Tile Drainage:

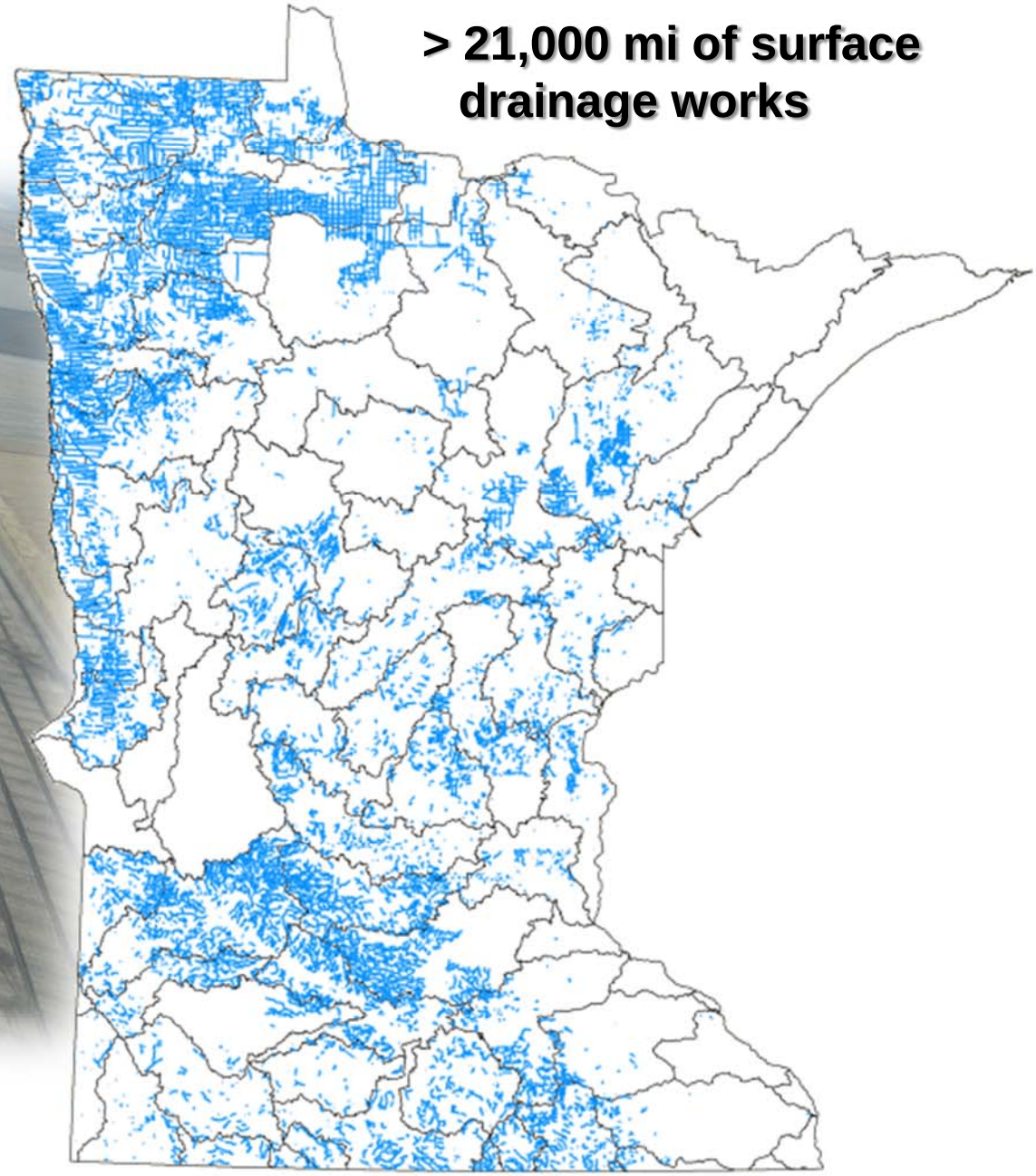
Hydrology and the RRB

A Presentation of the Tiling and Drainage Workshop

August 28-29, 2012
Hankinson, ND

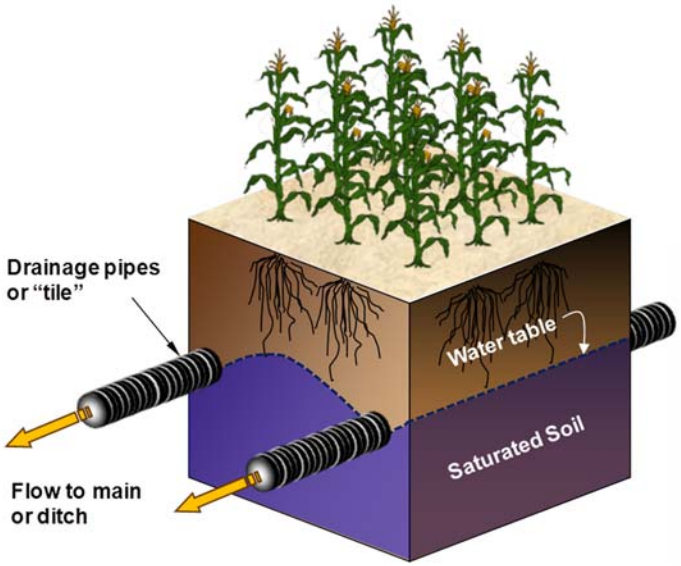
Gary R. Sands
Professor & Extension Engineer

Drainage in Minnesota



> 21,000 mi of surface drainage works

Tile Drainage ⟷ Hydrology



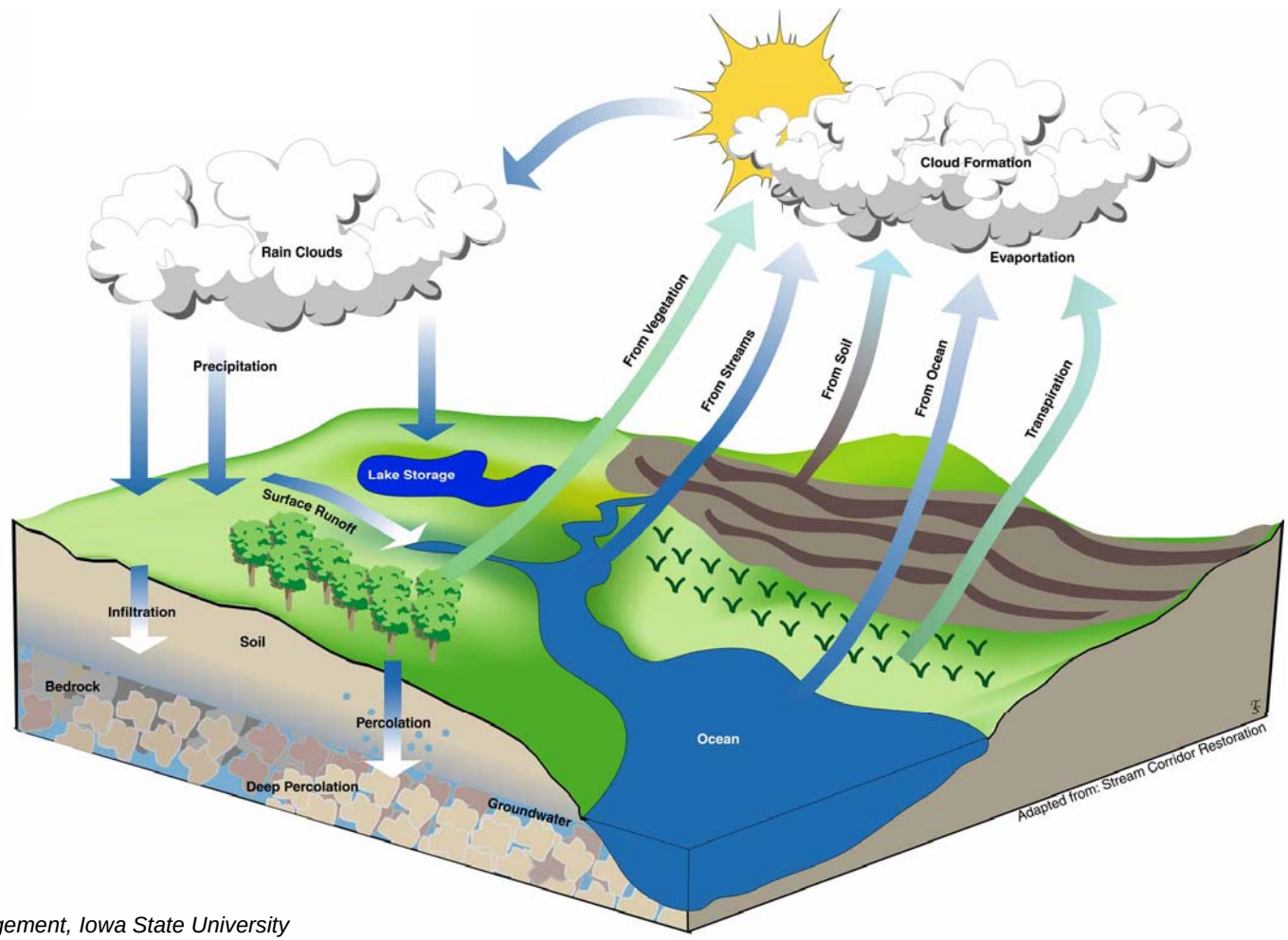
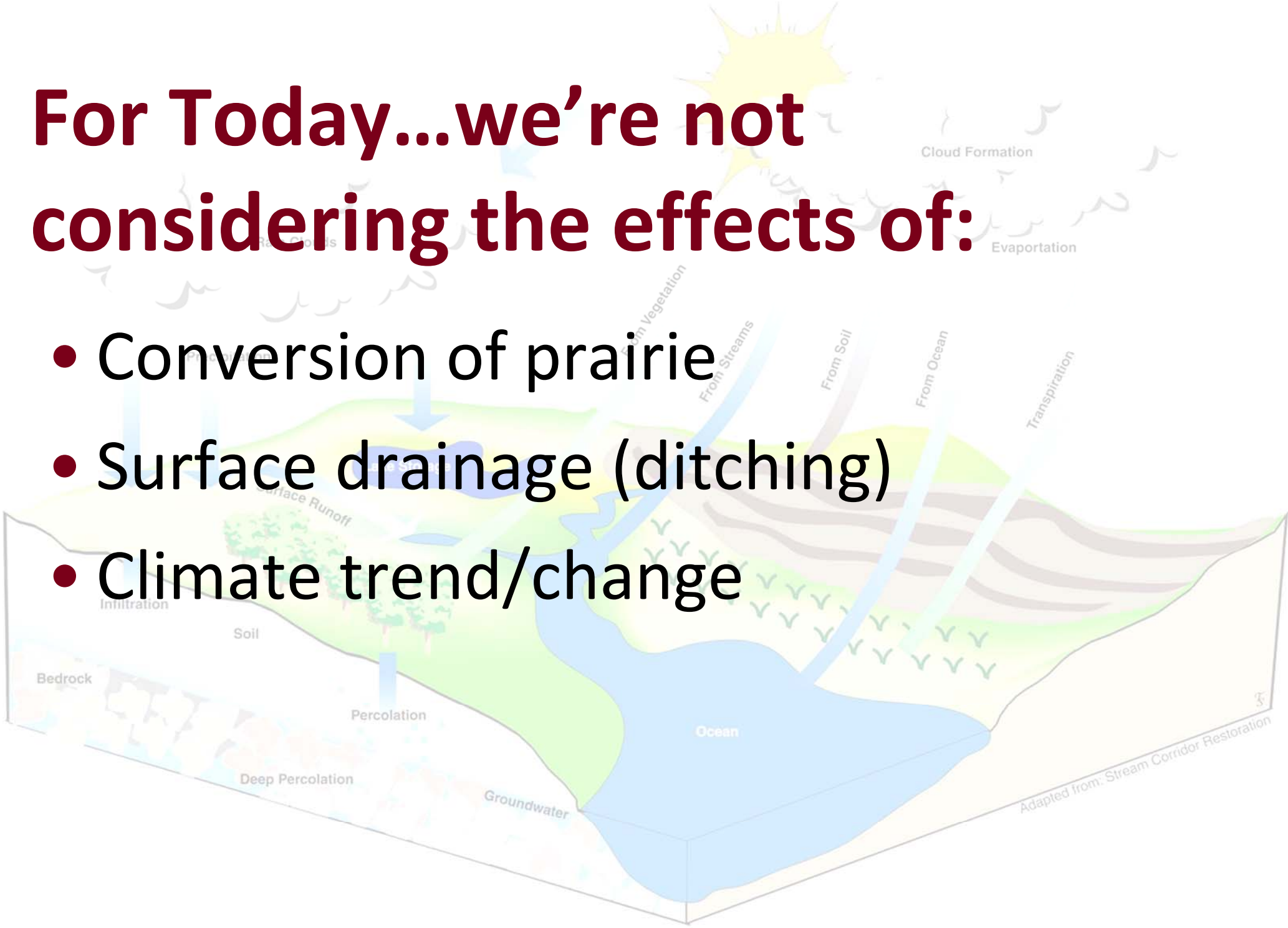


Image Source: Department of Natural Resource Ecology and Management, Iowa State University

For Today…we're not considering the effects of:

- Conversion of prairie
- Surface drainage (ditching)
- Climate trend/change



Q: Can tile drainage affect hydrology & streamflow?

A: Of course it can!

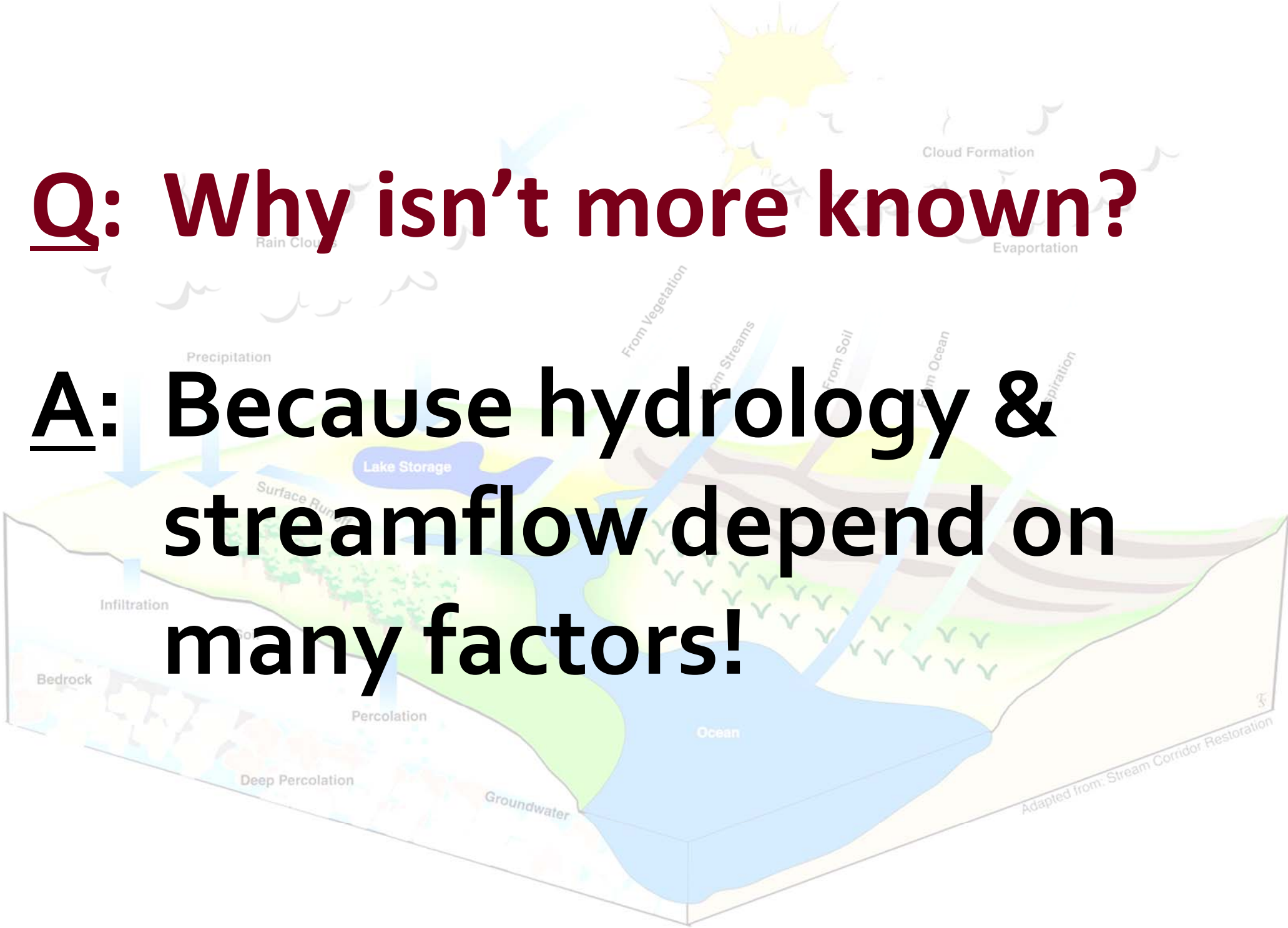
Q: Do we know precisely what these effects are?

A: Not really!

A: They could be pos, neg, or neutral

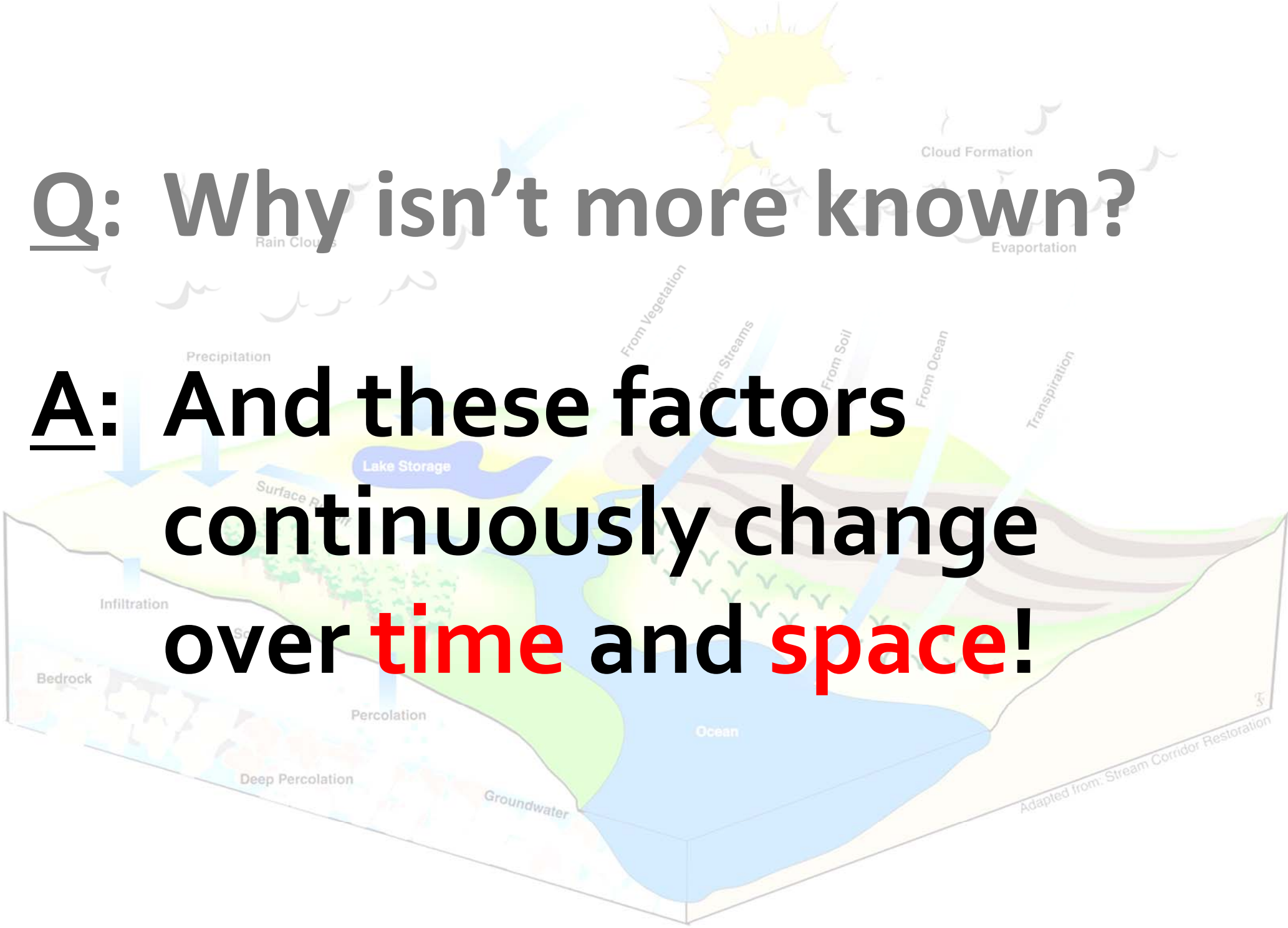
Q: Why isn't more known?

A: Because hydrology & streamflow depend on many factors!



Q: Why isn't more known?

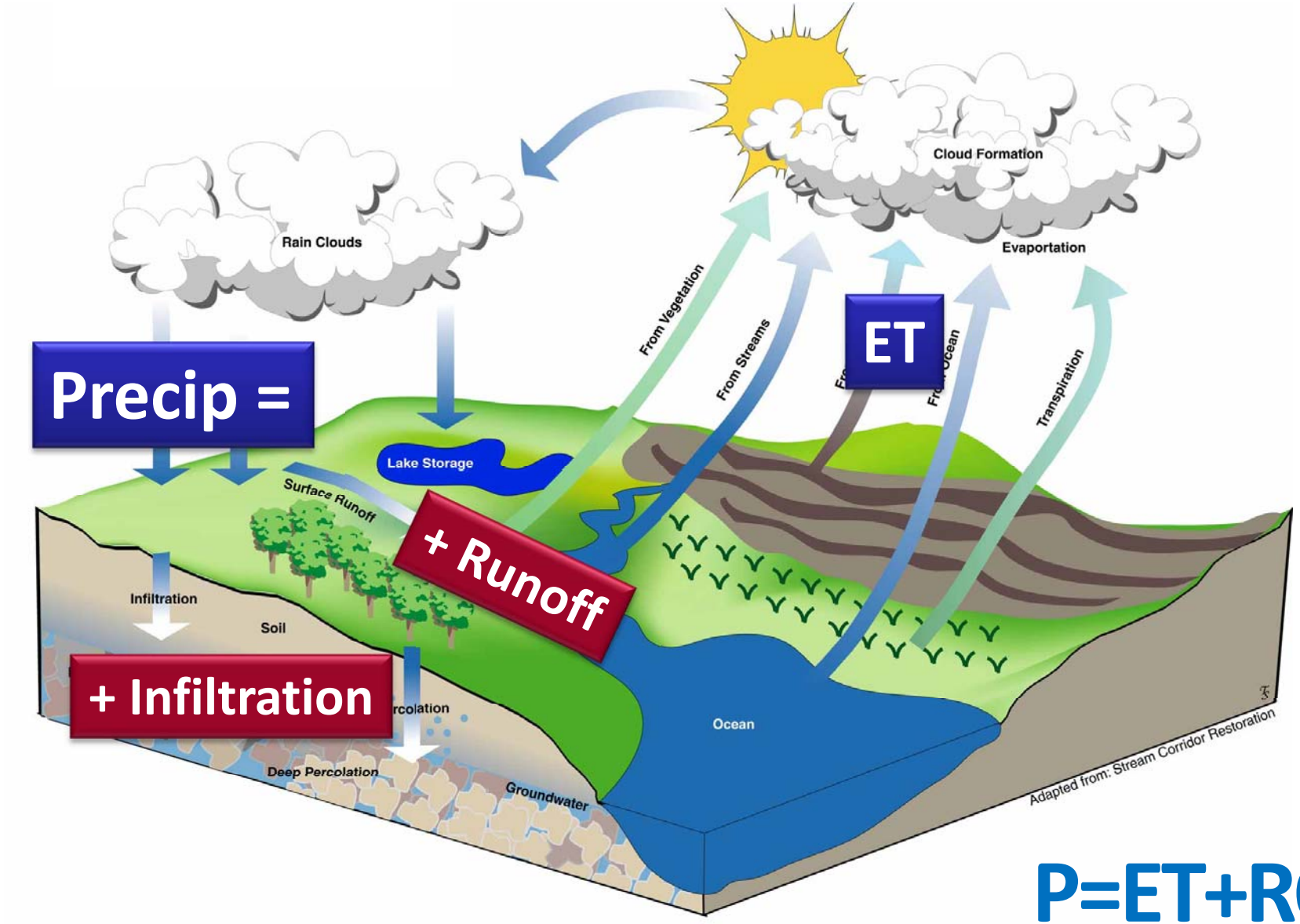
A: And these factors continuously change over time and space!



Q: So what DO we know?

A: We know what factors are important and general relationships

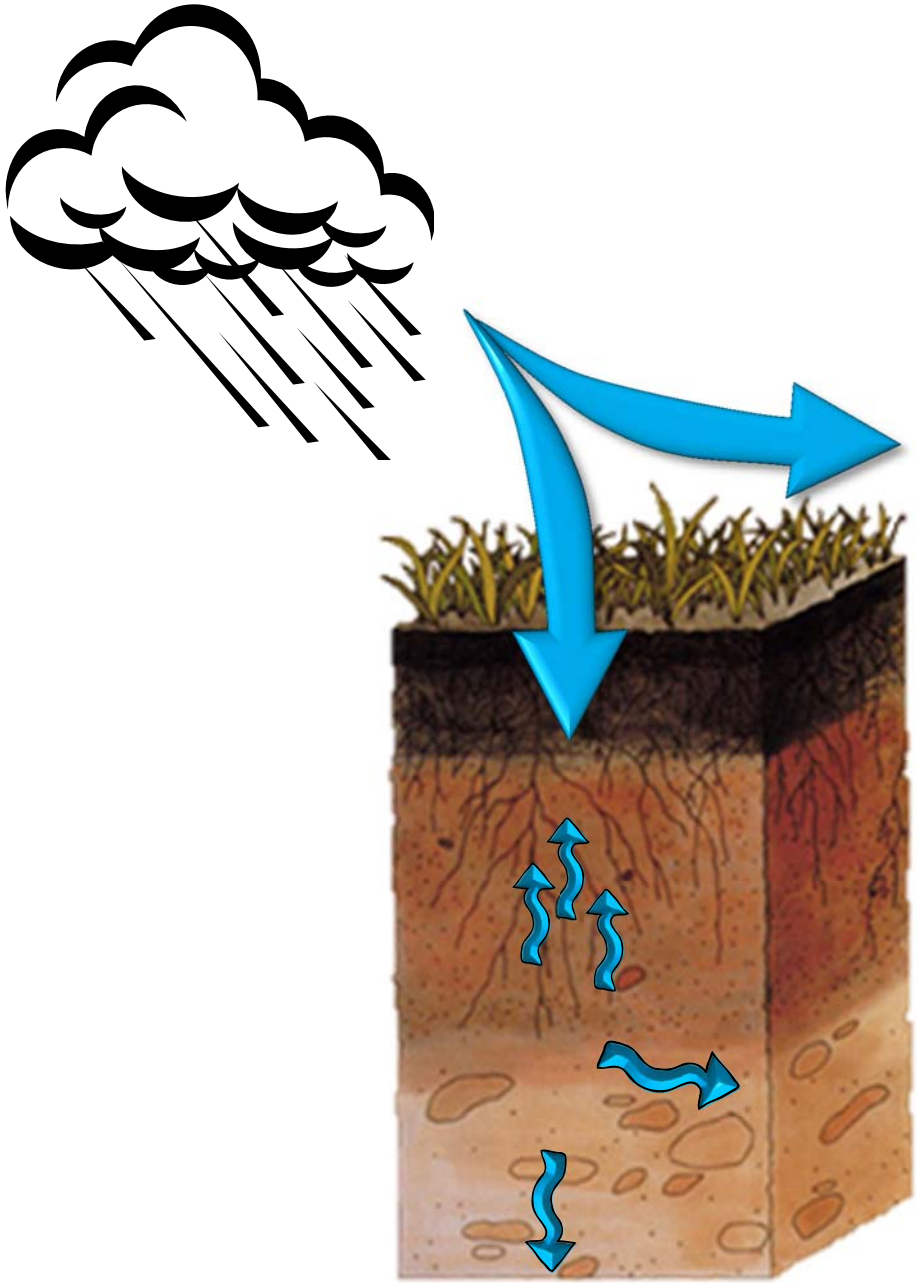
Hydrology



P=ET+RO+I

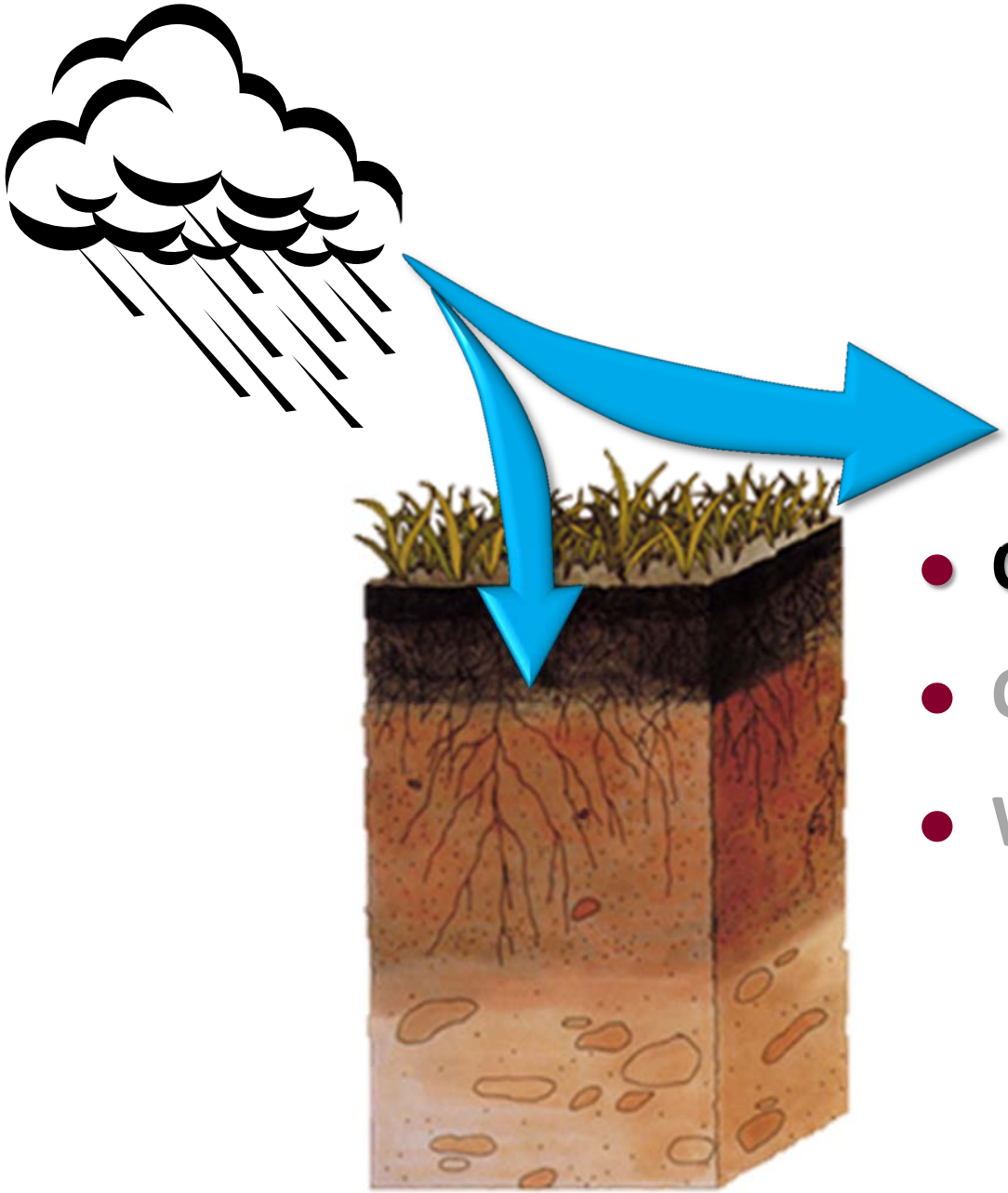
Image Source: Department of Natural Resource Ecology and Management, Iowa State University

Soil is a Key Factor



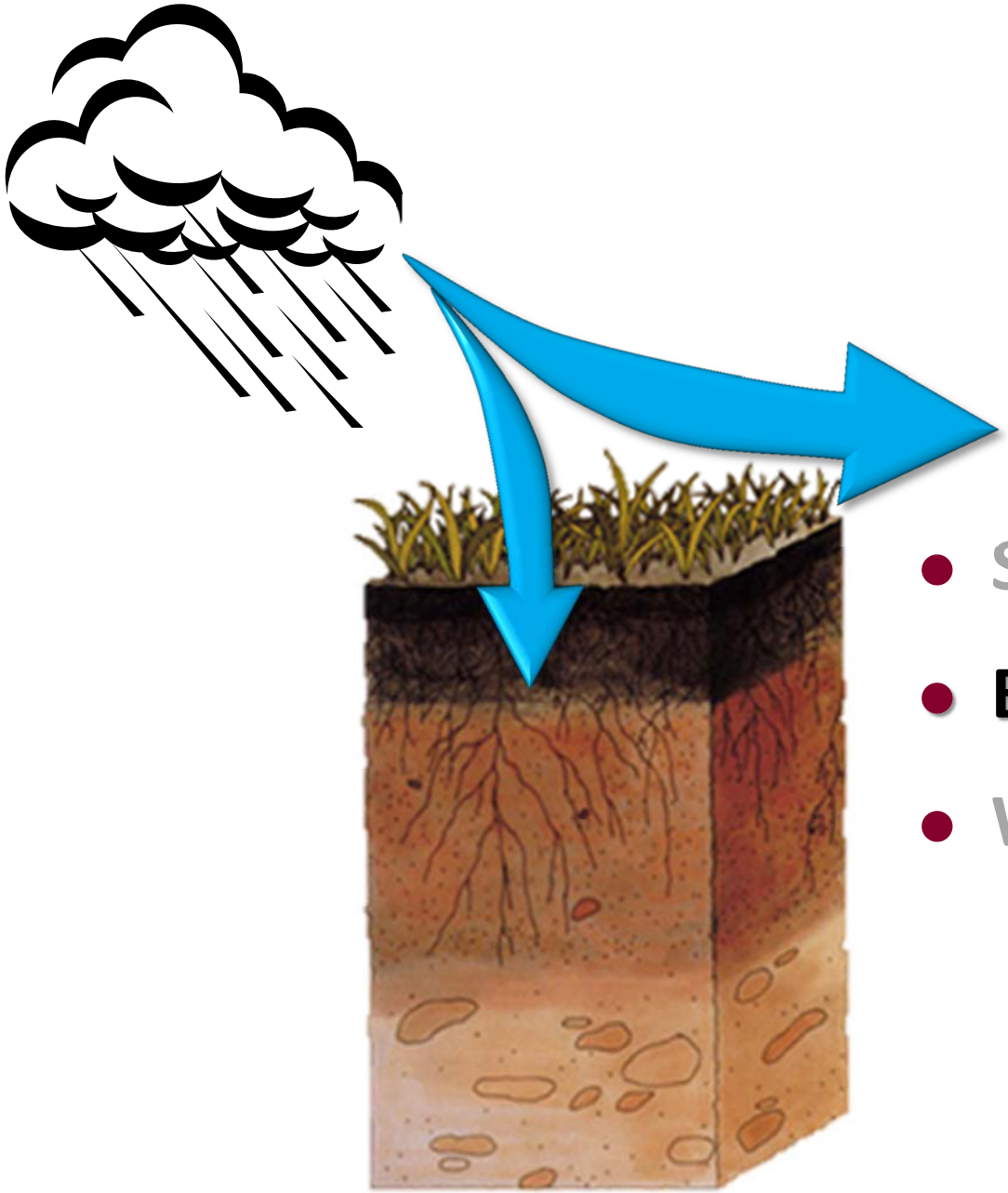
- Soil type (fine, coarse)?
- Cover or crop?
- Wet?, dry?, frozen?
- Redistribution

Soil is a Key Factor – Soil Type



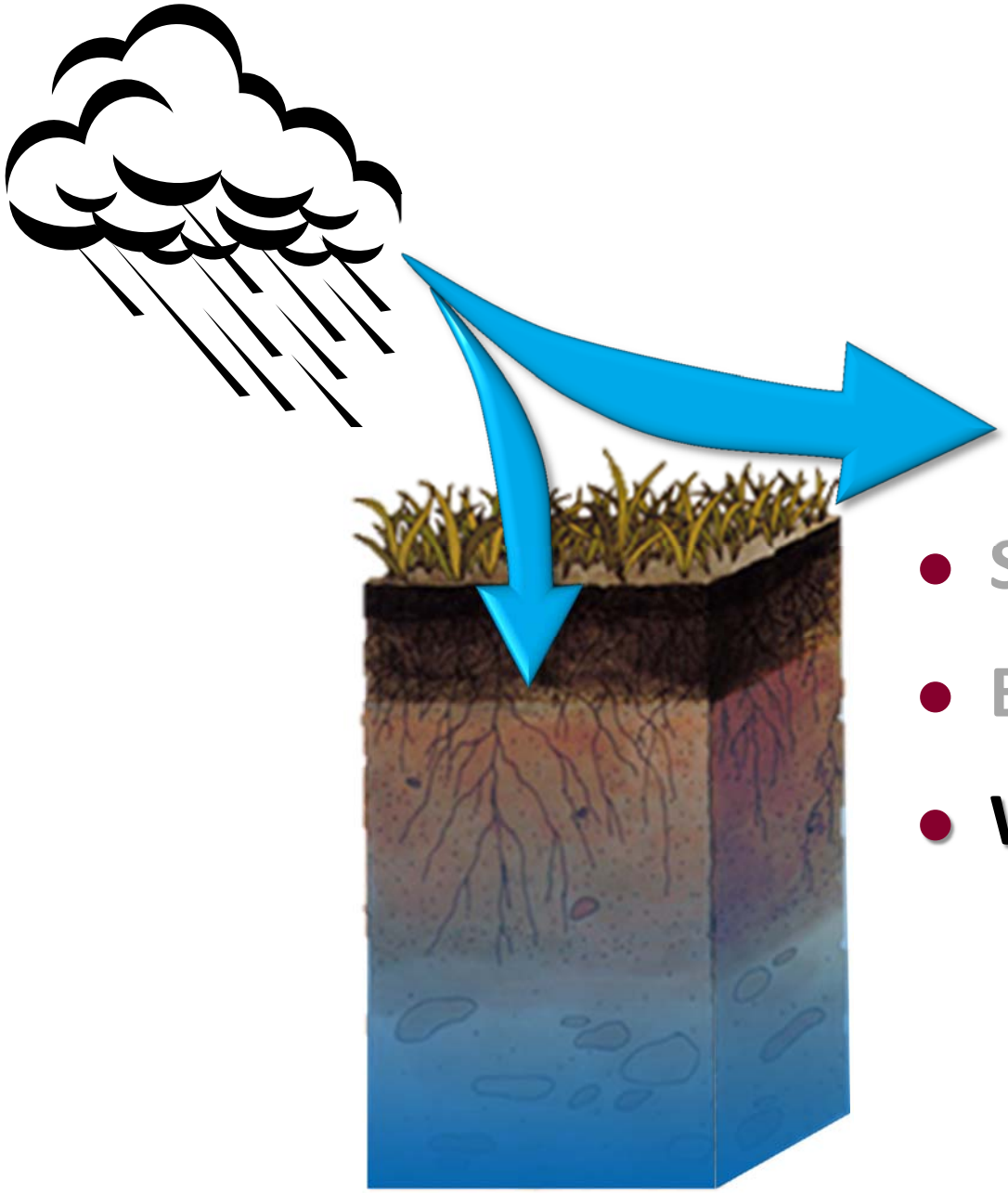
- **Clay Soil?**
- Cover or crop?
- Wet?, dry?, frozen?

Soil is a Key Factor – Soil Cover



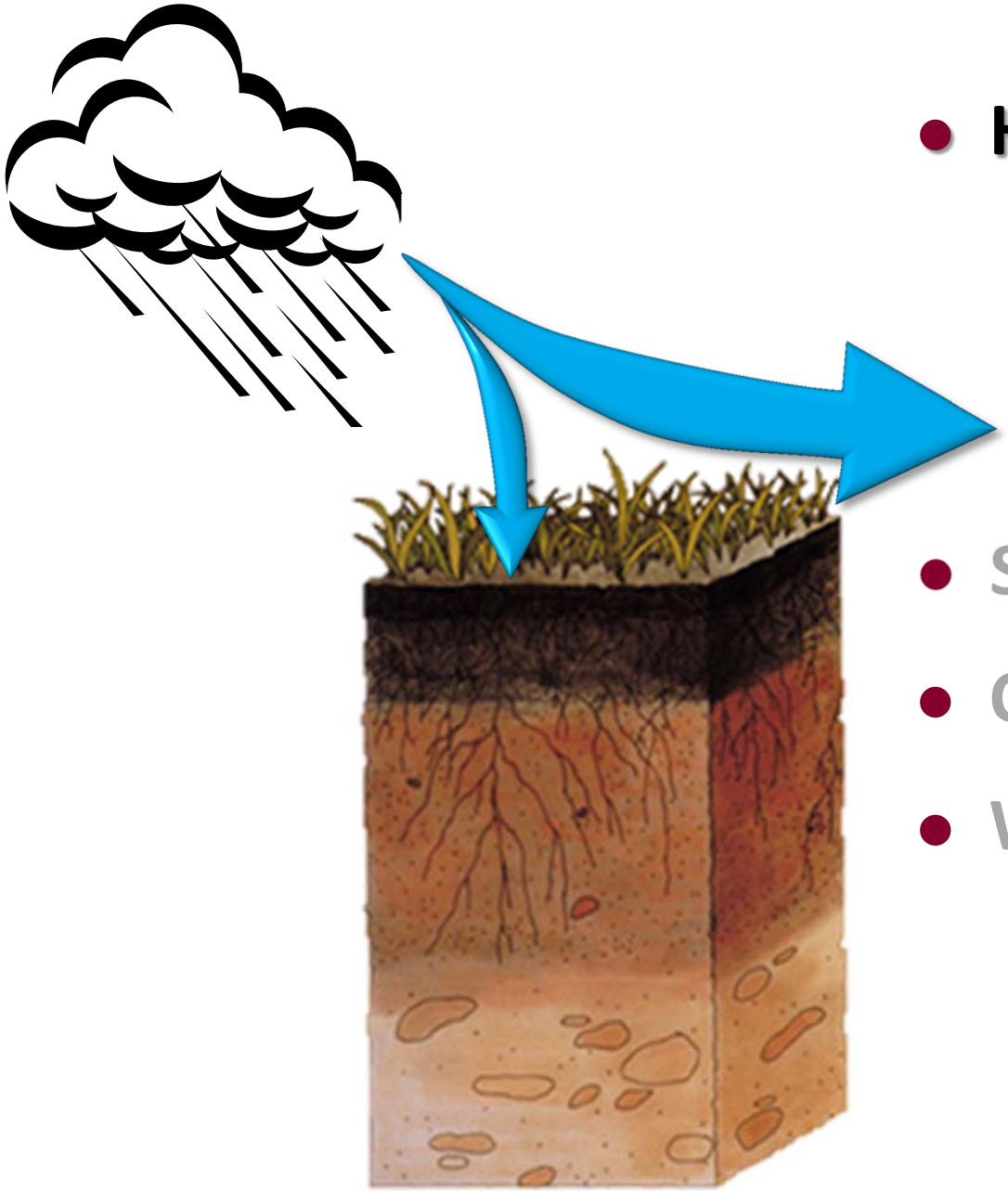
- Soil type (fine)?
- **Bare or minimal cover?**
- Wet?, dry?, frozen?

Soil is a Key Factor – Soil Moisture



- Soil type (fine)?
- Bare-min cover?
- **Wet conditions?**

Precipitation Trumps Soil



- **High Precip Intensity?**

- Soil type (fine, coarse)?
- Cover or crop?
- Wet?, dry?

Rainfall Intensity

Gentle Rainfall Event

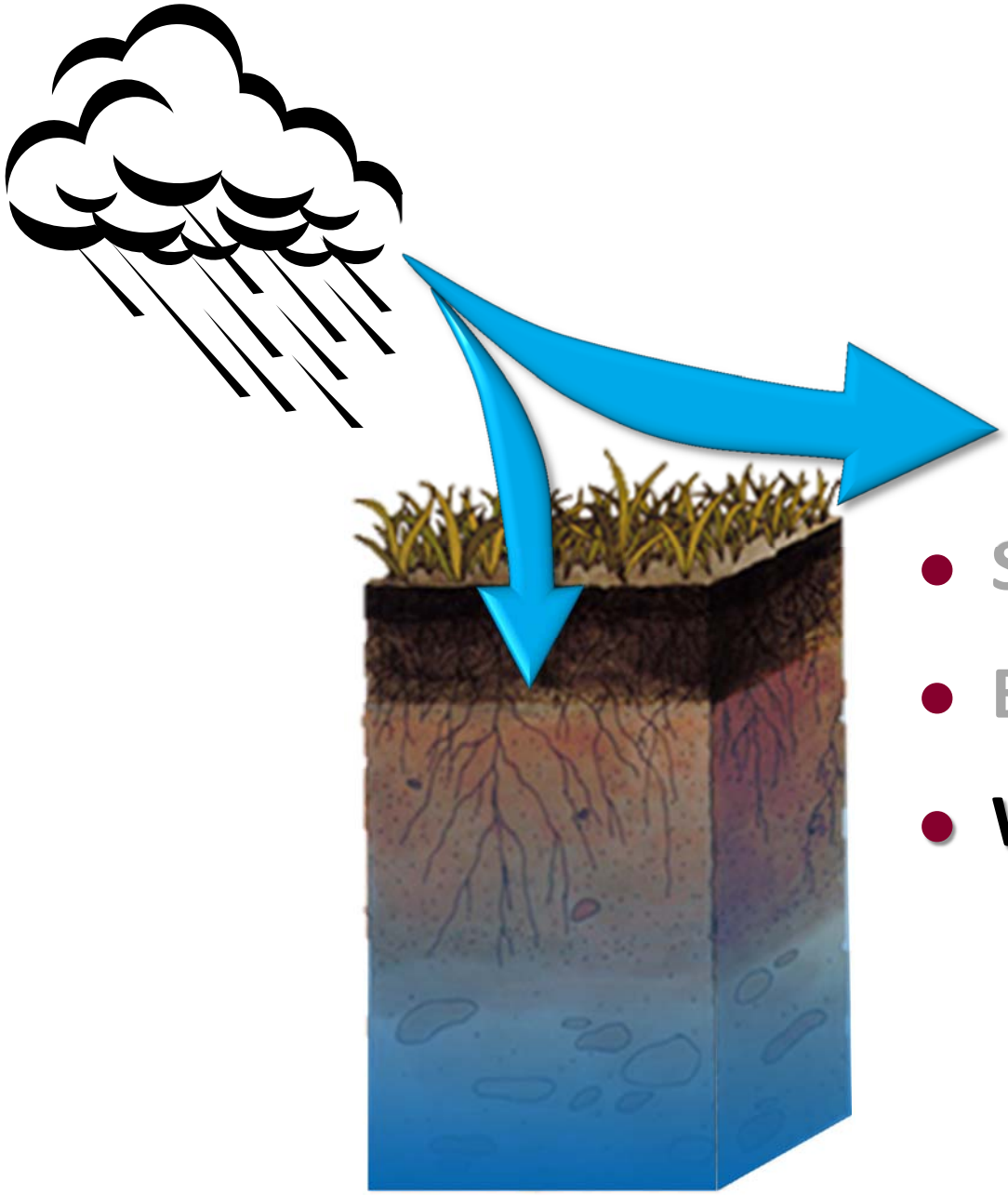
- Favors infiltration
- Tile drainage system influences flow
- Surface drainage system out of the picture

Intense Rainfall Event

- Favors surface runoff
- Surface drainage system influences flow
- Tile drainage system out of picture

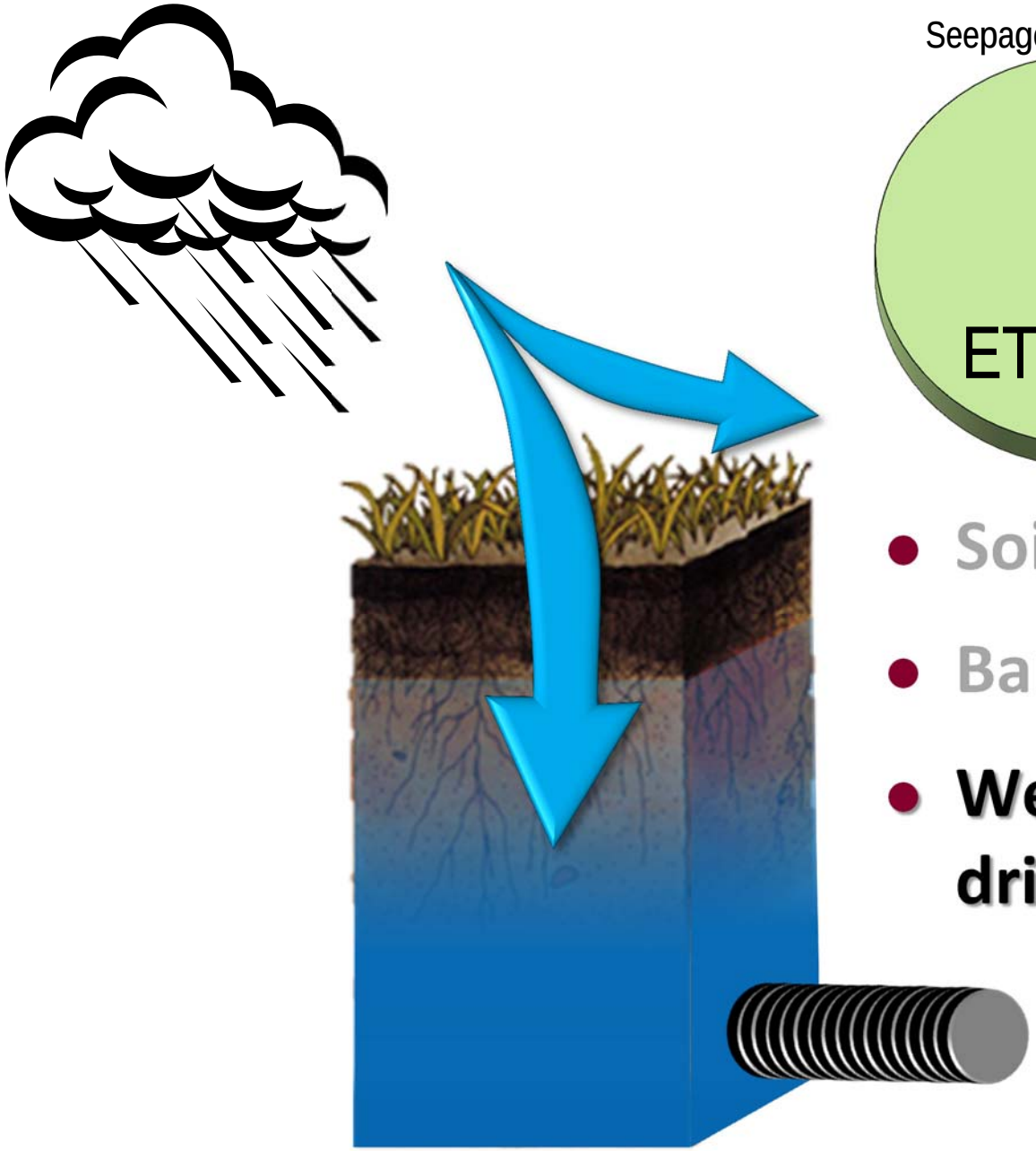
Q: So what difference does tile drainage make?

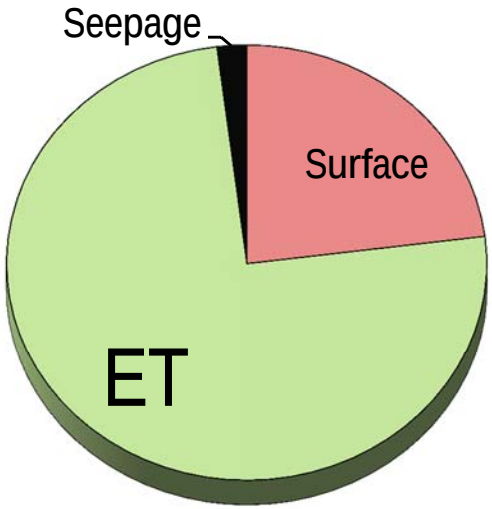
Effect of Tile Drainage

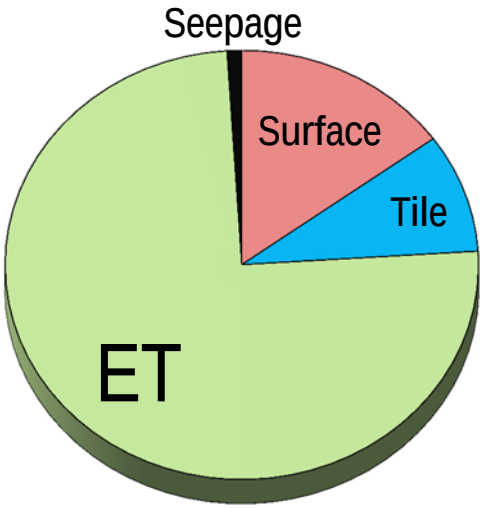


- Soil type (fine)?
- Bare-min cover?
- **Wet conditions**

Effect of Tile Drainage

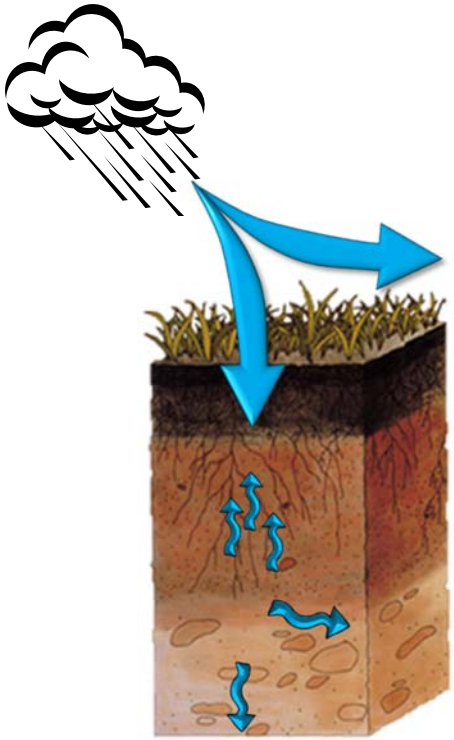


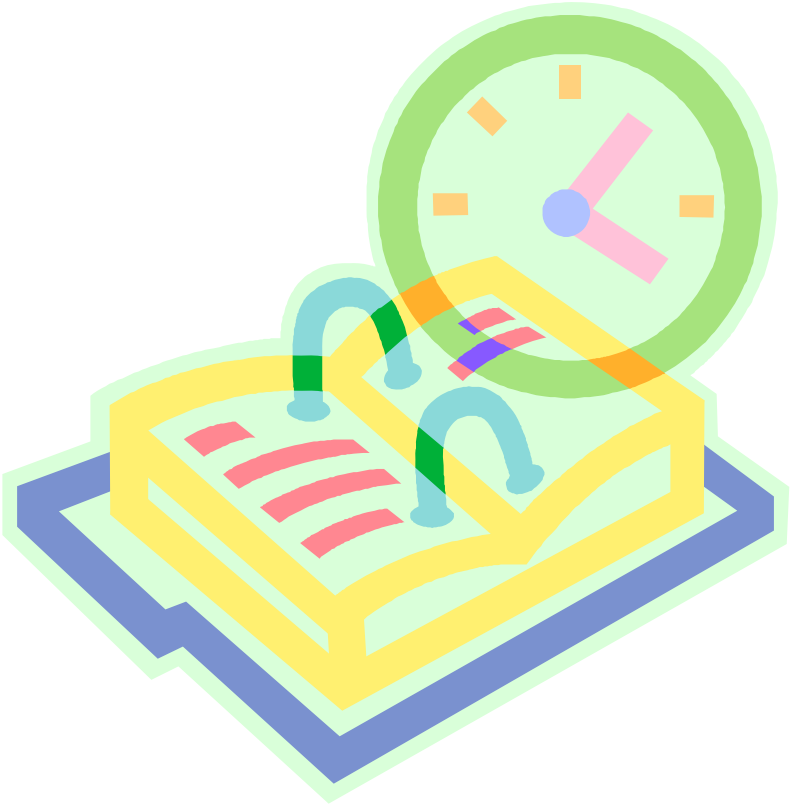




- Soil type (fine)?
- Bare-min cover?
- **Wet conditions become drier conditions**
- **<u>Q</u>: When would this not be true?**

BUT……

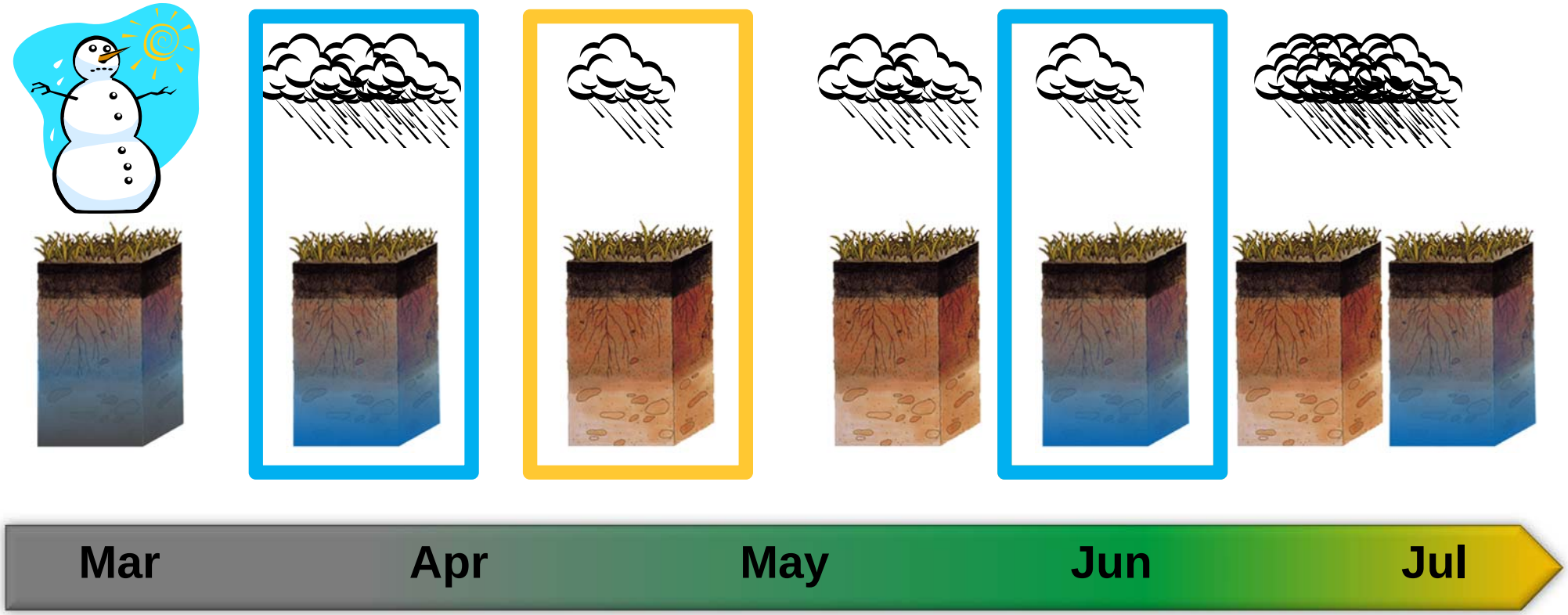




Soil & Precip Factors

CHANGE WITH TIME & SEASON

Changes Over Time & Season



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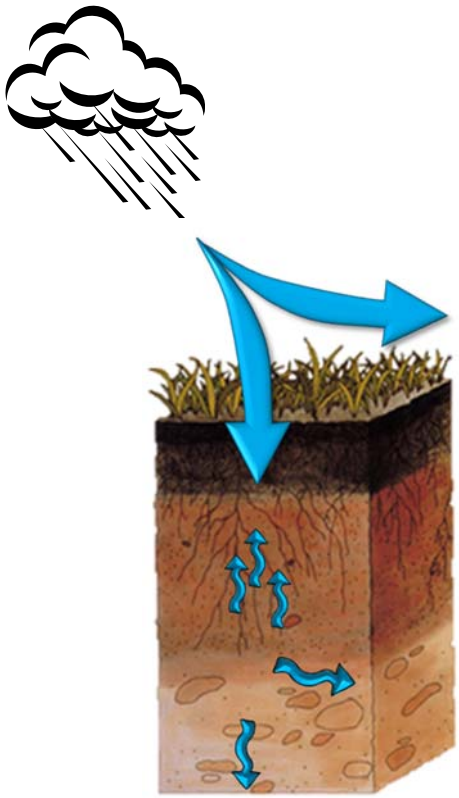
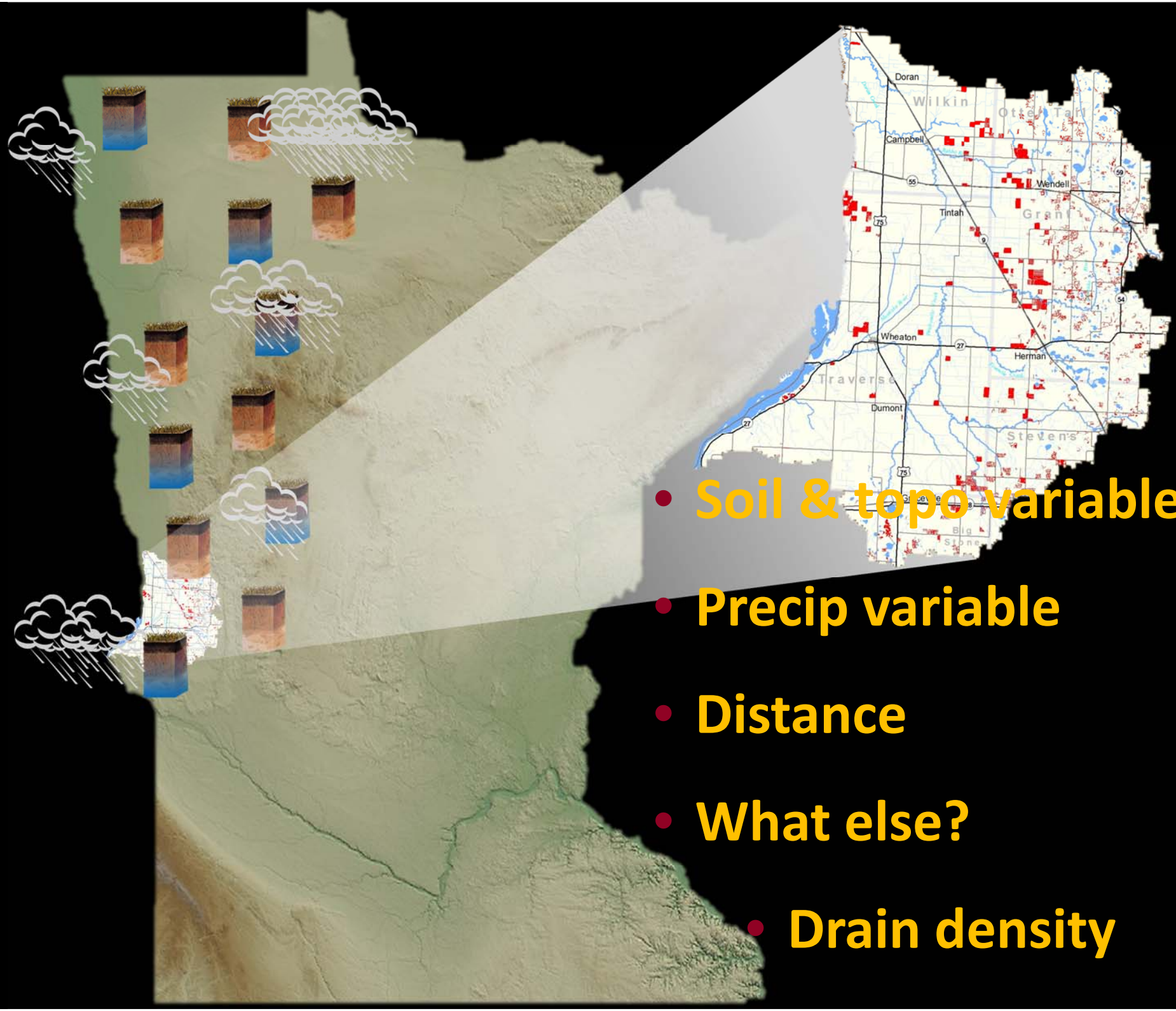


Soil and Precip Factors

CHANGE OVER SPACE (SCALE)



- Soil & topo variable
- Precip variable
- Distance
- What else?
  - Drain density

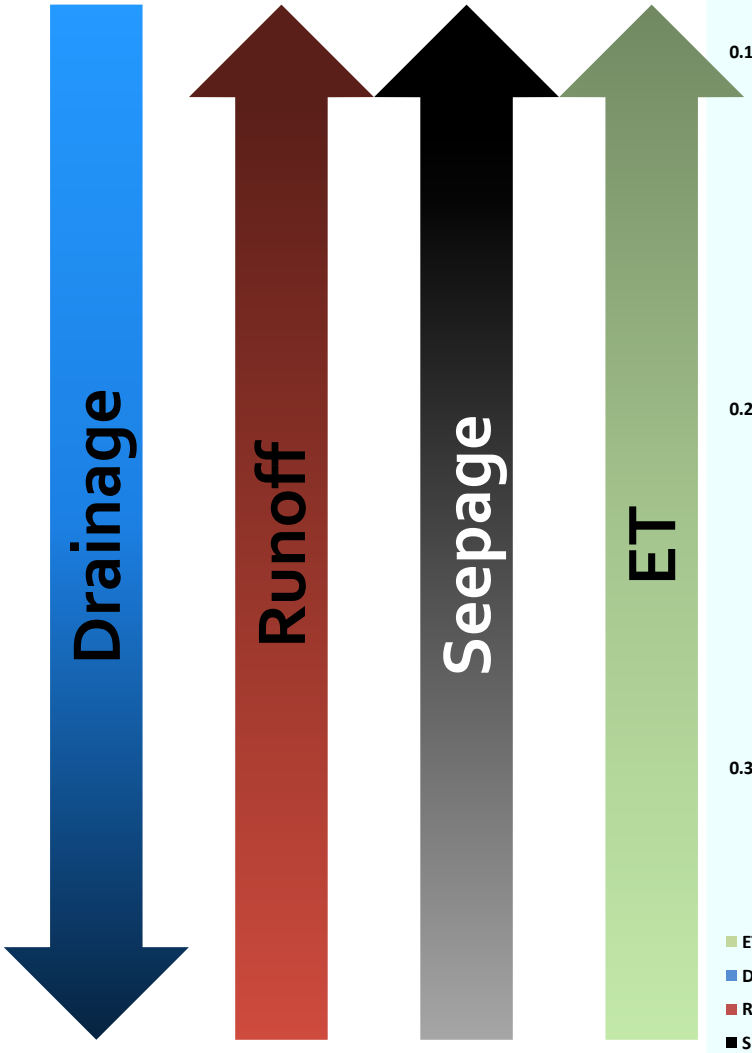
Q: Can't we sort out all the factors 1-by-1 and estimate effects on hydrology & streamflow?

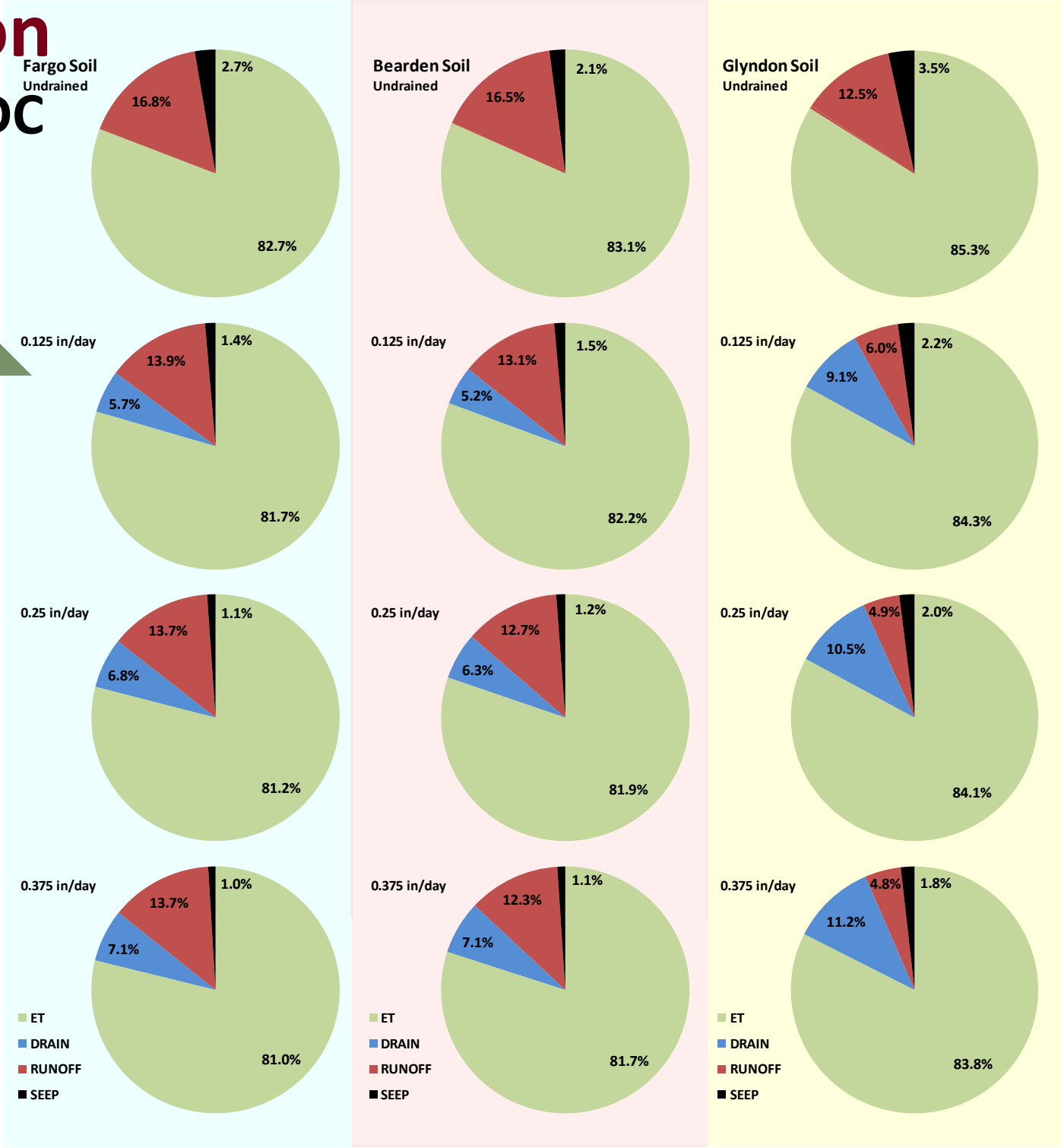
A: Welcome to the world of computer modeling!

100-yr Simulation

Crookston, 3 soils, 4 DC

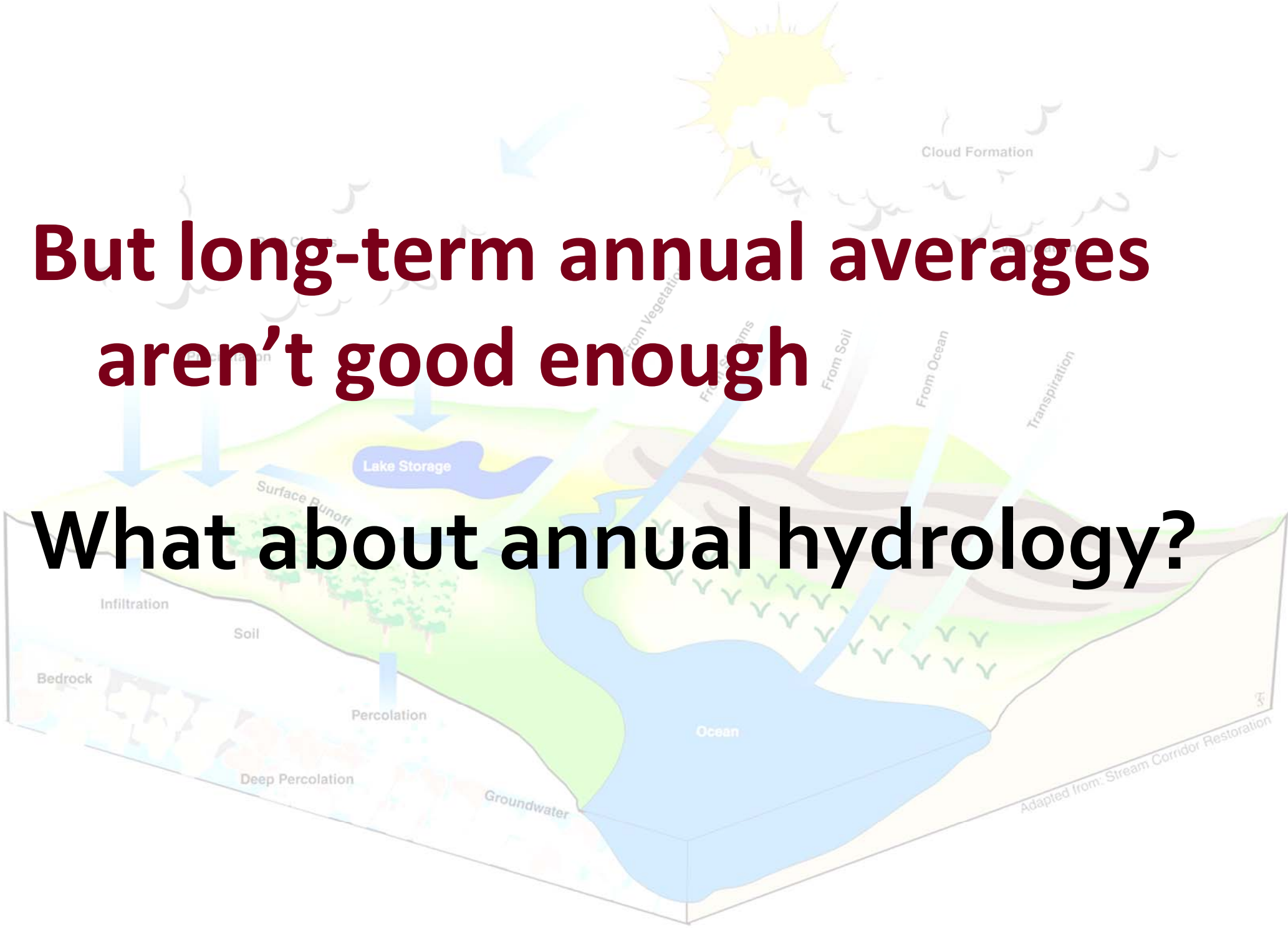
DRAINMOD



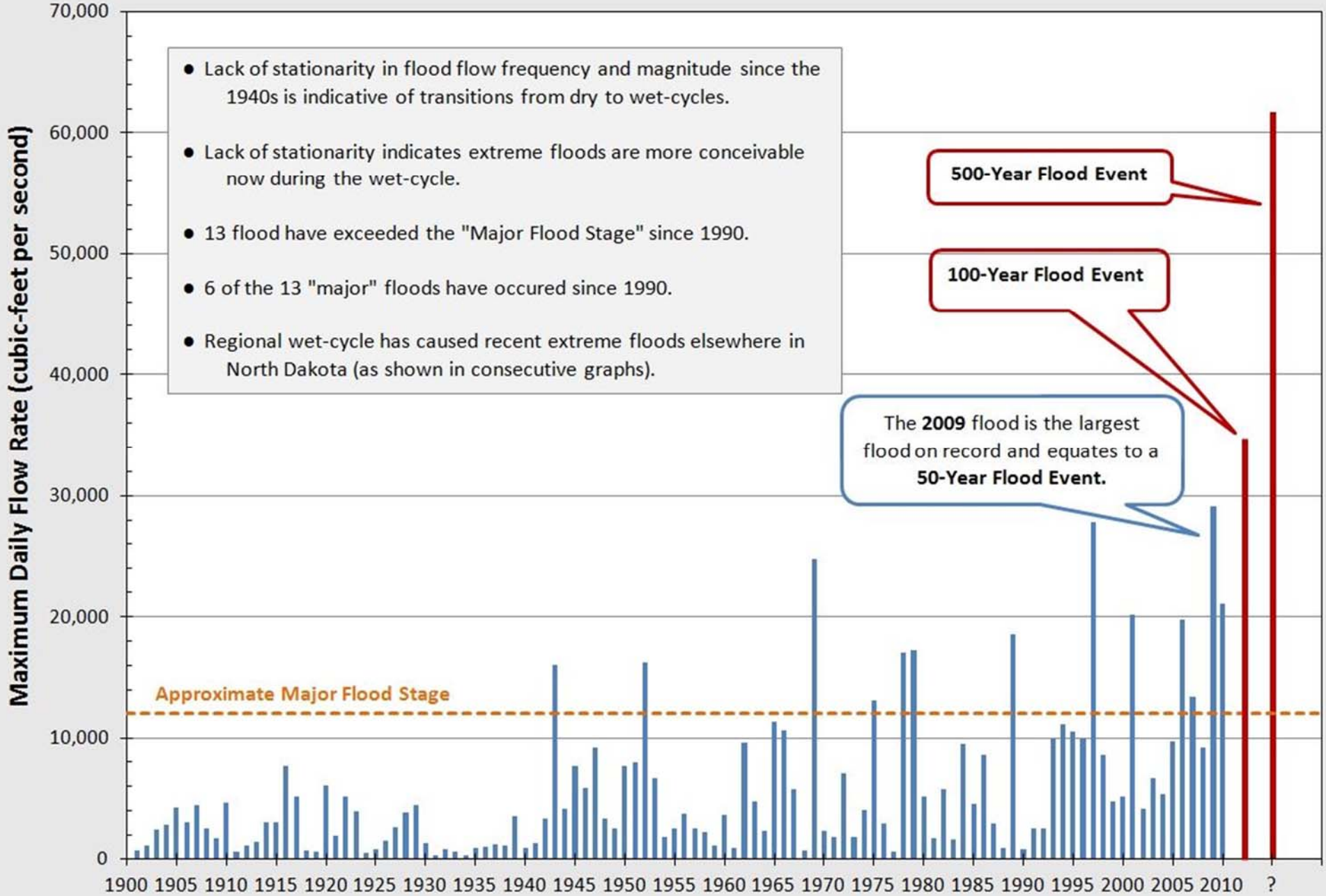


But long-term annual averages aren't good enough

What about annual hydrology?

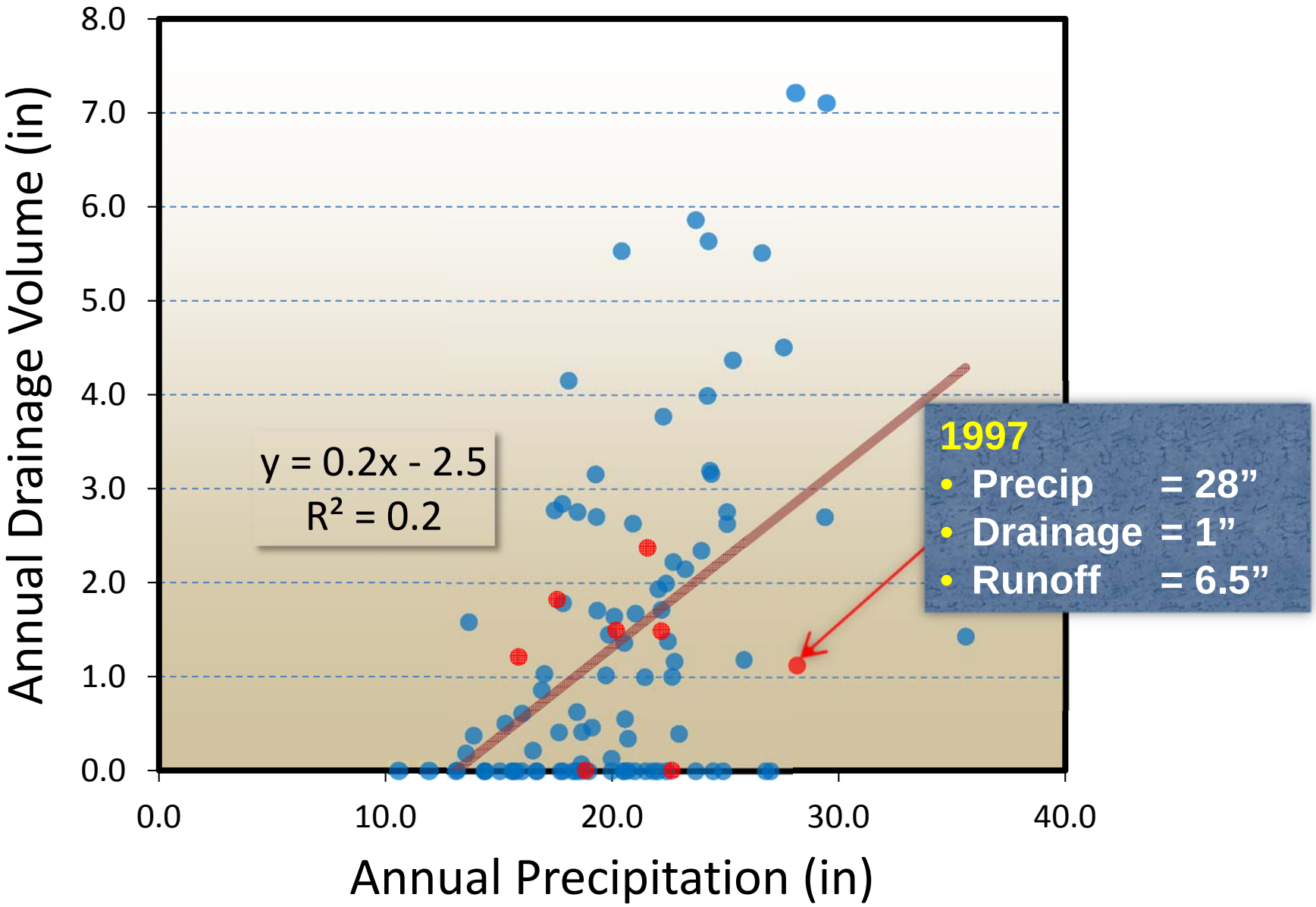


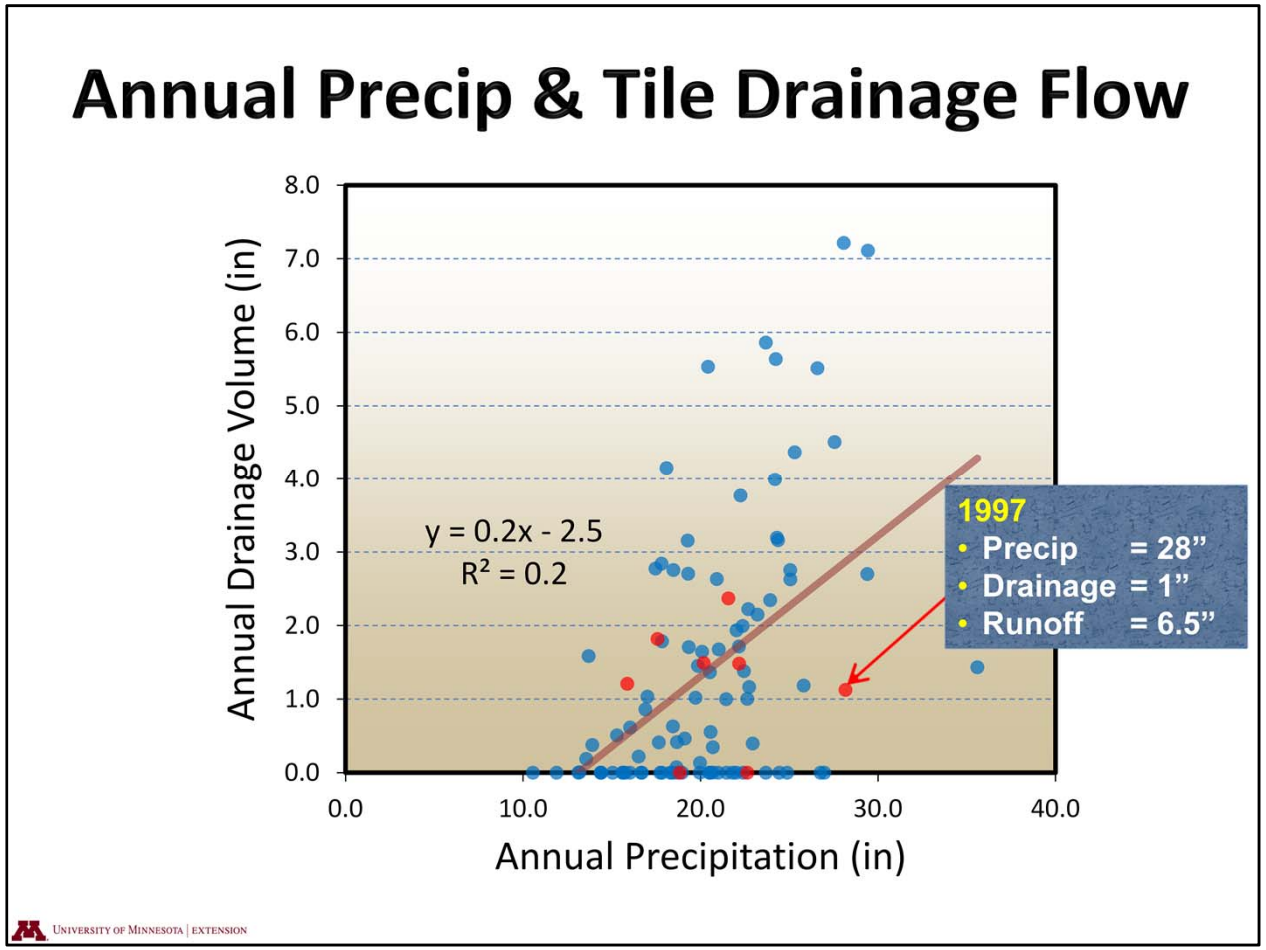
Red River of the North at Fargo, North Dakota



Source: USGS river flow data from USGS Station 05054000

Annual Precip & Tile Drainage Flow



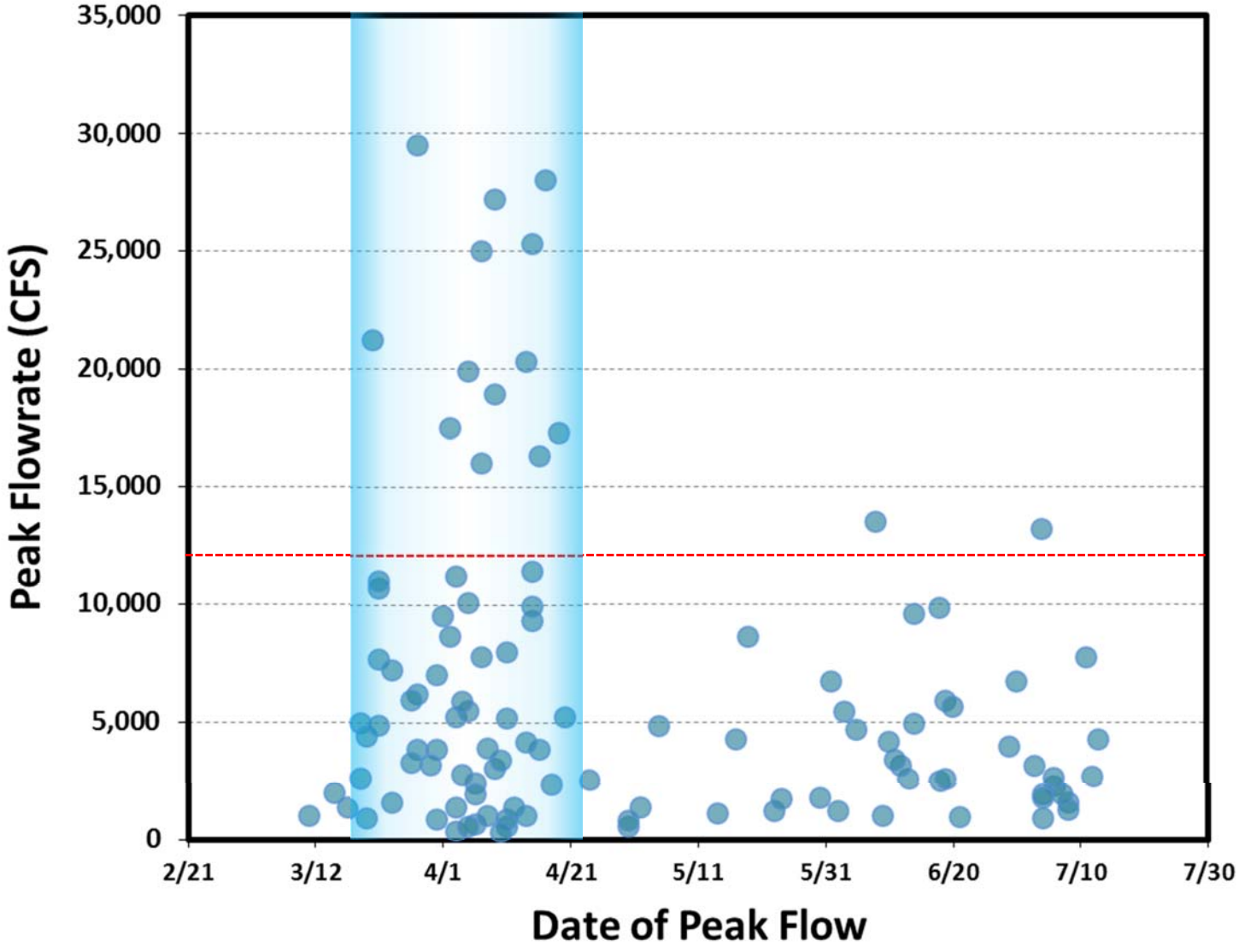


Annual simulated tile drainage, plotted versus precipitation, for Crookston, 1900-1990. Annual drainage doesn’t correlate well with annual precipitation, and we see many years and a wide range of precipitation values for which no annual tile drainage is predicted. The reason for this poor correlation is that the timing and intensity of precipitation is more important when it some to tile flow, than the annual precip amount. The red colored points are the annual tile flow predicted during 8 of the 13 major flooding years that have occurred since 1990 for the Red River (through 1997). The flow volumes highlighted in the box indicate that in 1997, the model predict that the system would have been dominated by surface flows, and tile drainage would have played a minor role in hydrology.

But annual numbers aren't good enough either

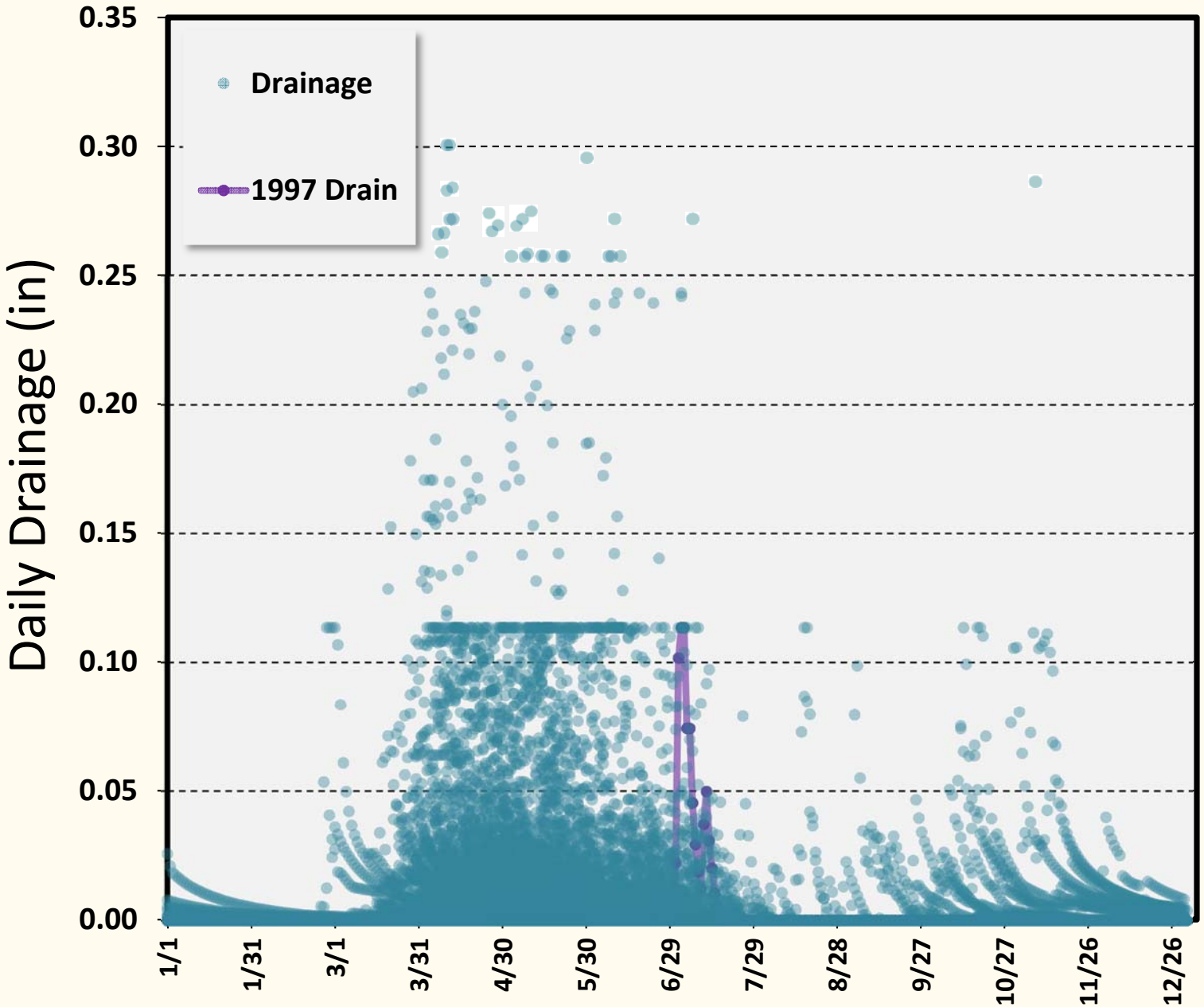
We need to understand hydro on seasonal/daily basis

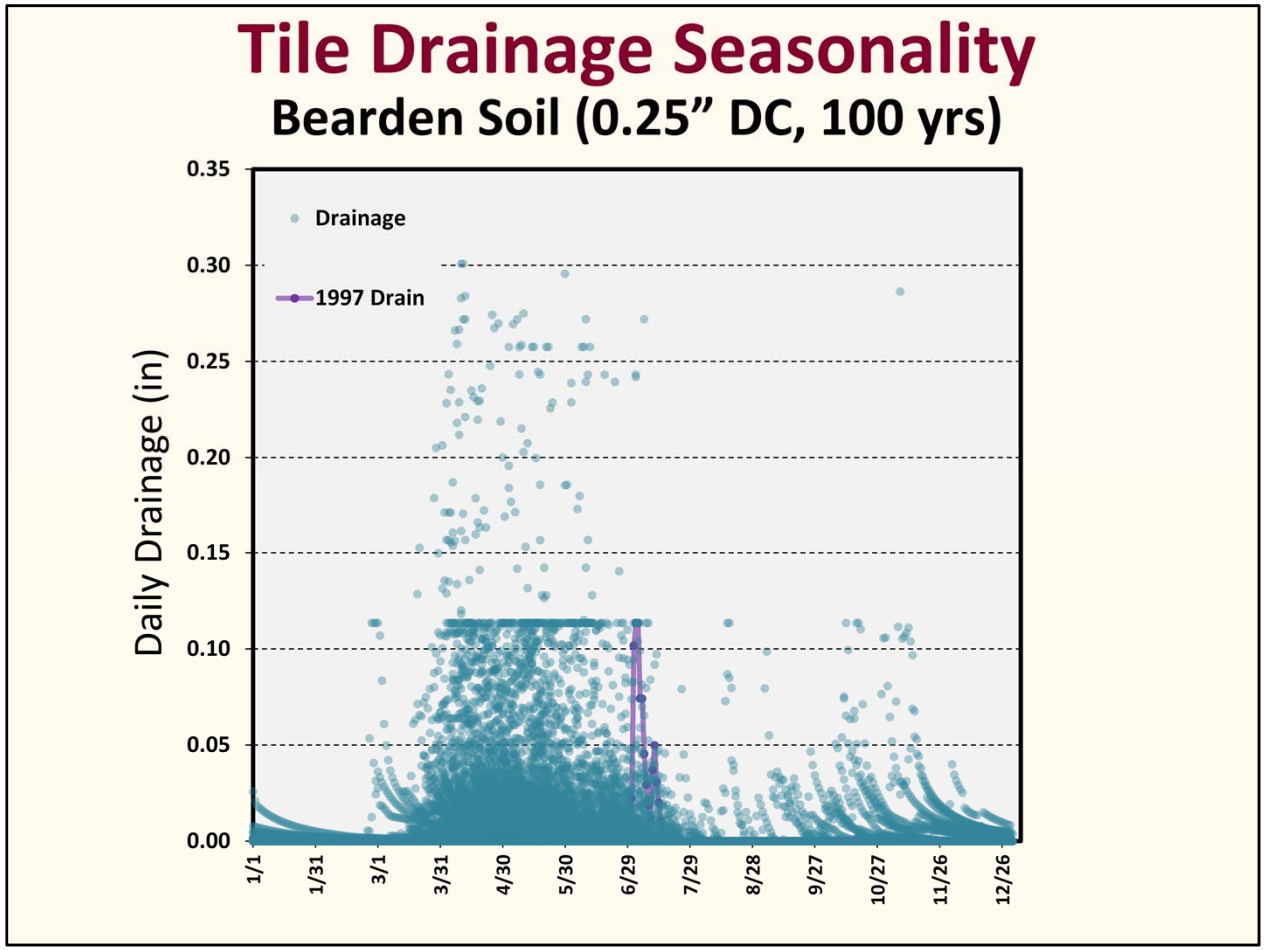
Timing of Ann Peak Flows at Fargo



Tile Drainage Seasonality

Bearden Soil (0.25” DC, 100 yrs)

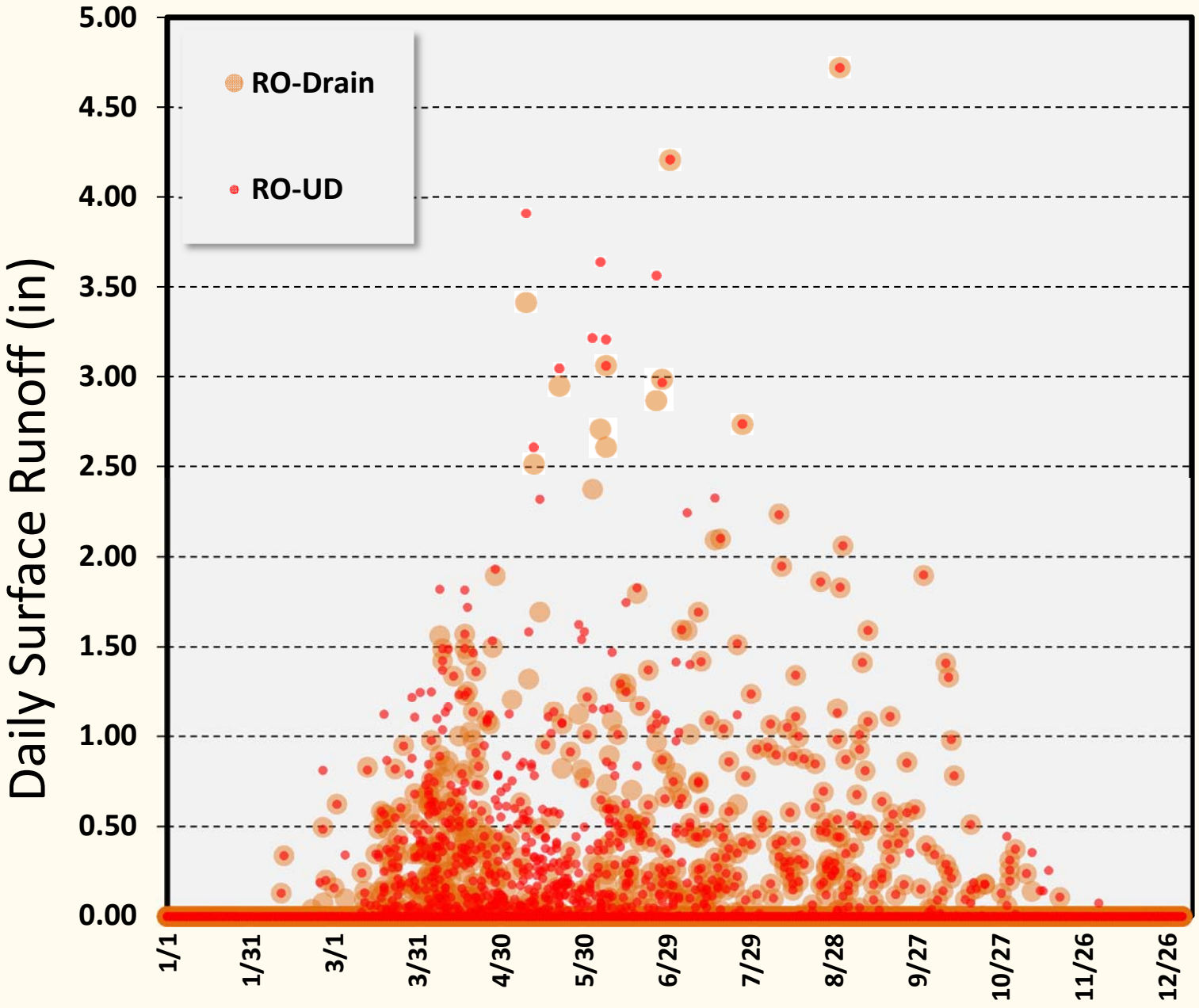


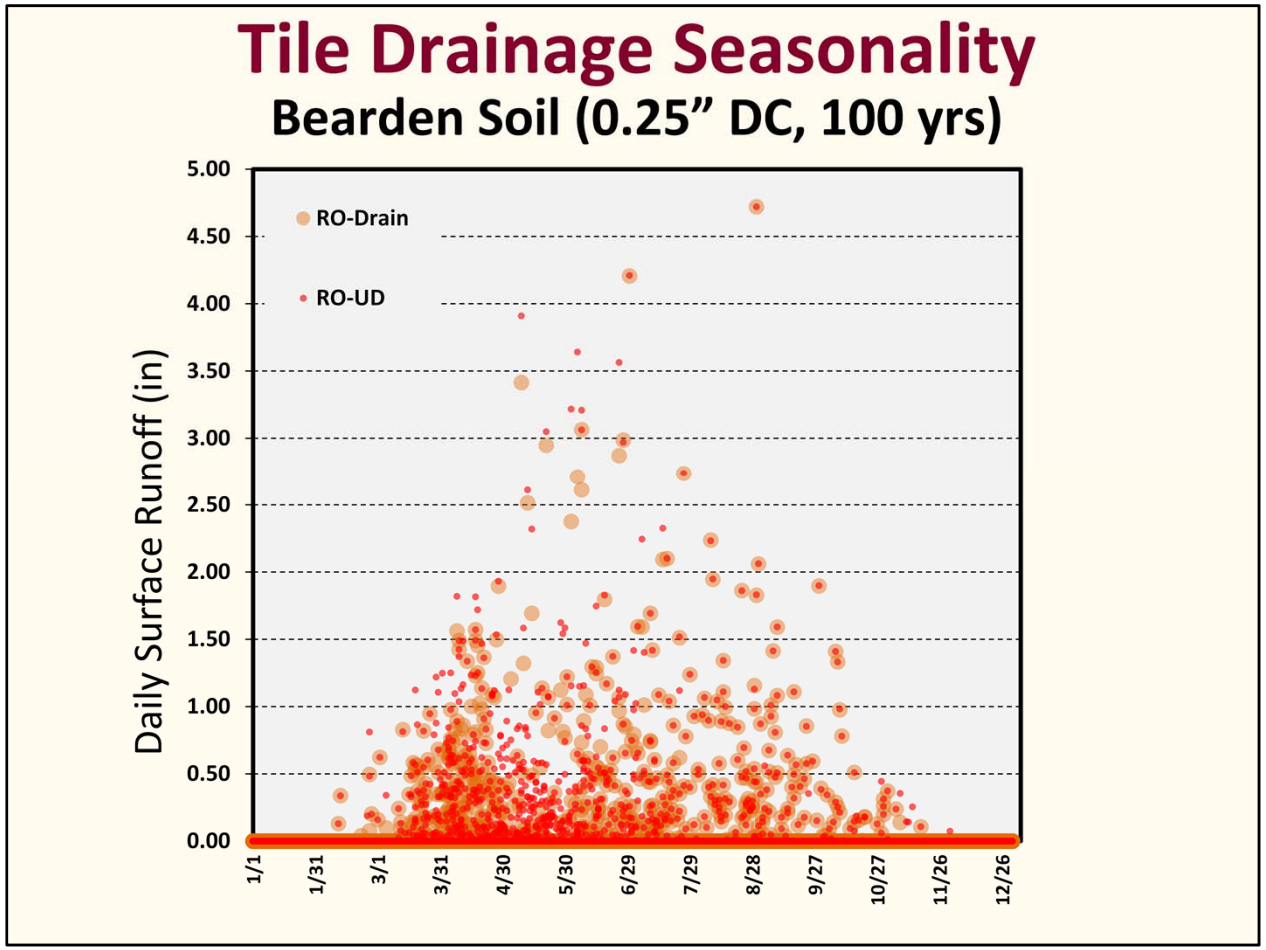


The blue dots represent simulated daily tile flow over 100 years. The clustering of the points between March and the end of June illustrate that this is the primary tile flow season. In addition, all the largest daily tile flows occur in this part of the year. The purple line is the daily tile flow for the 1997 season, indicating that the tile flow peak occurred well after the flooding season, where flows were dominated by surface runoff (not tile flow).

Tile Drainage Seasonality

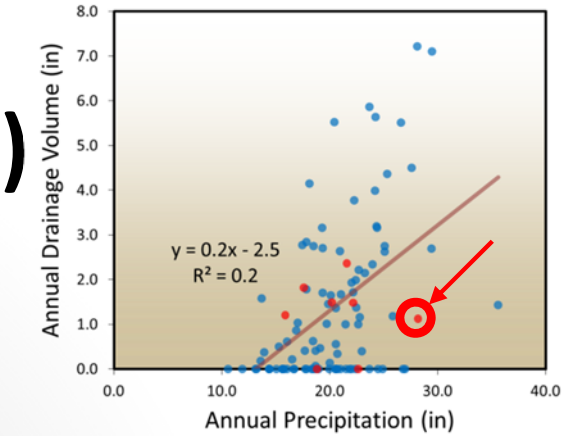
Bearden Soil (0.25” DC, 100 yrs)

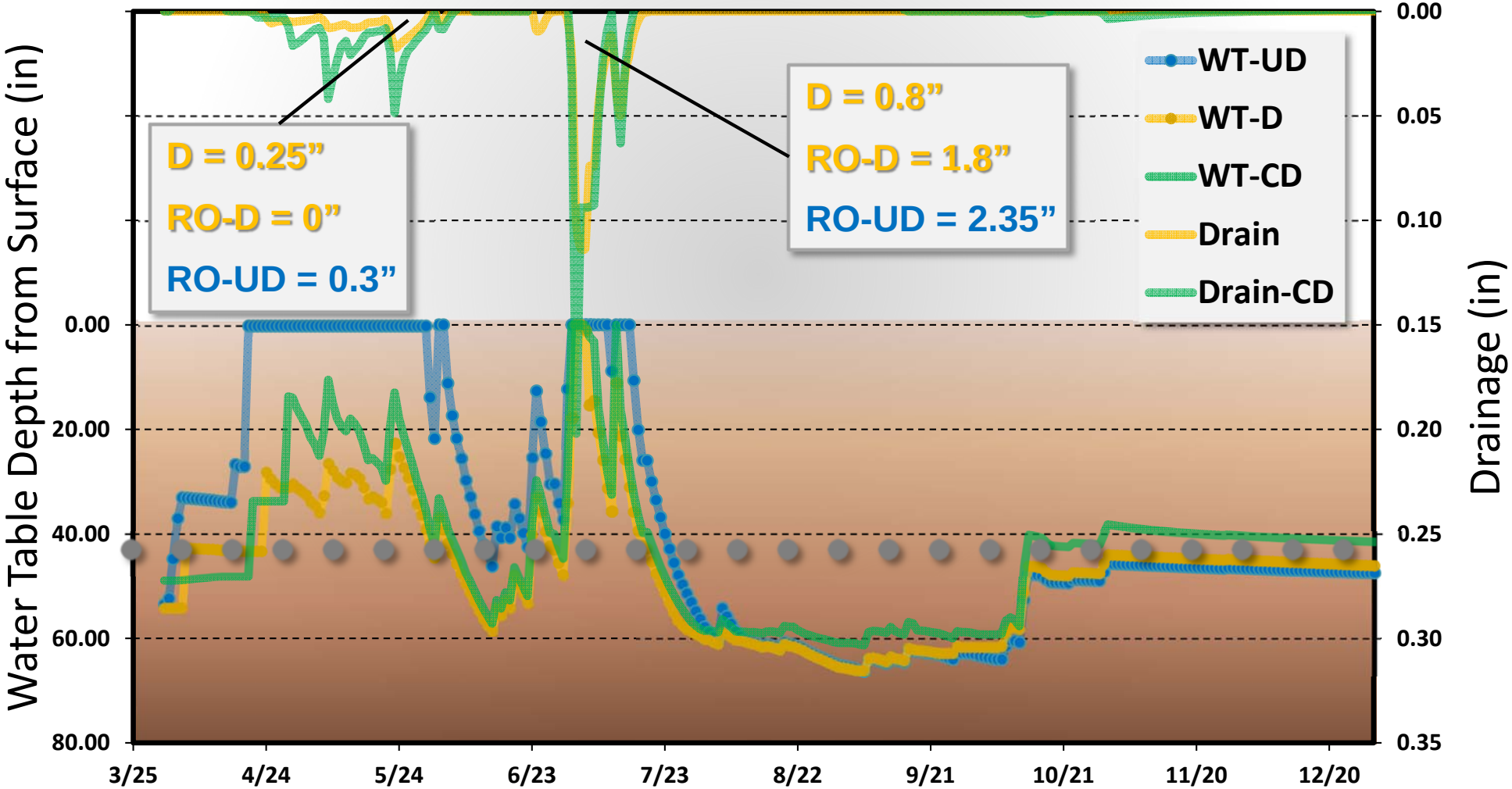


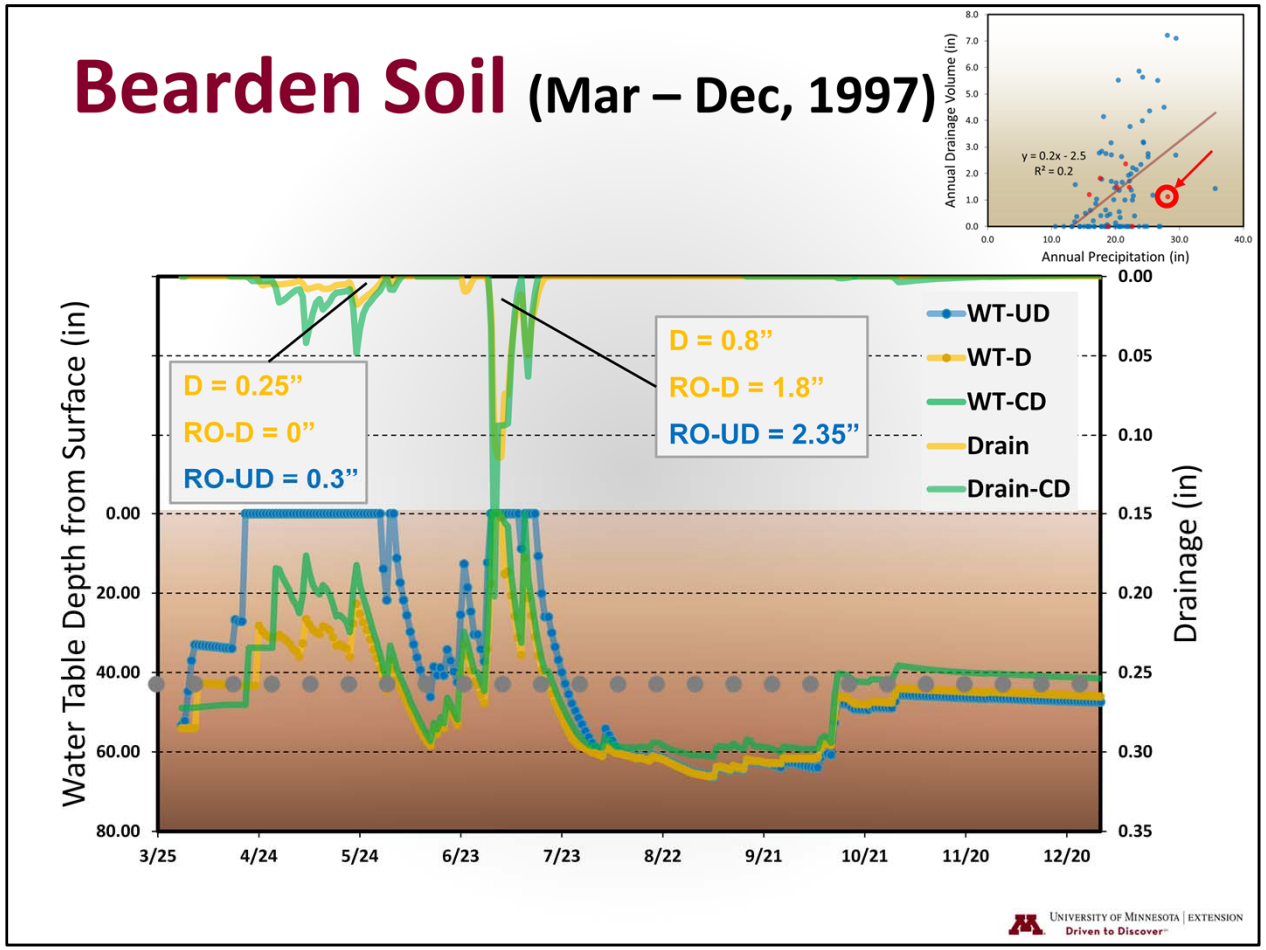


Here we have simulated daily surface runoff, under both drained (orange), and undrained (red) conditions. We find that beginning in June or so, the runoff values for both drained and undrained conditions are aligned, indicating that the tile system is basically out of the picture at this point in the growing season. Earlier in the growing season, we see that on many occasions, the undrained surface runoff values exceed those of the drained conditions, illustrating that tile drainage tends to reduce surface runoff and increase infiltration.

Bearden Soil (Mar – Dec, 1997)







In this slide we show the predicted water table depths and tile flow for 1997, to illustrate the differences in hydrology between drained and undrained conditions (the gray dotted line indicates the tile depth of 3.5 ft, for these simulations). The undrained water table (blue) rises quickly to the surface and remains there through the flooding season, and returns to the surface in late June. The drained water table (amber) remains well below the surface, but rises above the tile and produces drainage from late April to late May. The tile flow (read from the upper axis) for 1997 shows a smaller flow volume during flooding season and a larger spike in late June, early July. The flow volumes shown in the boxes for the two events indicate reduced surface runoff with the tile drained conditions.

In Summary

- Tile drainage – hydrology relationship is complex and involves many factors:
  - Soil & precip conditions VERY important
  - Precip can trump soil (or vice-versa, for frozen soil)
  - Everything changes in TIME & SPACE
- General cause-effect statements <u>unrealistic</u>
- Large-scale effects unknown—most work at field scale
- Studies suggest tiling may reduce surface runoff and increase infiltration
- Modeling studies suggest overall water yield may increase with tiling
- Surface flows may dominate in major flooding years
- We will have to be comfortable with probability basis

THANK YOU!

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Gary R. Sands, Ph.D.
Professor and Extension Engineer

Department of Bioproducts and Biosystems Engineering
College of Food, Agricultural and Natural Resource Sciences
College of Science and Engineering *612-625-4756*
209 Biosystems & Agricultural Engineering Bldg. *612-625-7733*
1390 Eckles Avenue *Fax: 612-624-3005*
St. Paul MN 55108-6005 *email: grsands@umn.edu*
http://www.bbe.umn.edu