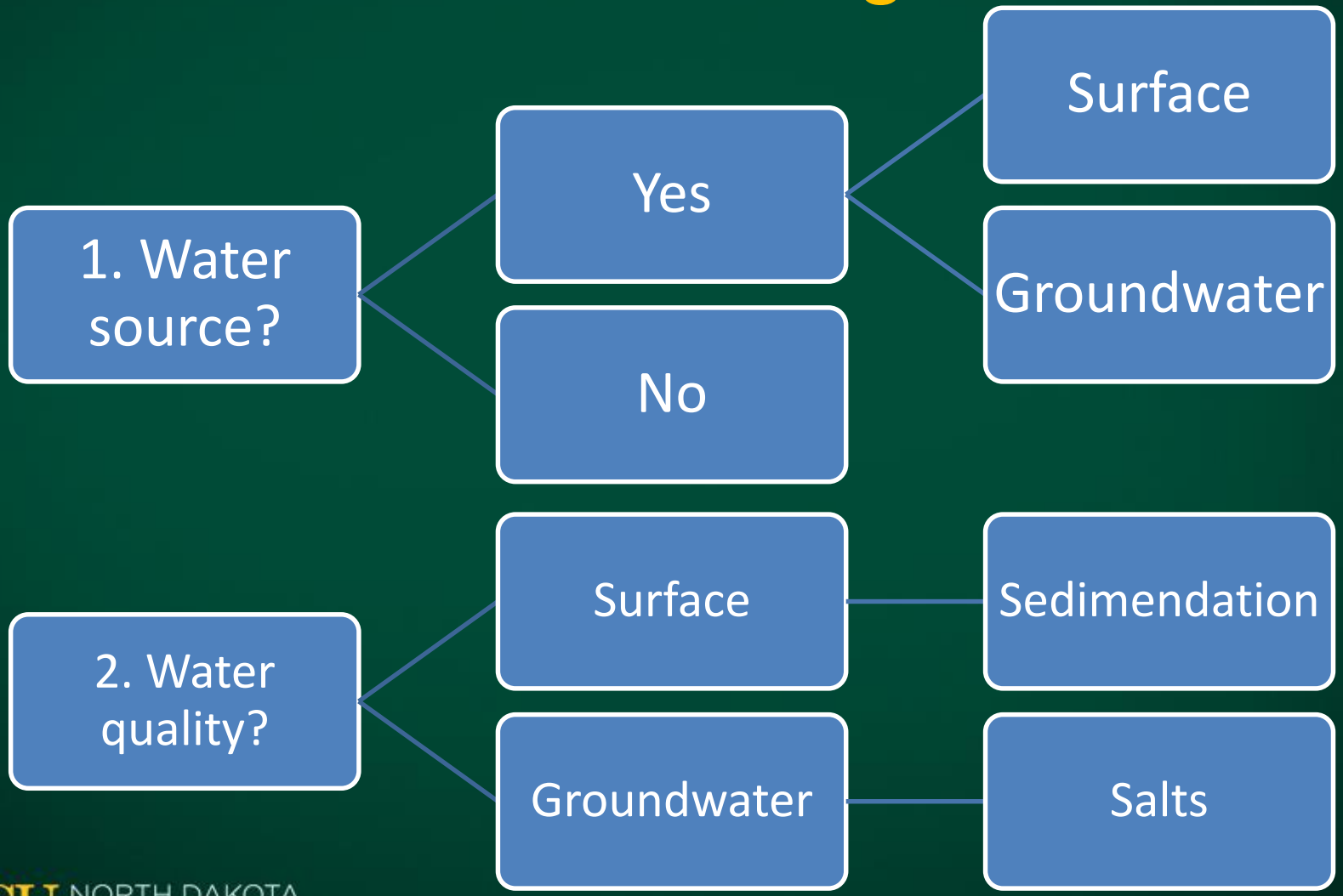
	2012	2013
Starting date	6/25/12	7/30/13
Ending date	7/19/12	8/15/13
Flow volume (Gal)	5,765,000	190,800
Flow rate (gpm)	110-480	200
Water level in the tank (ft)	5-8	7
Corn area (ac)	94	86
Irrigation depth (in)	2.26	0.16
Total SI area (ac)	254 (94 – corn and 160 - sugarbeet)	236 (86 – corn and 150 - sugarbeet)
Total pumping amount (Mgal)	24.486	23.614
Avg irrigation depth (in)	0.30	0.31

Subirrigation for sugar beets

6.3 tons/bu more

MASTER
160LC

How do I start to subirrigate?



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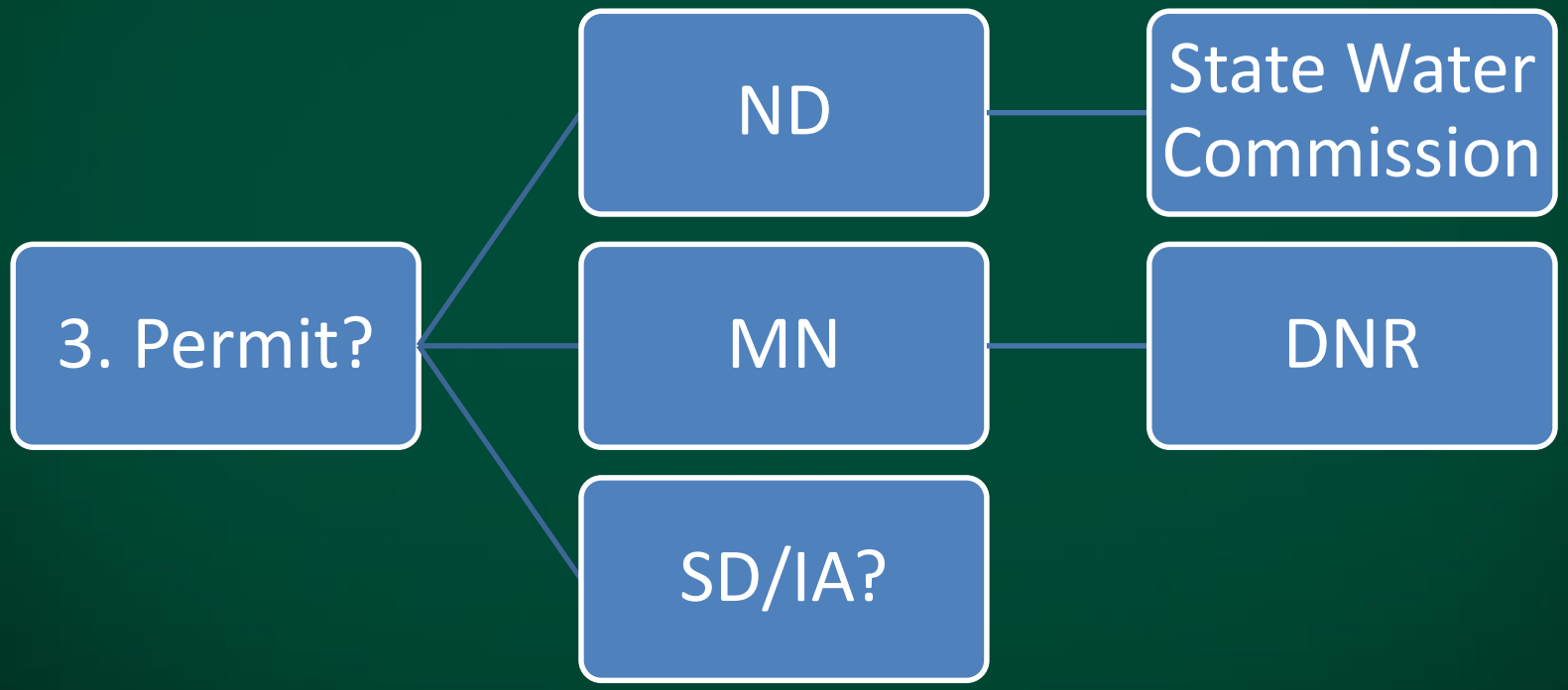
How do I start to subirrigate?



How do I start to subirrigate?

4. Main Location?

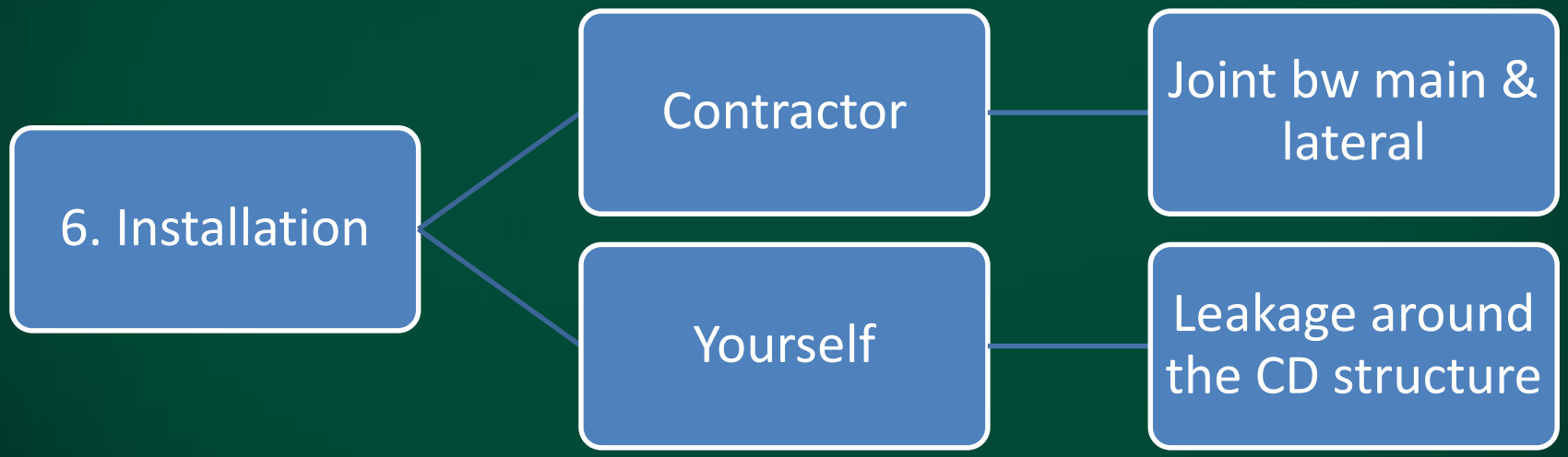
- One main – Fairmount site – short laterals
- Two mains – N. Moorhead site – long laterals

How do I start to subirrigate?

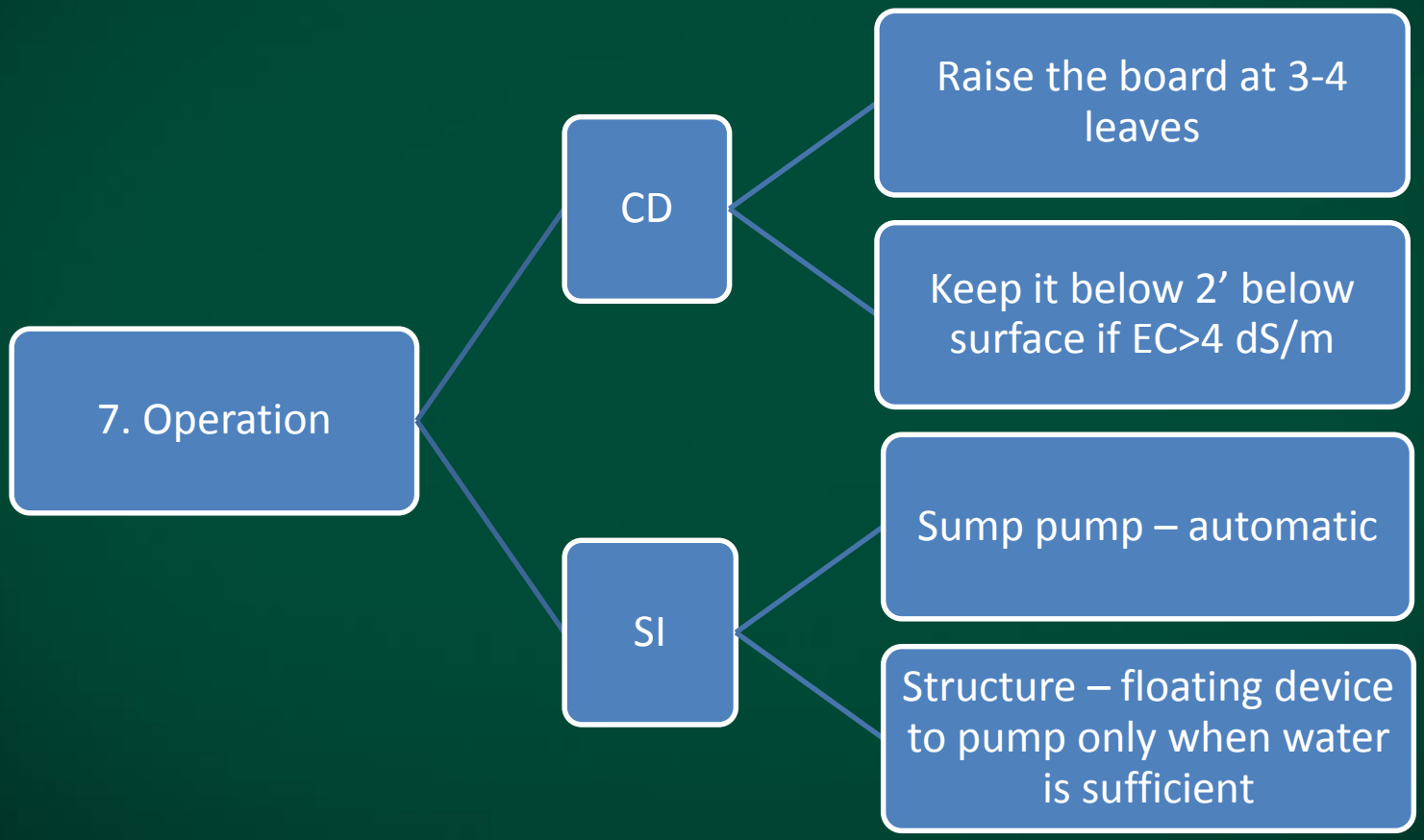
5. Design (ASABE standard, EP479)

- Topography - < 0.5% grade
- Soil/crop
- Depth/spacing

How do I start to subirrigate?



How do I start to subirrigate?



Acknowledgements

"This product was developed with support from the Sustainable Agriculture Research and Education (SARE) program, which is funded by the U.S. Department of Agriculture — National Institute of Food and Agriculture (USDA-NIFA). Any opinions, findings, conclusions or recommendations expressed within do not necessarily reflect the view of the SARE program or the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer."

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Questions - Comments

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