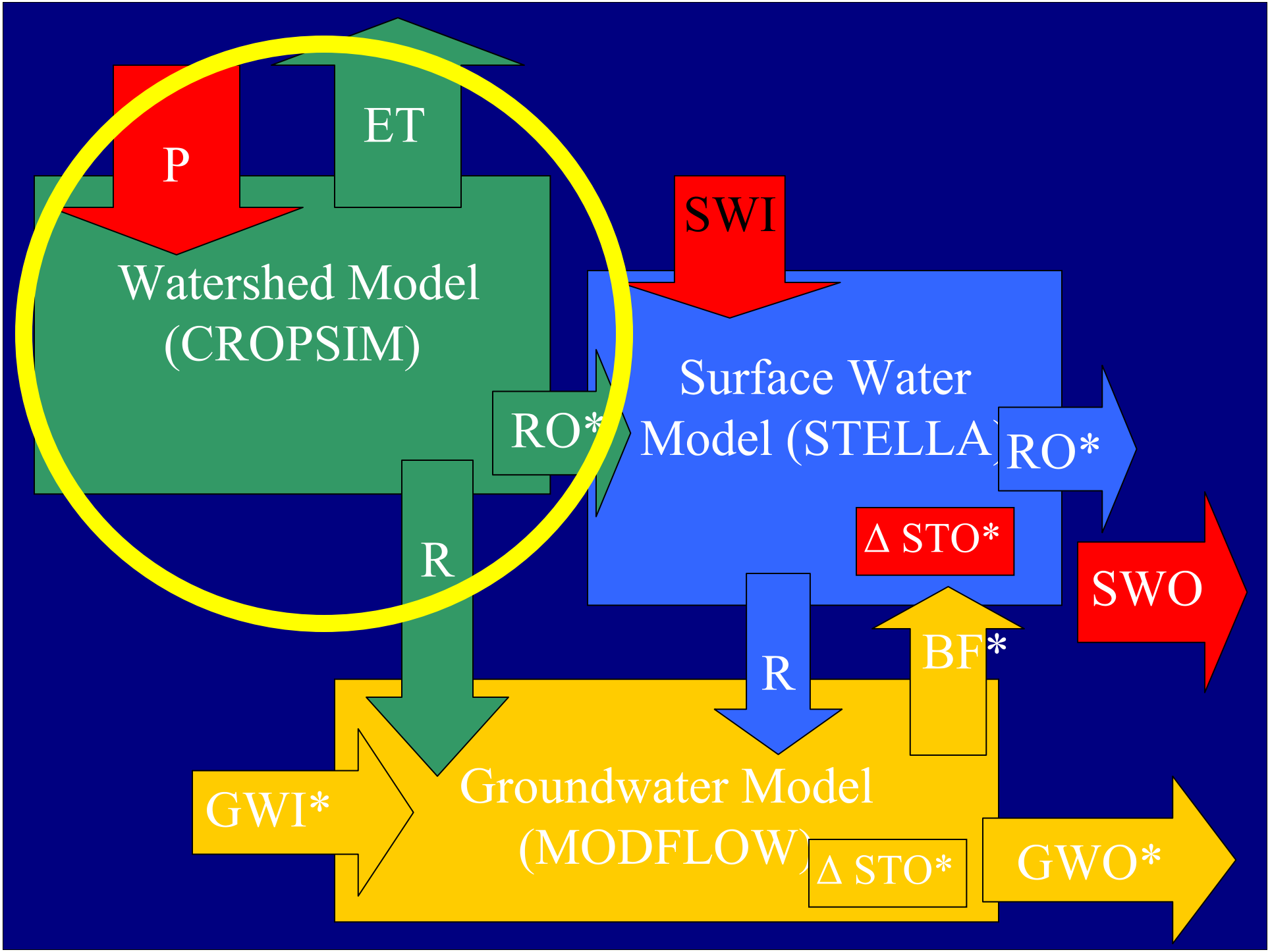
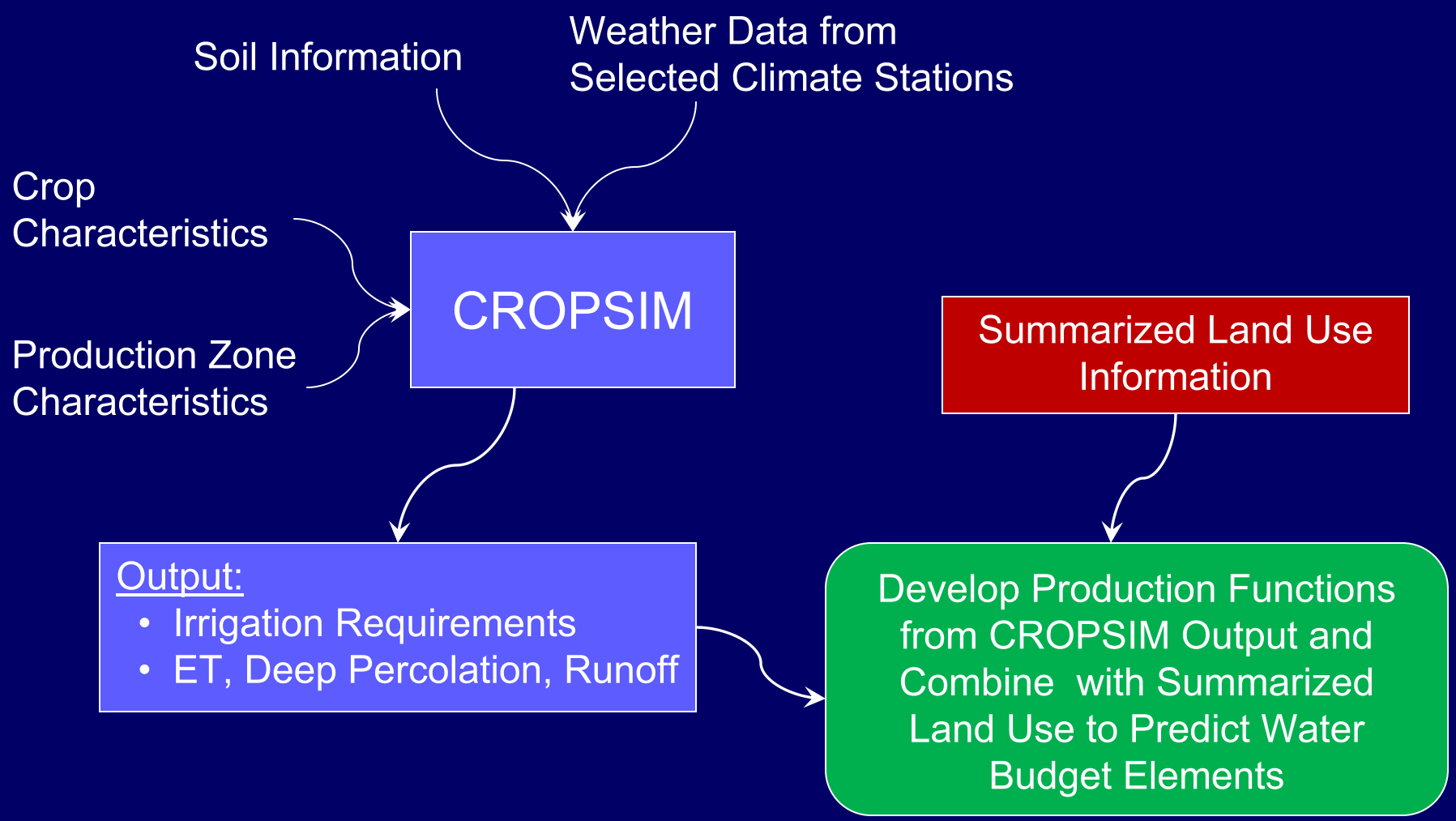
COHYST 2010

The Watershed Model

Marc Groff – The Flatwater Group, Inc

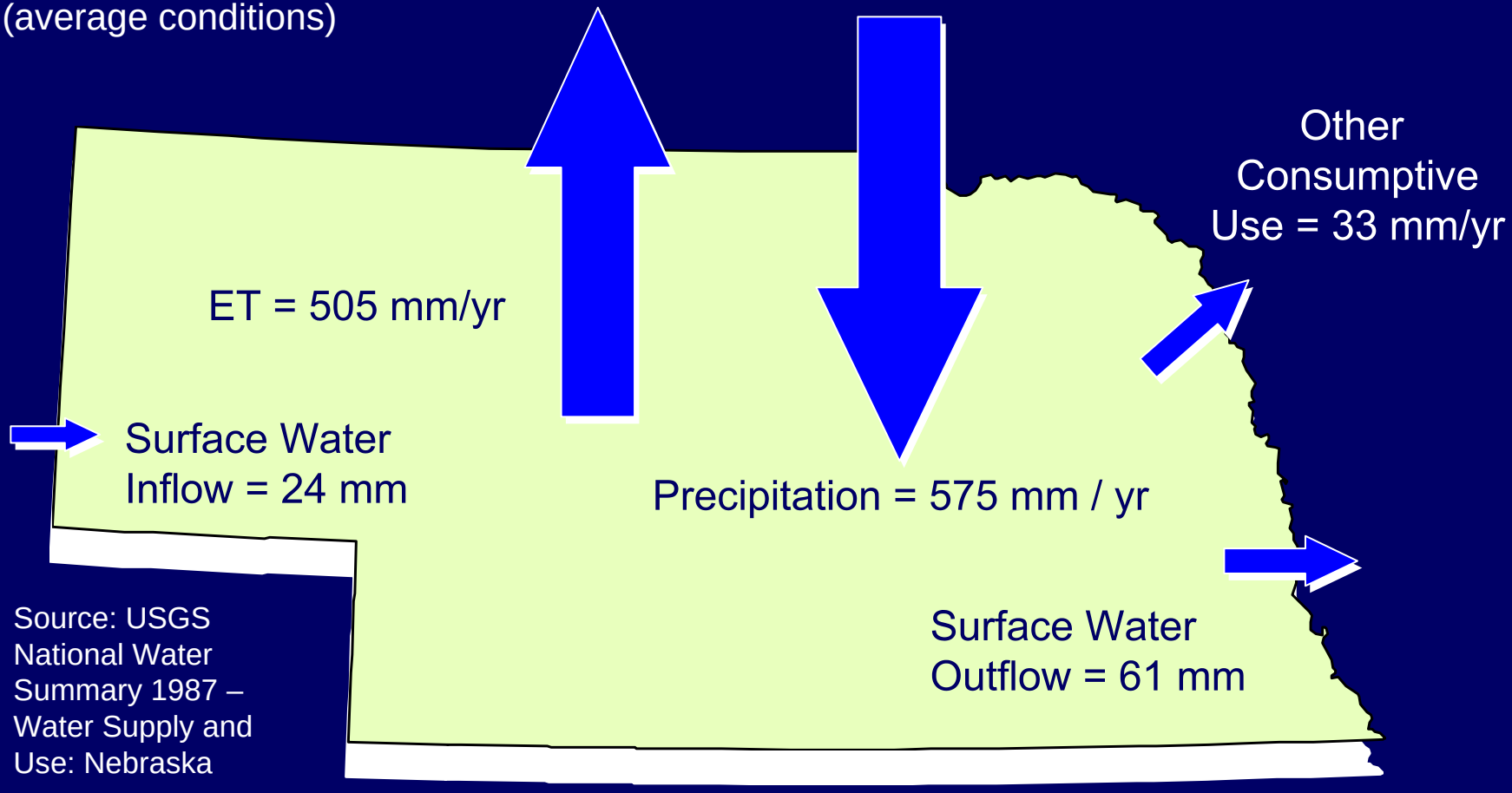

P
ET
Watershed Model
(CROPSIM)
SWI
Surface Water
Model (STELLA)
RO*
RO*
Δ STO*
SWO
R
R
BF*
GWI*
Groundwater Model
(MODFLOW)
Δ STO*
GWO*

GENERAL APPROACH



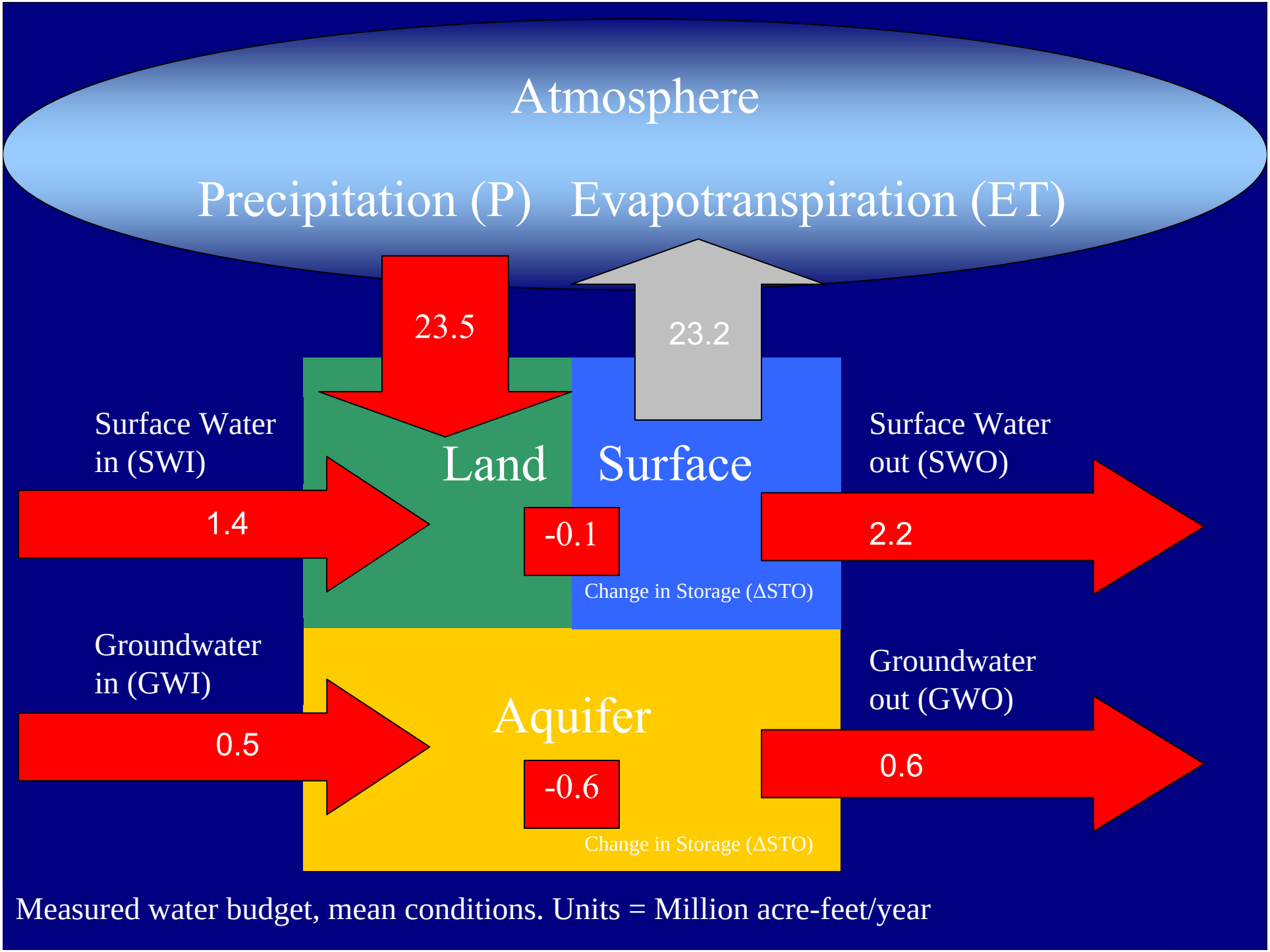
Nebraska's Water Supply

(average conditions)



Source: USGS National Water Summary 1987 – Water Supply and Use: Nebraska

~88% of Precipitation Goes to Evapotranspiration
~6% of Precipitation Goes to Increased Stream Flow
~8% of Evapotranspiration due to Irrigation



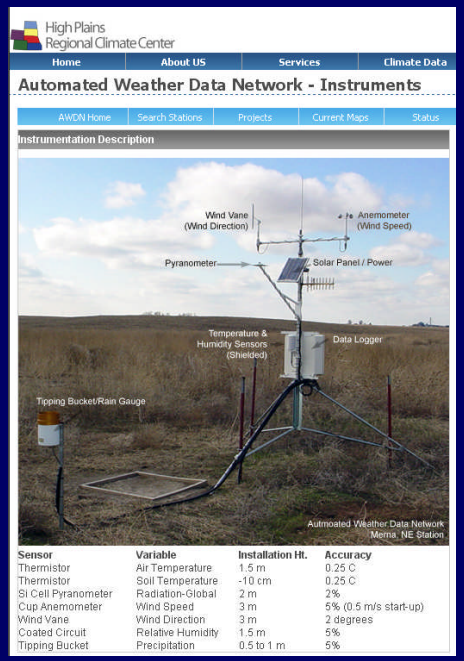
Measured water budget, mean conditions. Units = Million acre-feet/year

CROPSIM

- The Crops Simulation Model (CROPSIM) is a daily soil water balance model developed by Dr. Derrel Martin at UNL to aid in the prediction of:
  - Evapotranspiration (ET)
    - Based on the reference crop ET (ETr) method
  - Runoff
    - SCS Curve Number (CN) method
  - Deep Percolation
    - Volume of water which leaves the root zone

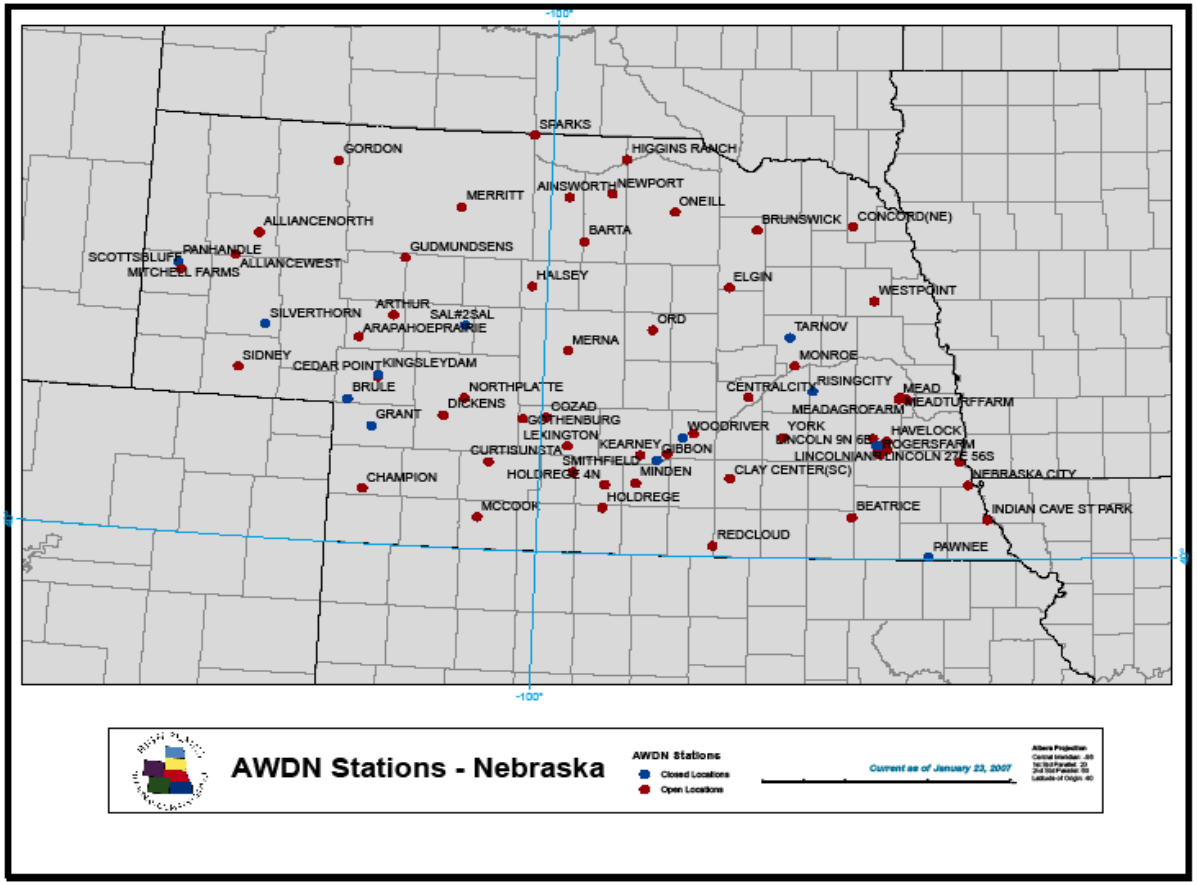
- CROPSIM is written in Fortran and requires formatted input text files related to:
  - Climate
  - Soils
  - Farming Practices

CLIMATE INPUTS



Sensor	Variable	Installation Ht.	Accuracy
Thermistor	Air Temperature	1.5 m	0.25 C
Thermistor	Soil Temperature	-10 cm	0.25 C
Si Cell Pyranometer	Radiation-Global	2 m	2%
Cup Anemometer	Wind Speed	3 m	5% (0.5 m/s start-up)
Wind Vane	Wind Direction	3 m	2 degrees
Coated Circuit	Relative Humidity	1.5 m	5%
Tipping Bucket	Precipitation	0.5 to 1 m	5%

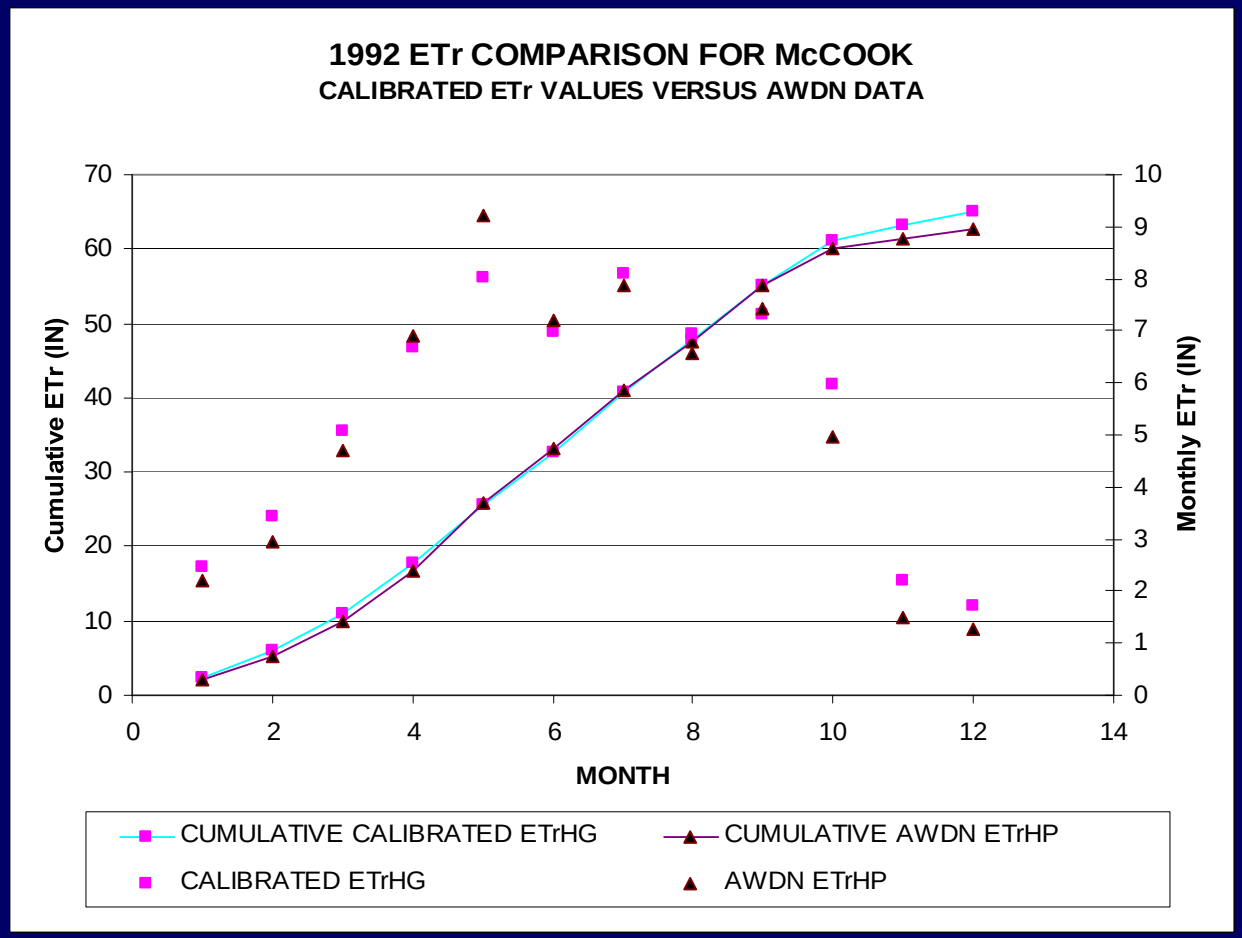
- Calibration process pooled data from multiple automated weather stations (AWDN stations)



Data available after ~ 1985

CLIMATE INPUTS

- Pooling allows for a single calibrated equation to be used for multiple stations within the calibration area



$ETr = (A + B * Long^2)HF^c$

where a, b, and c are monthly regression coefficients; HF = Hargreaves factor
Long = Longitude of the weather station, degrees

CLIMATE INPUTS

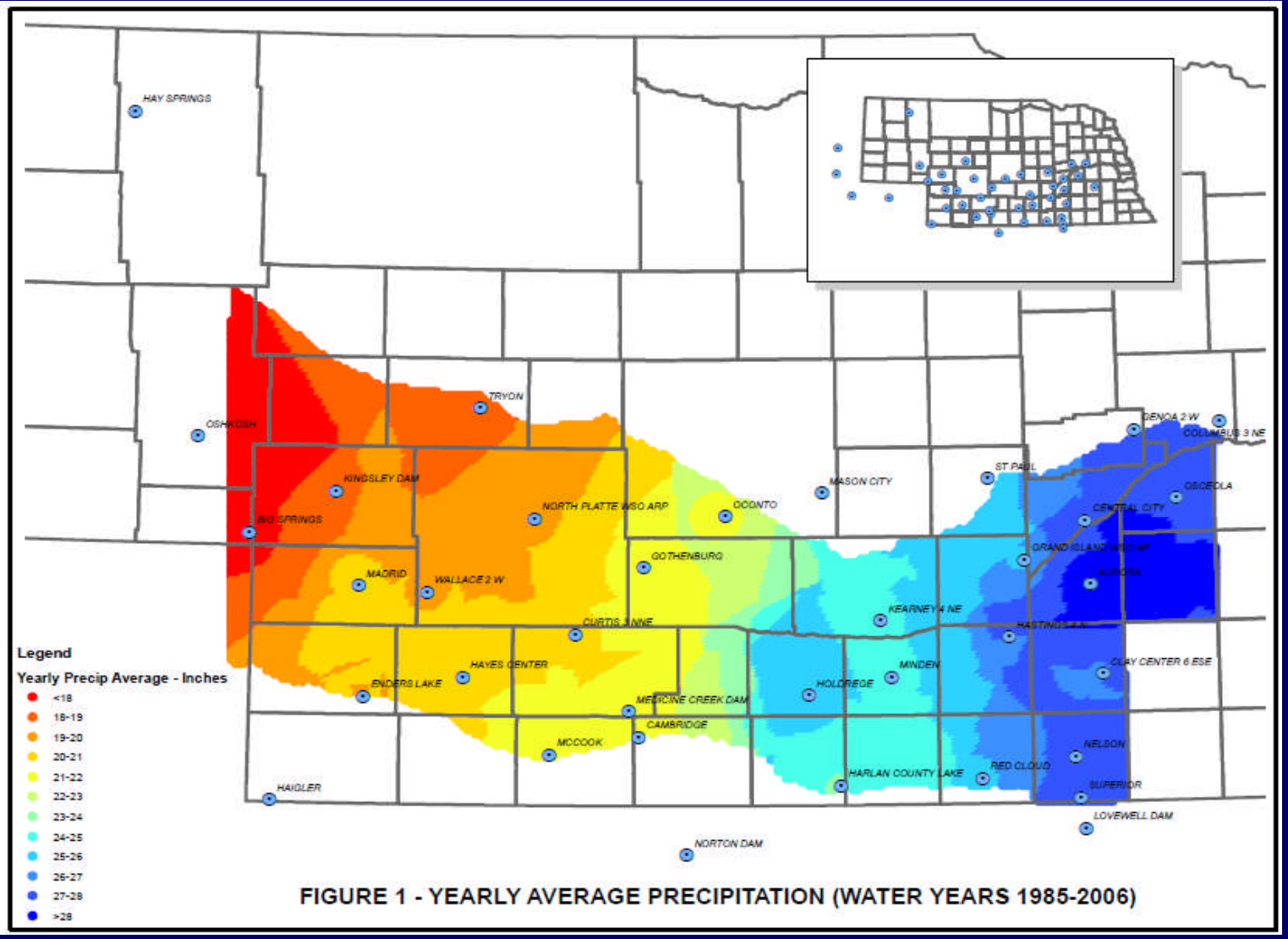
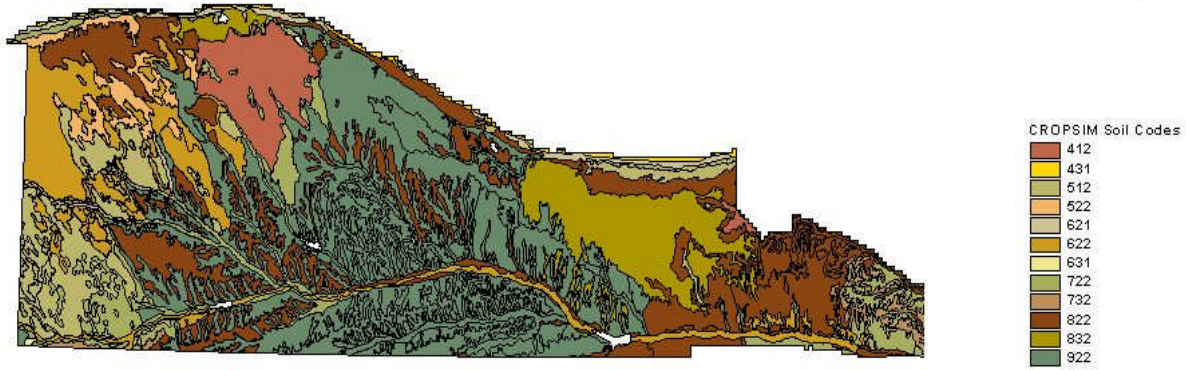


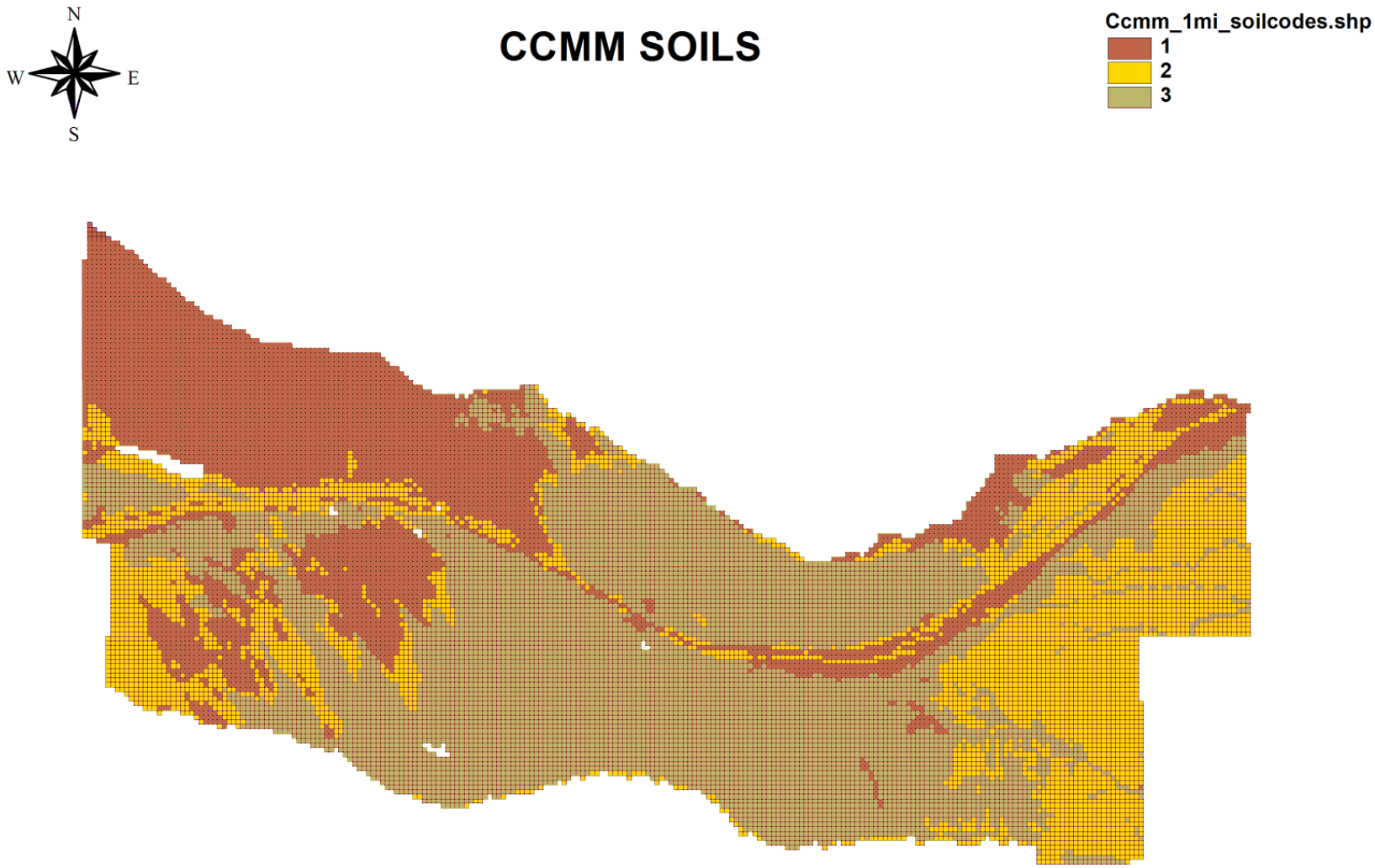
FIGURE 1 - YEARLY AVERAGE PRECIPITATION (WATER YEARS 1985-2006)

SOIL INPUTS

- CROPSIM Soil Code Definition
  - Available water holding capacity (1/4” water/foot soil)
  - NRCS Hydrologic Soil Group
    - 1=A
    - 2=B
    - 3=C
    - 4=D
  - Depth to ground water indicator
    - 1<=6 feet
    - 2>6 feet



SOIL INPUTS



CROP CHARACTERISTICS

- Crop and Zone specific
  - Files can be used for both spatial and temporal variations in practices

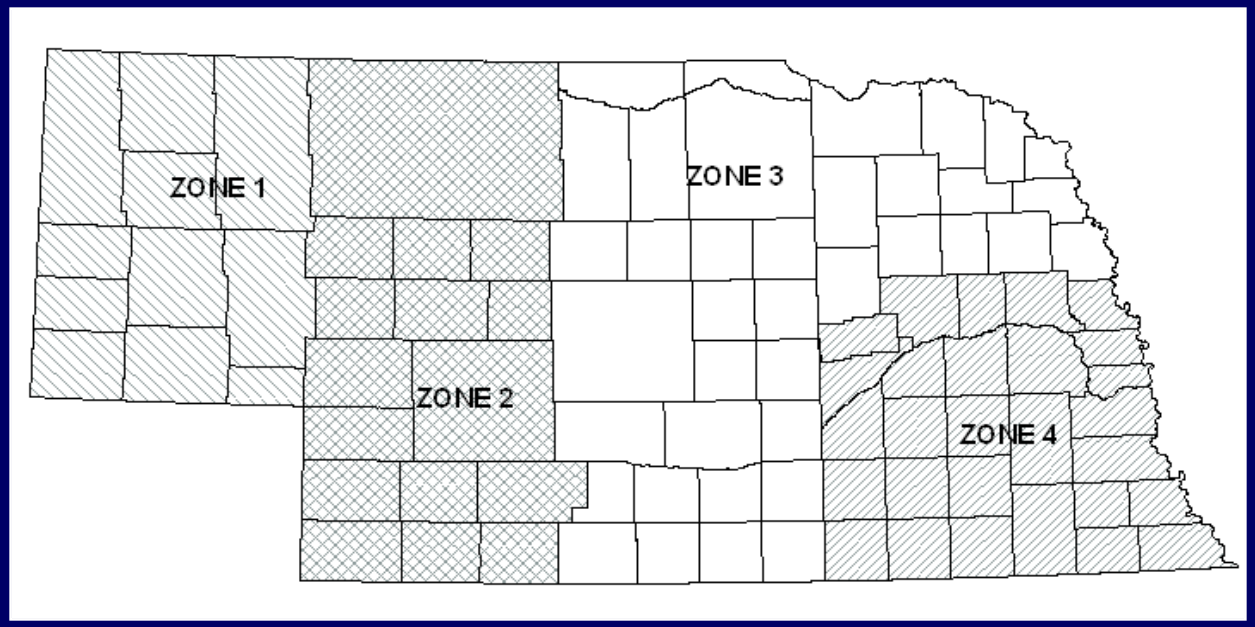
```
8  10                                CROP, LAYERS
05 01  1 01 12 31                    PLANT, BEGIN, ENDING DATE
450. 1200. 1700. 2160. 1050. 2400.   GDD: VEG,FLOWER,RIPEN,YIELD FORM, ECOVER, MATURE
6. 72.  20.0  200.   48.             ROOT DEPTH: MIN, MAX,TBREAK,GDDROOT, MGMT RDEPTH
2    200.  1.25                        IYIELD, YMAX,YCOEF
0  1.5   30.    180.                 ITERRC, CHAND, CHANW, TINTRV

7      1                             NUMBER OF TILLAGE OPERATIONS, TILLAGE CODE (1=CONV,2=CONS,3=FALLOW)
1       61      38      Harrow - Springtooth
1       47      39      Knife Applicator
1       11      36      Harrow - Roller
2       1       62      Rowcrop Planter with Ripple/Bubble Coulters
2       24      53      Row Cultivator - Finger Wheel
2       56      54      Row Cultivator - Multiple Sweeps per Furrow
3       1       2       Chilsel Plow with Spike Points

3 0.50 0.50 0.50 0.50 0.50           IRRIG TYPE, PERCENT ALLOW DEPL
Center Pivot System with Impact Sprinklers
0.25 0.25 0.25 0.25 0.25 0.40        RAINFALL ALLOWANCE, SYSTEM CAP
0.90 0.90 0.90 0.90 0.90             PERCENT OPERATION TIME
0.75 0.75 0.75 0.75 0.75             APMIN
1.00 1.00 1.00 1.00 1.00             APMAX
0.75 0.75 0.75 0.75 0.75             SMALL IRRIGATION
500. 2100.  1  121                   GSTART, GSTOP, IRRSUP, JFIRST
0.85 0.85 0.85 0.85 0.85             APPLICATION EFFICIENCY
0.00 0.00 0.00 0.00 0.00             REUSE EFFICIENCY
0.00 0.00 0.00 0.00 0.00             RUNOFF PERCENTAGE
```

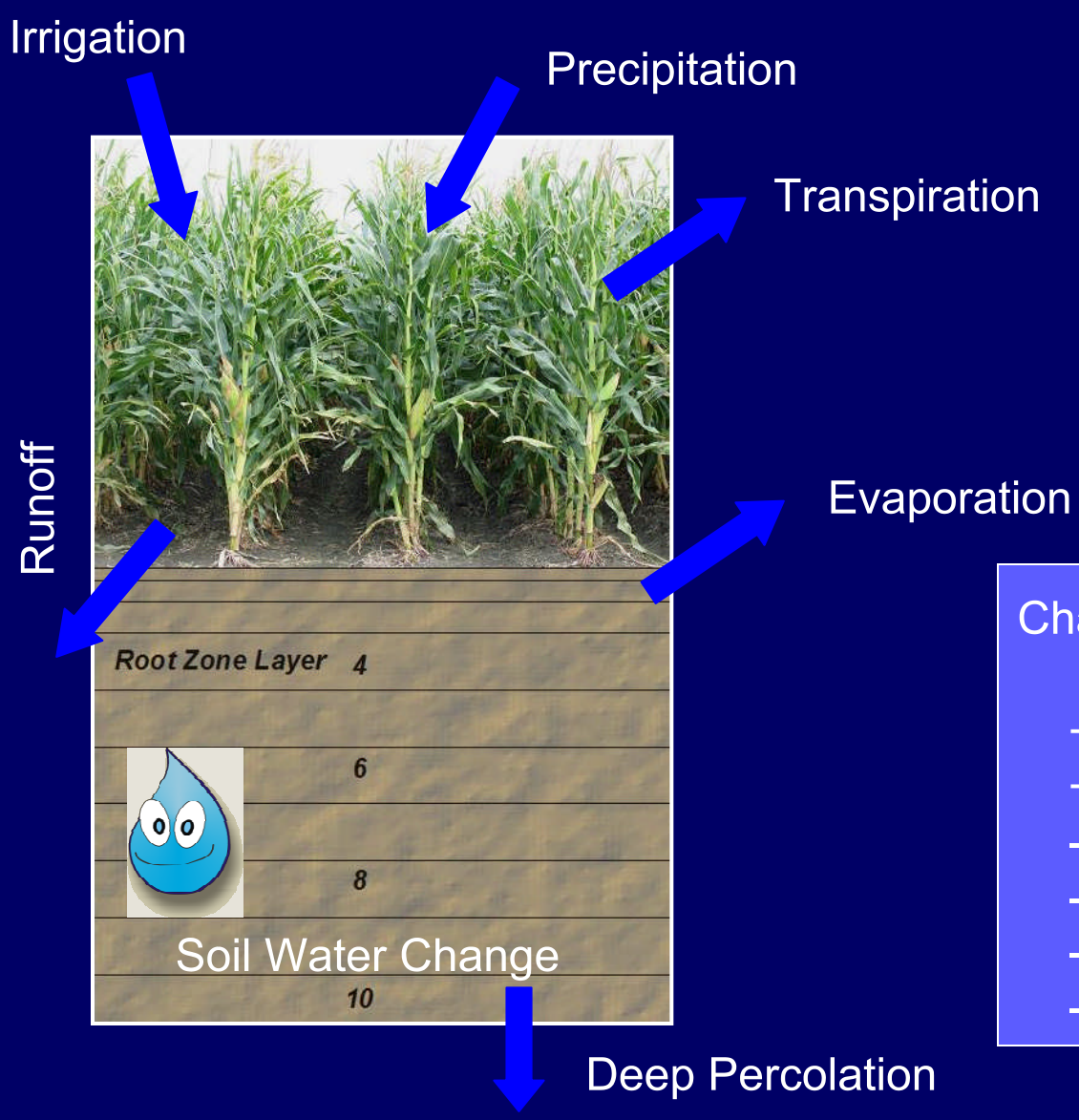
PRODUCTION ZONES

- Four management zones across Nebraska
- Zones allow farming practice variations
  - e.g. planting dates, tillage practices



Graphic from Appendix C, 2006 Fully Appropriated Basins Report, Nebraska Department of Natural Resources

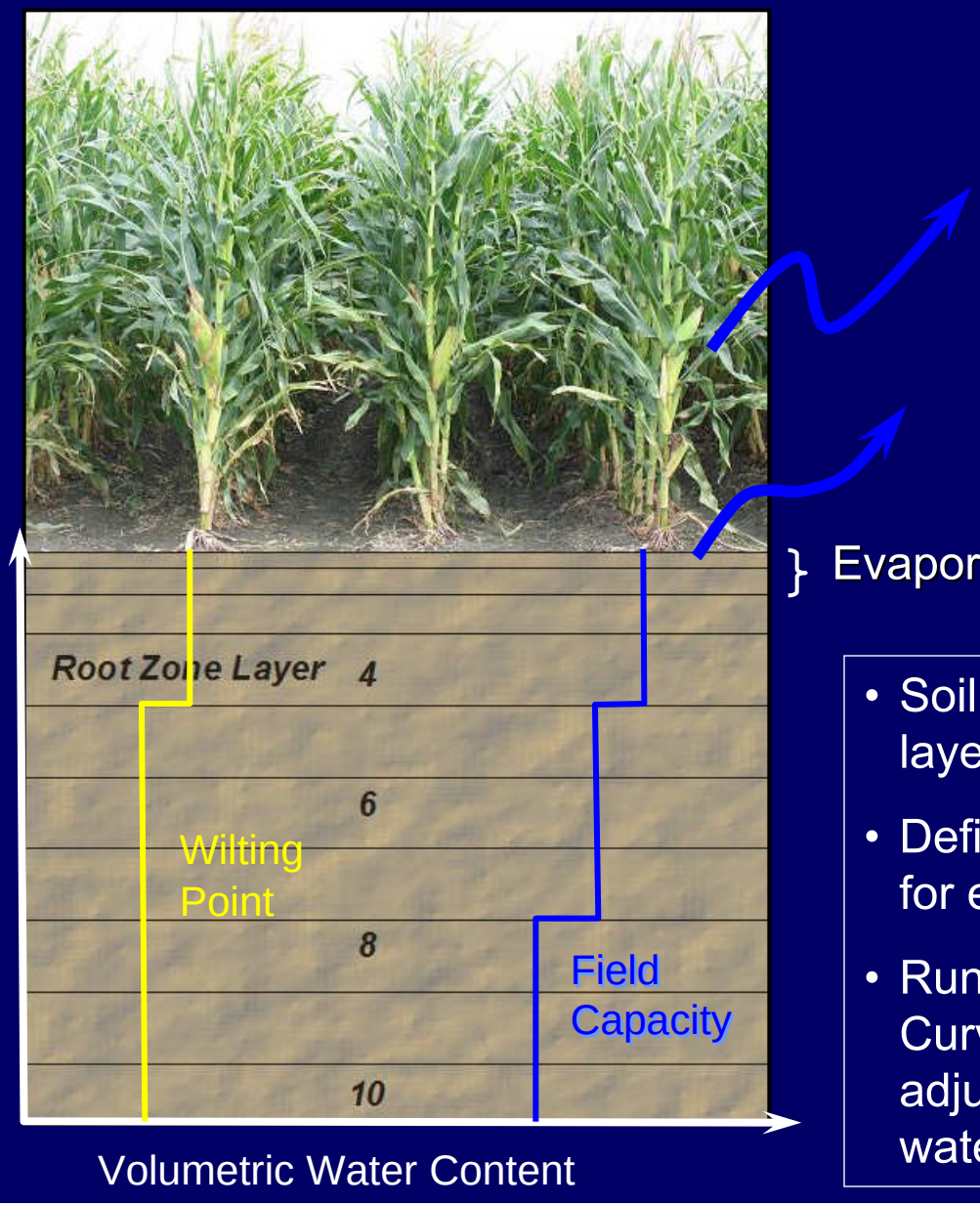
ROOT ZONE WATER BALANCE



Change In <u>Daily</u> Soil Water =

- \+ Precipitation
- \+ Irrigation
- \- Transpiration
- \- Evaporation
- \- Deep Percolation
- \- Runoff

ROOT ZONE WATER BALANCE



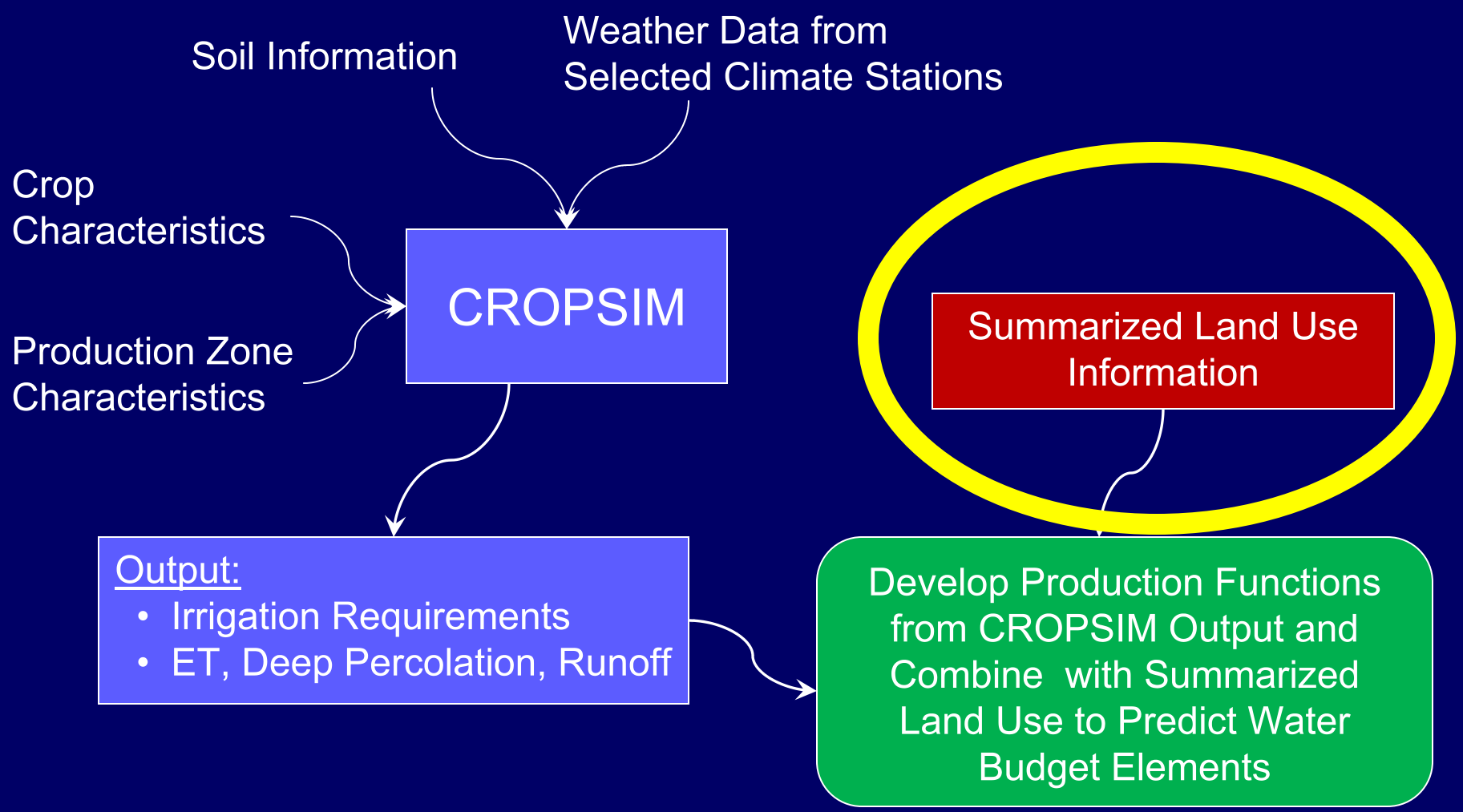
} Evaporation Zone

Transpiration based on:

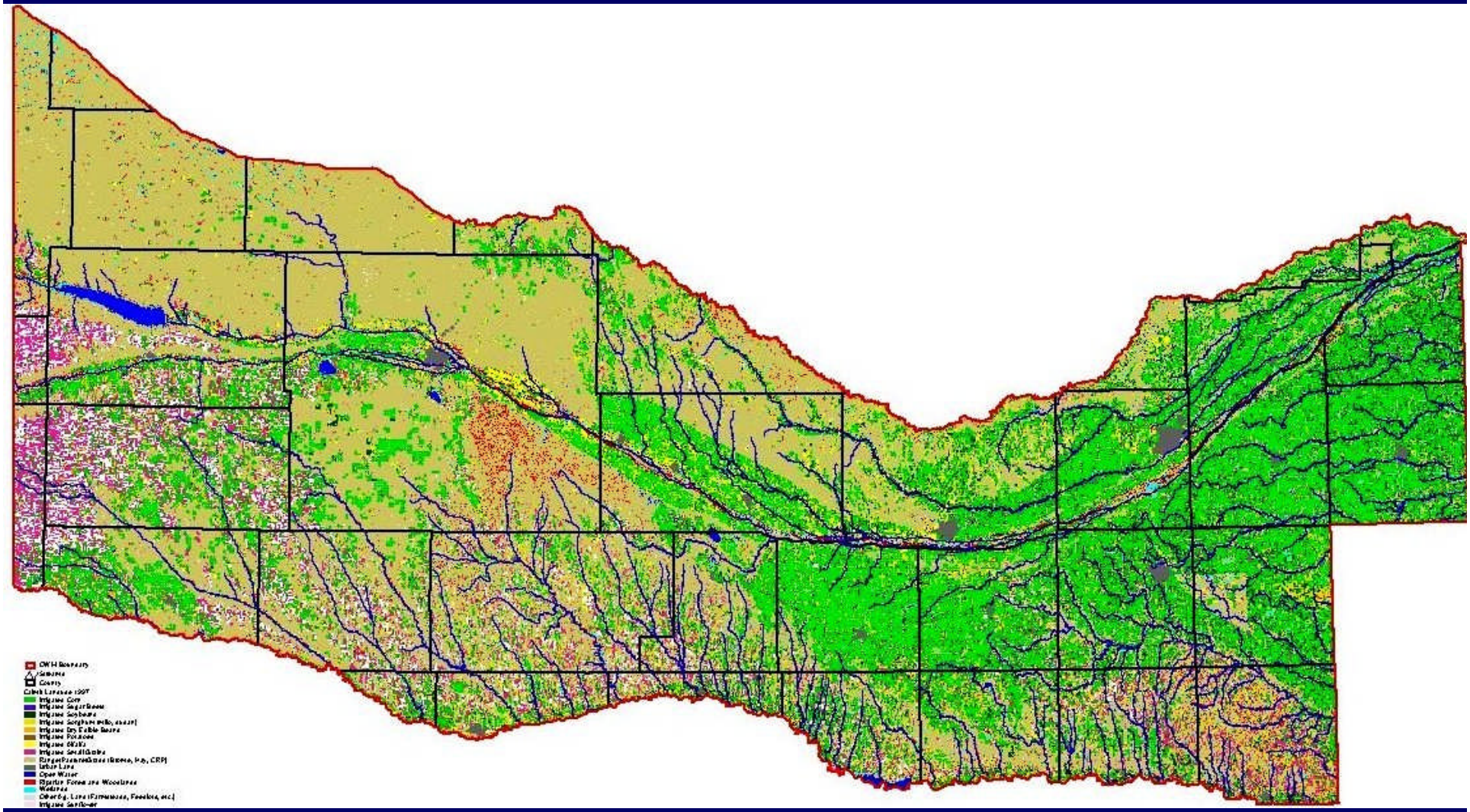
- Reference ET
- Crop coefficient
- Soil water depletion in the root zone

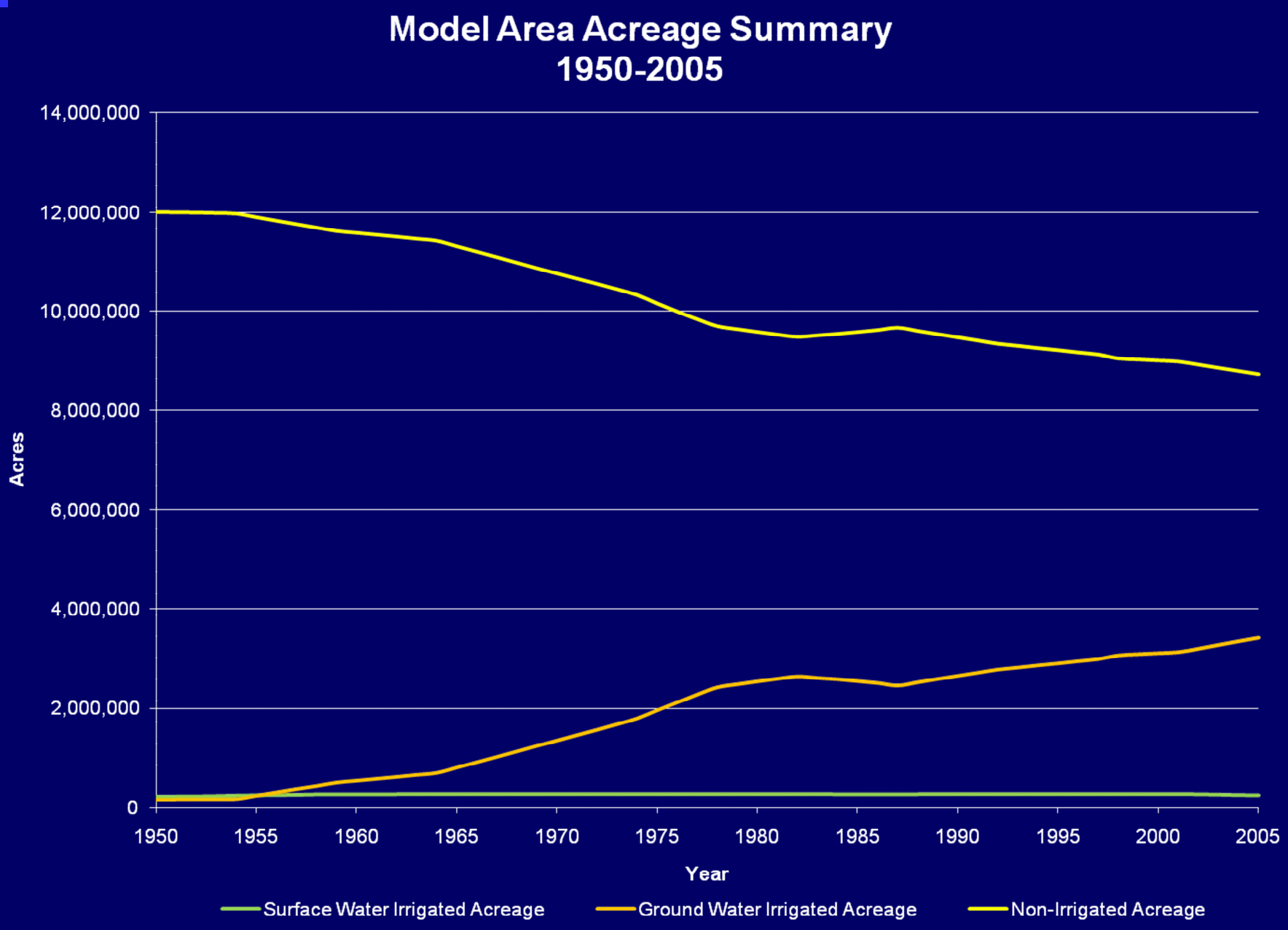
- Soil profile represented by up to 10 layers
- Define field capacity and wilting point for each layer
- Runoff computed with the NRCS Curve Number method with adjustments for crop residue and soil water content in top foot of soil.

GENERAL APPROACH

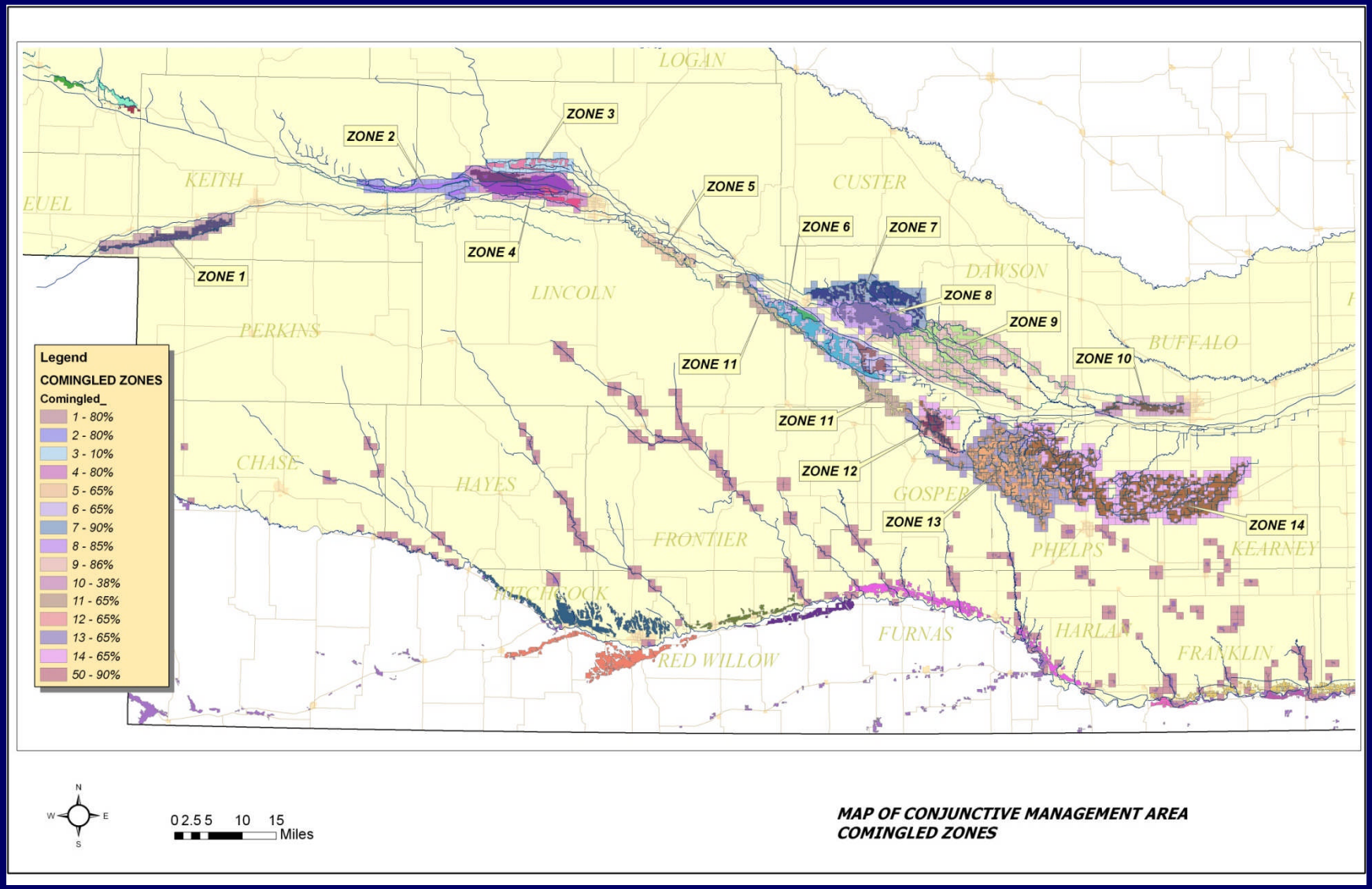


Land Use


Irrigated Corn
Irrigated Sugarbeets
Irrigated Soybeans
Irrigated Dry Edible Beans
Irrigated Potatoes
Irrigated Alfalfa
Irrigated Small Grains
Urban Land
Open Water
Riparian Forest and Woodlands
Wetlands
Irrigated Sunflower

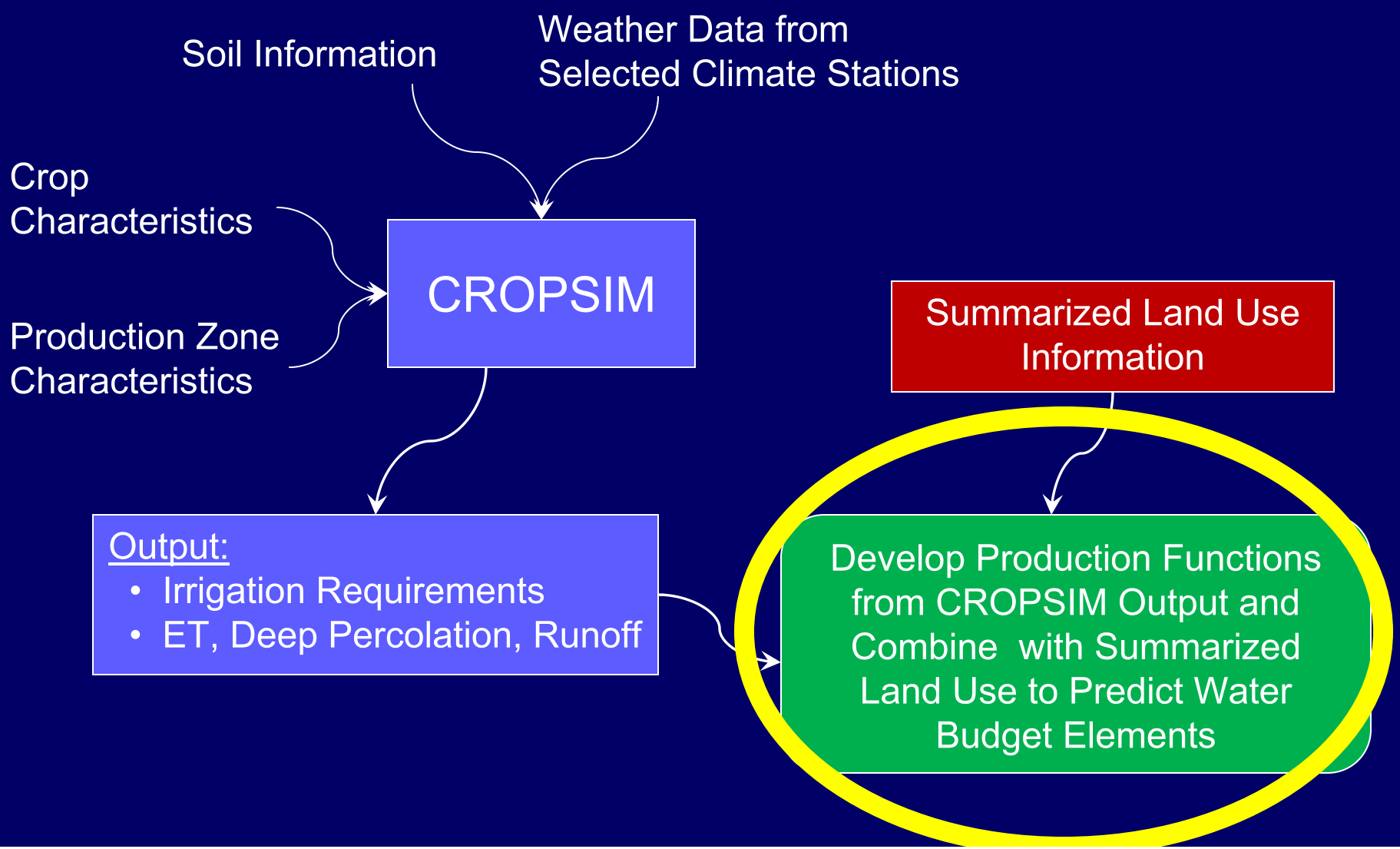

Model Area Acreage Summary
1950-2005
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
Acres
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year
Surface Water Irrigated Acreage
Ground Water Irrigated Acreage
Non-Irrigated Acreage

Land Use

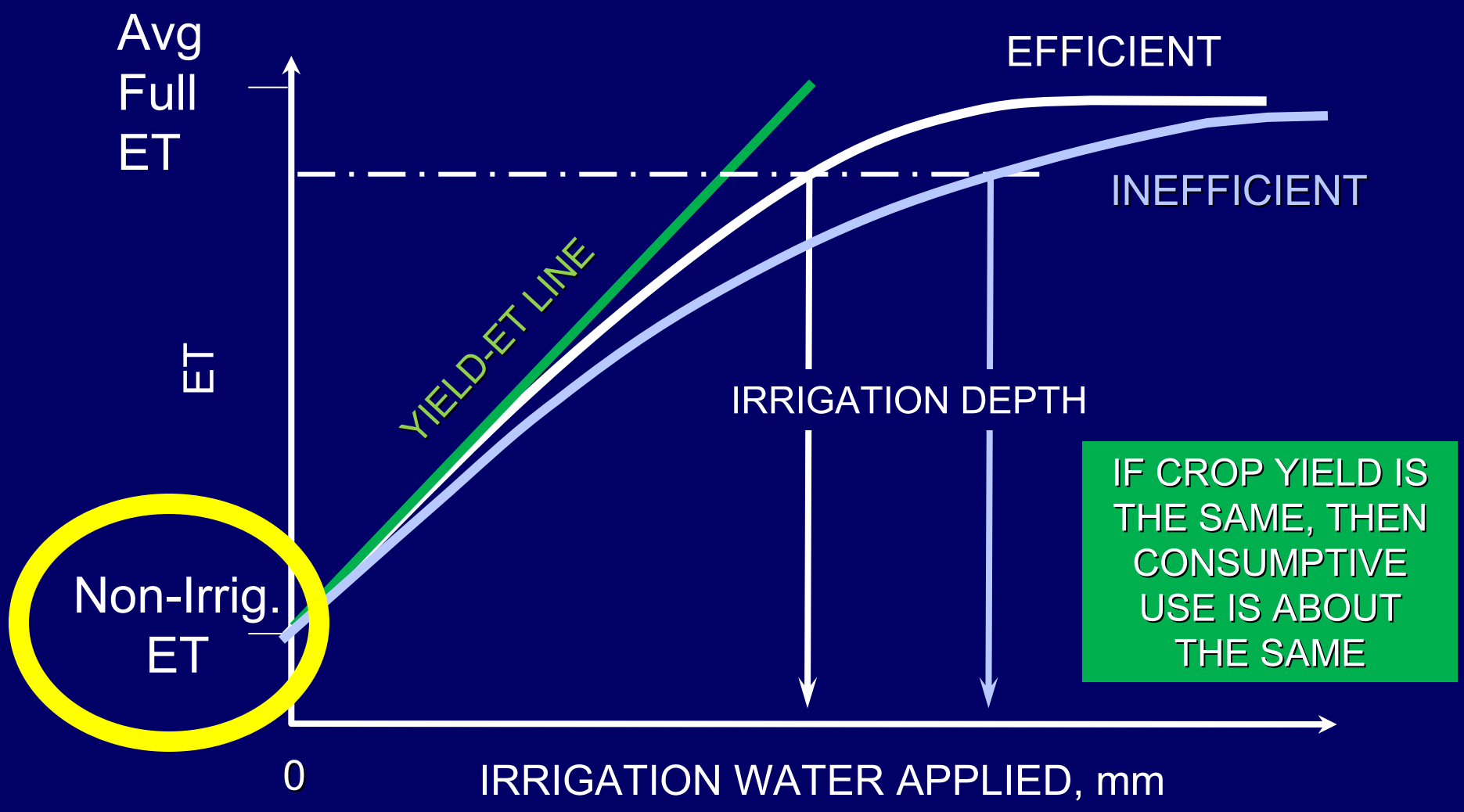


MAP OF CONJUNCTIVE MANAGEMENT AREA COMINGLED ZONES

GENERAL APPROACH

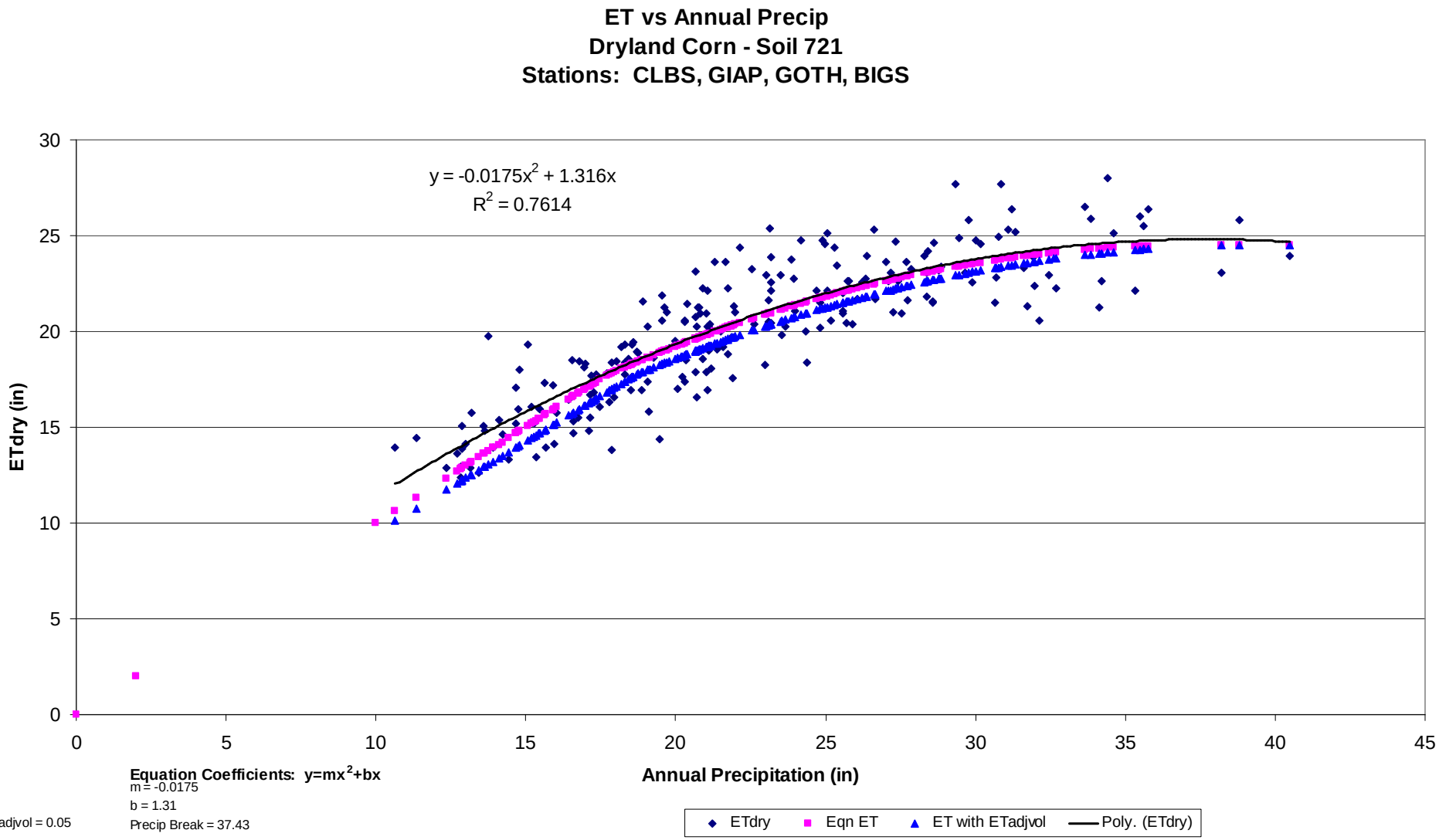


PRODUCTION FUNCTION



IF CROP YIELD IS THE SAME, THEN CONSUMPTIVE USE IS ABOUT THE SAME

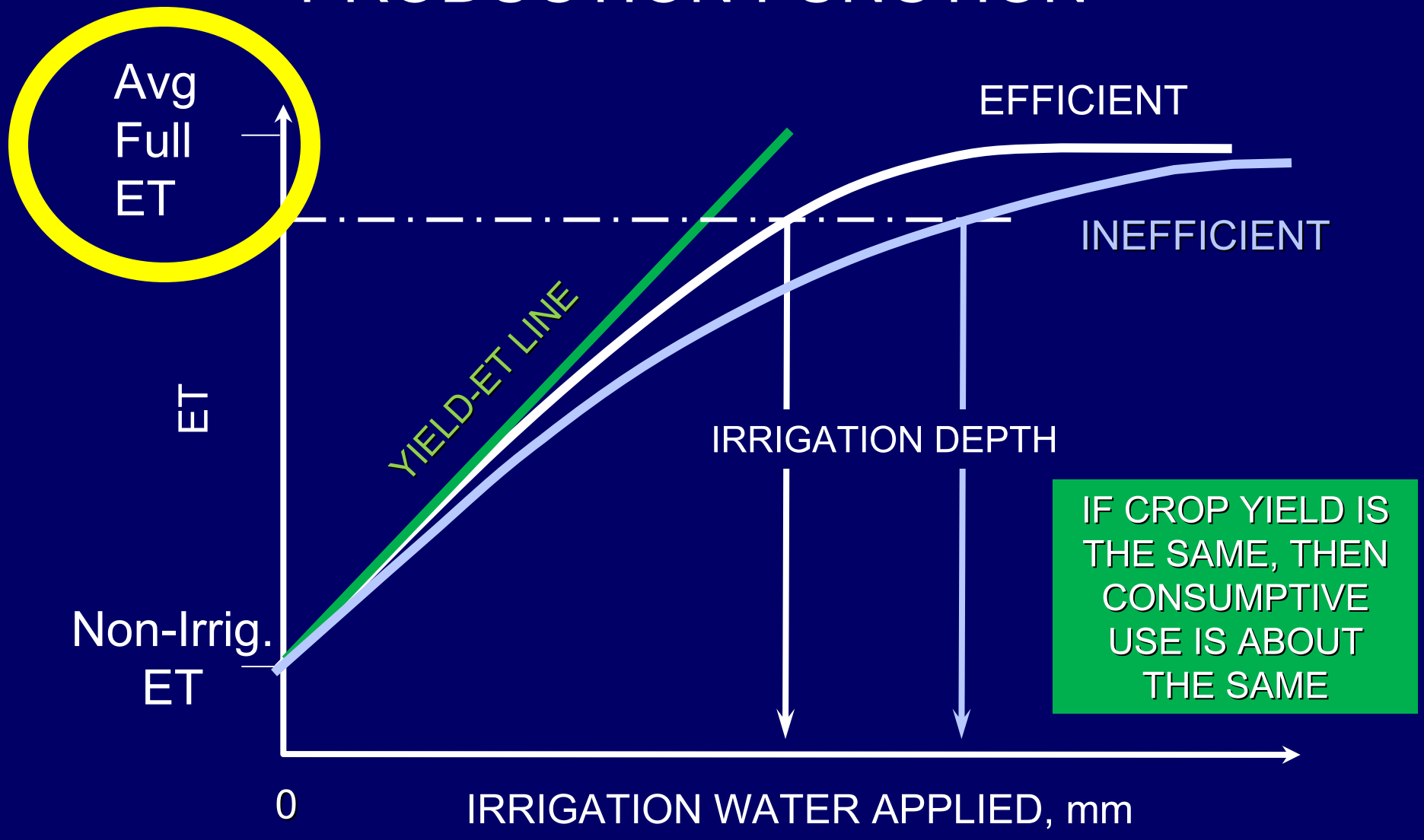
PRODUCTION FUNCTION



Equation Coefficients: $y=mx^2+bx$
m = -0.0175
b = 1.31
Precip Break = 37.43

ETadjvol = 0.05

PRODUCTION FUNCTION



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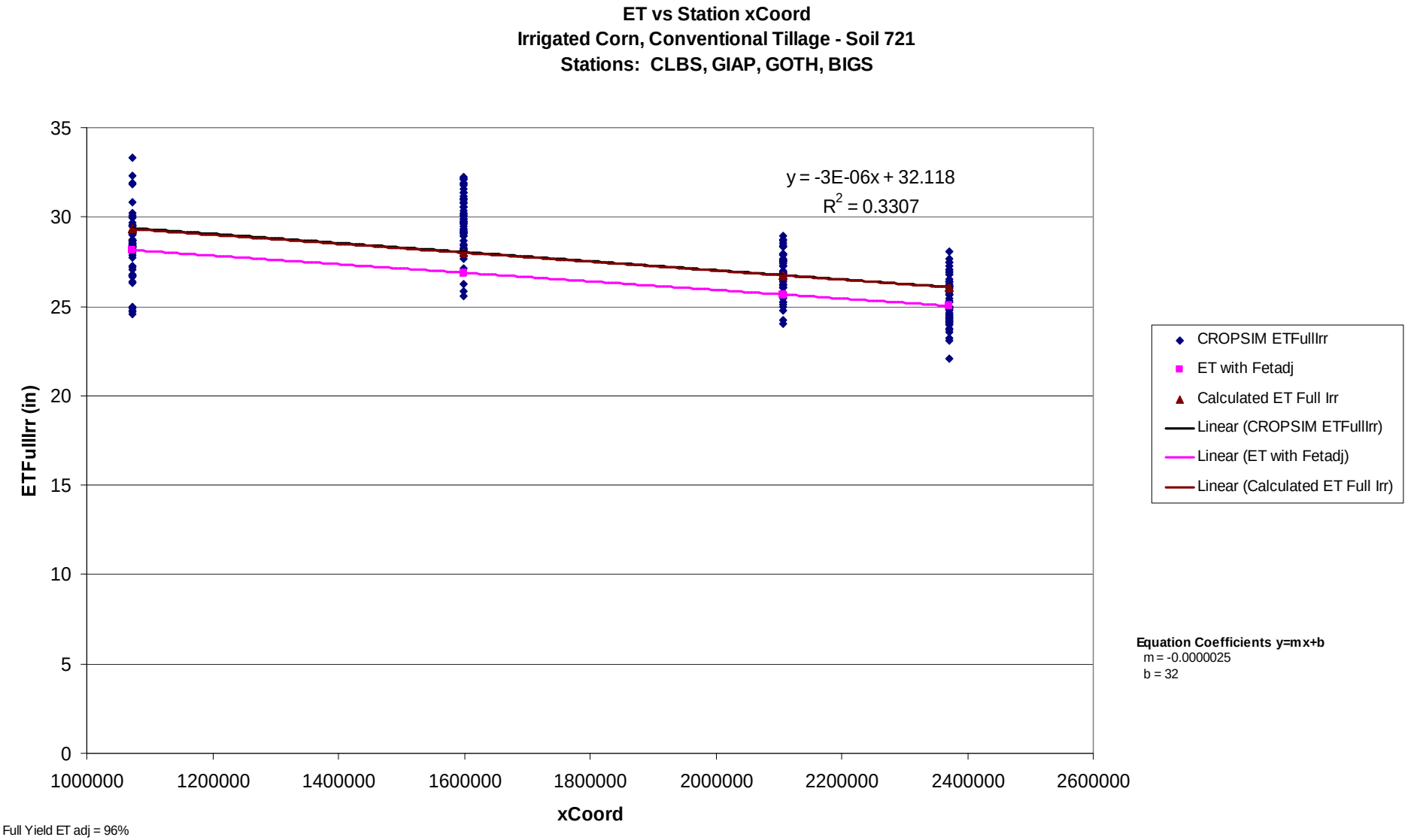
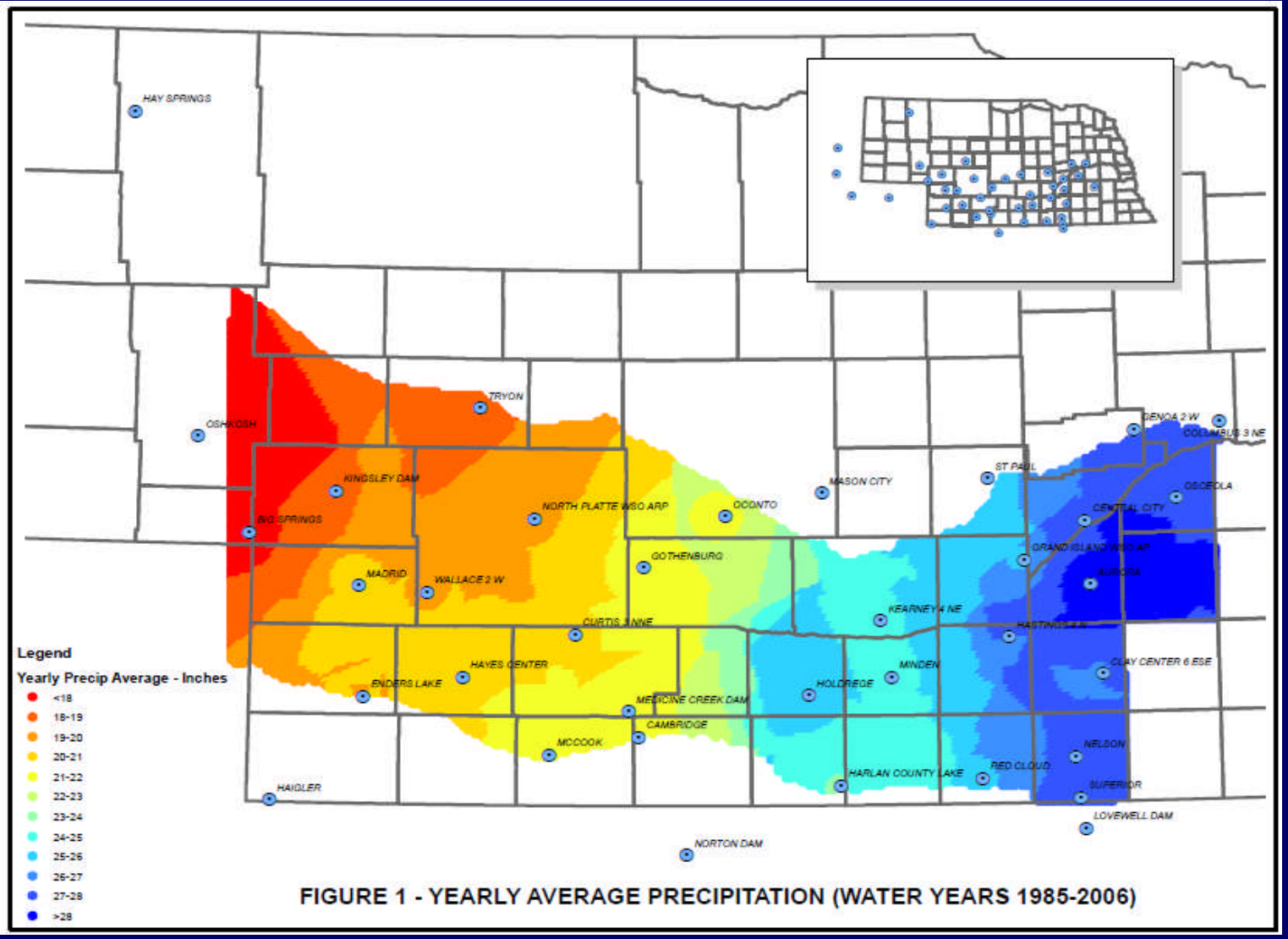


Full Yield ET adj = 96%

PRODUCTION FUNCTION



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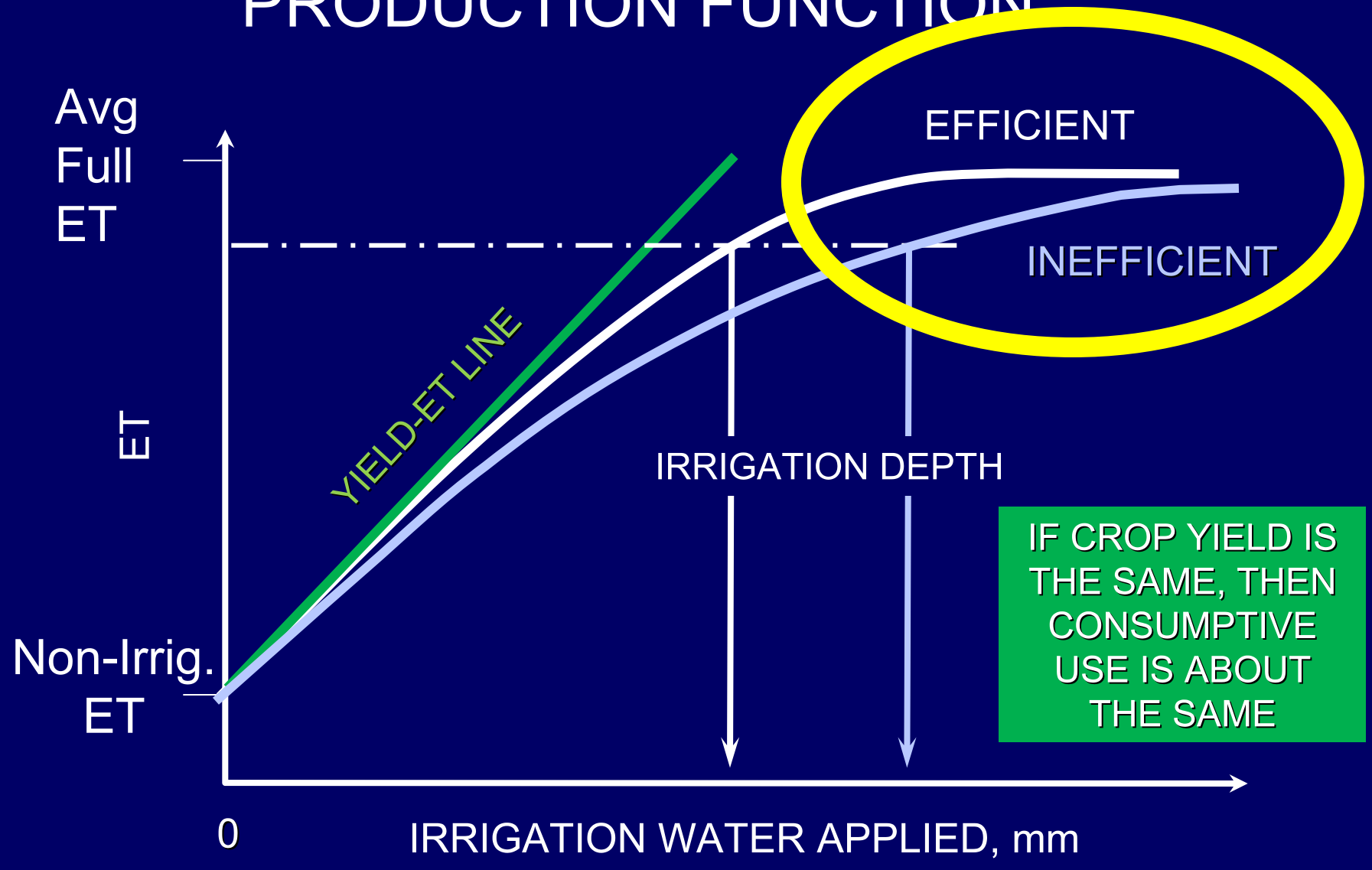

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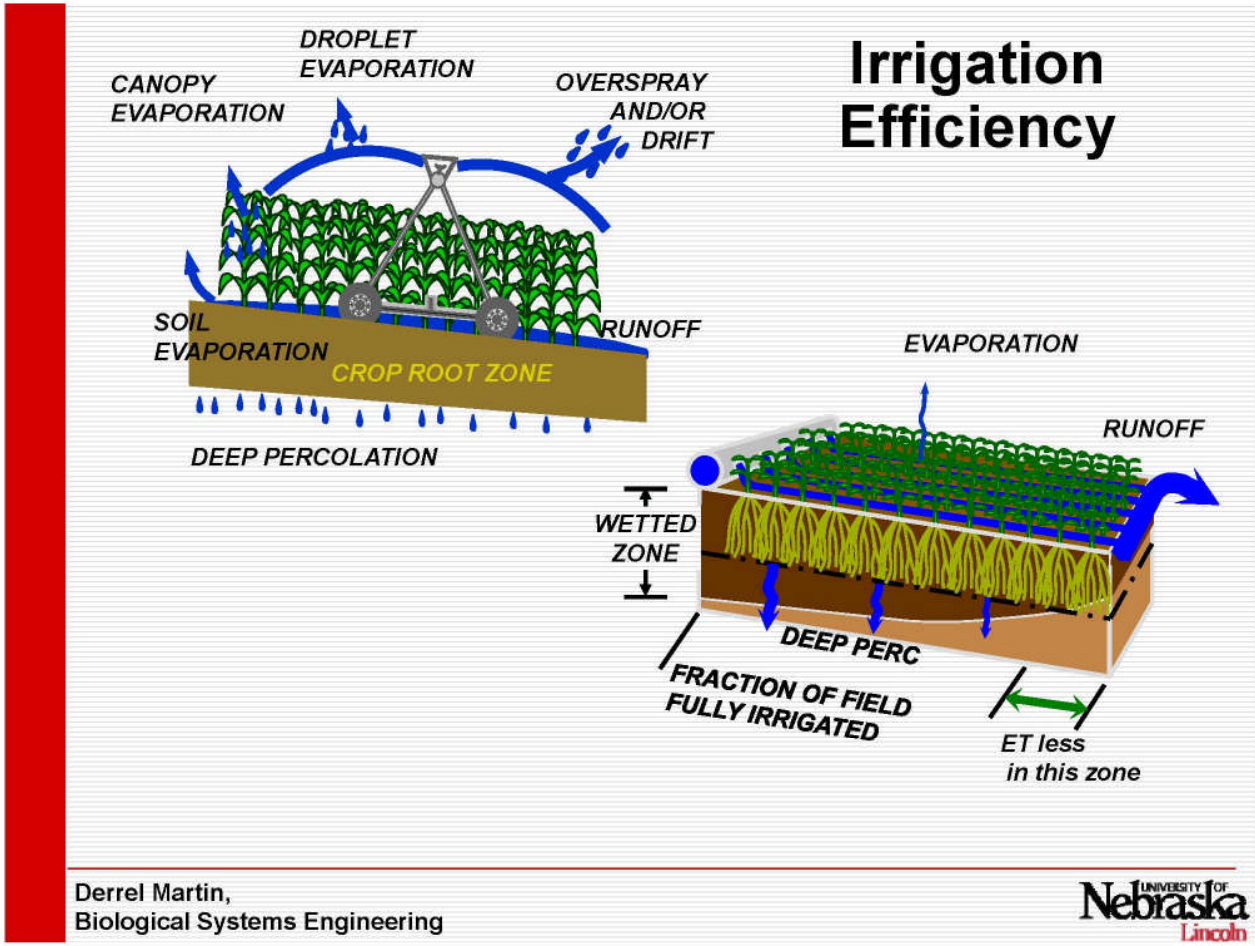
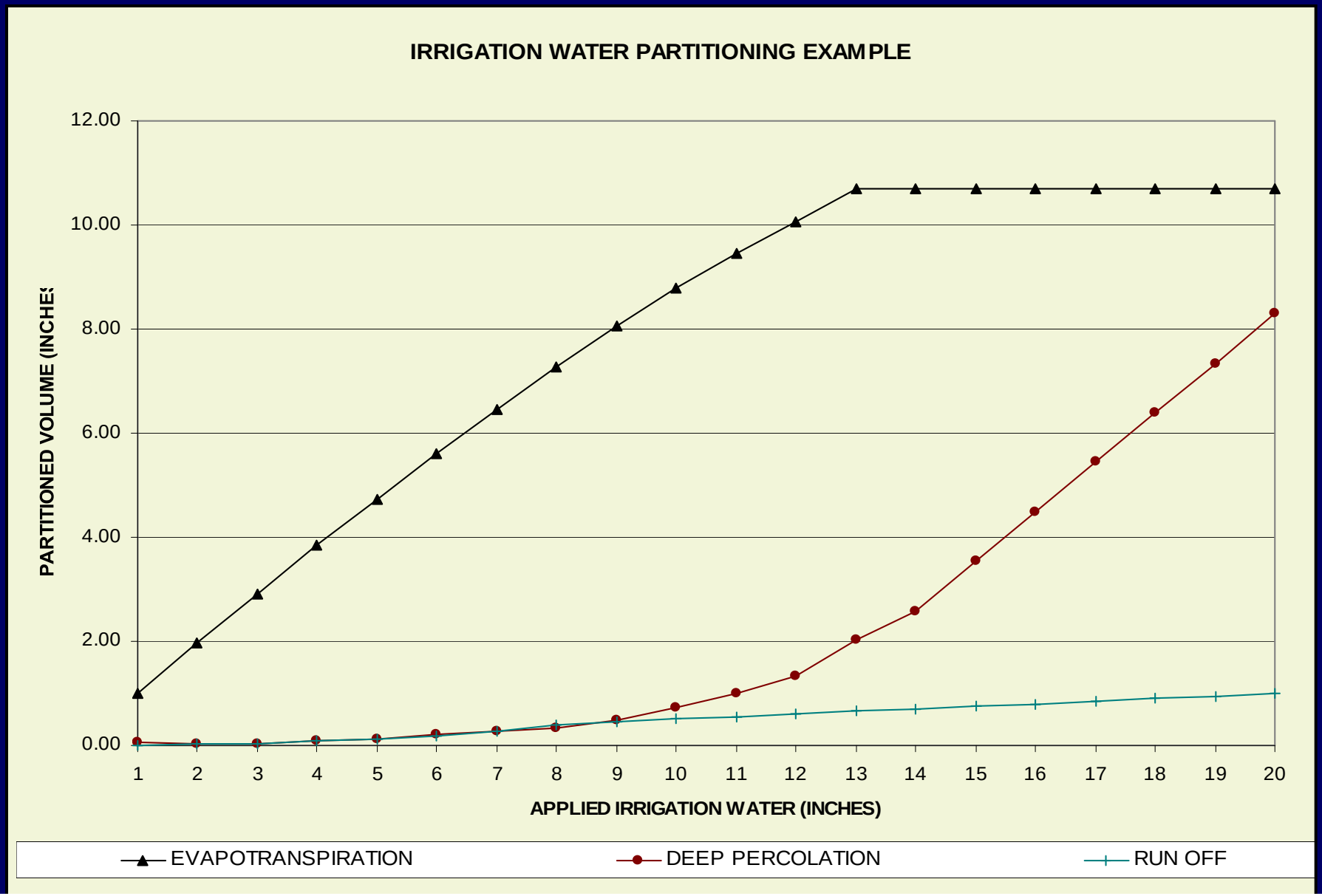


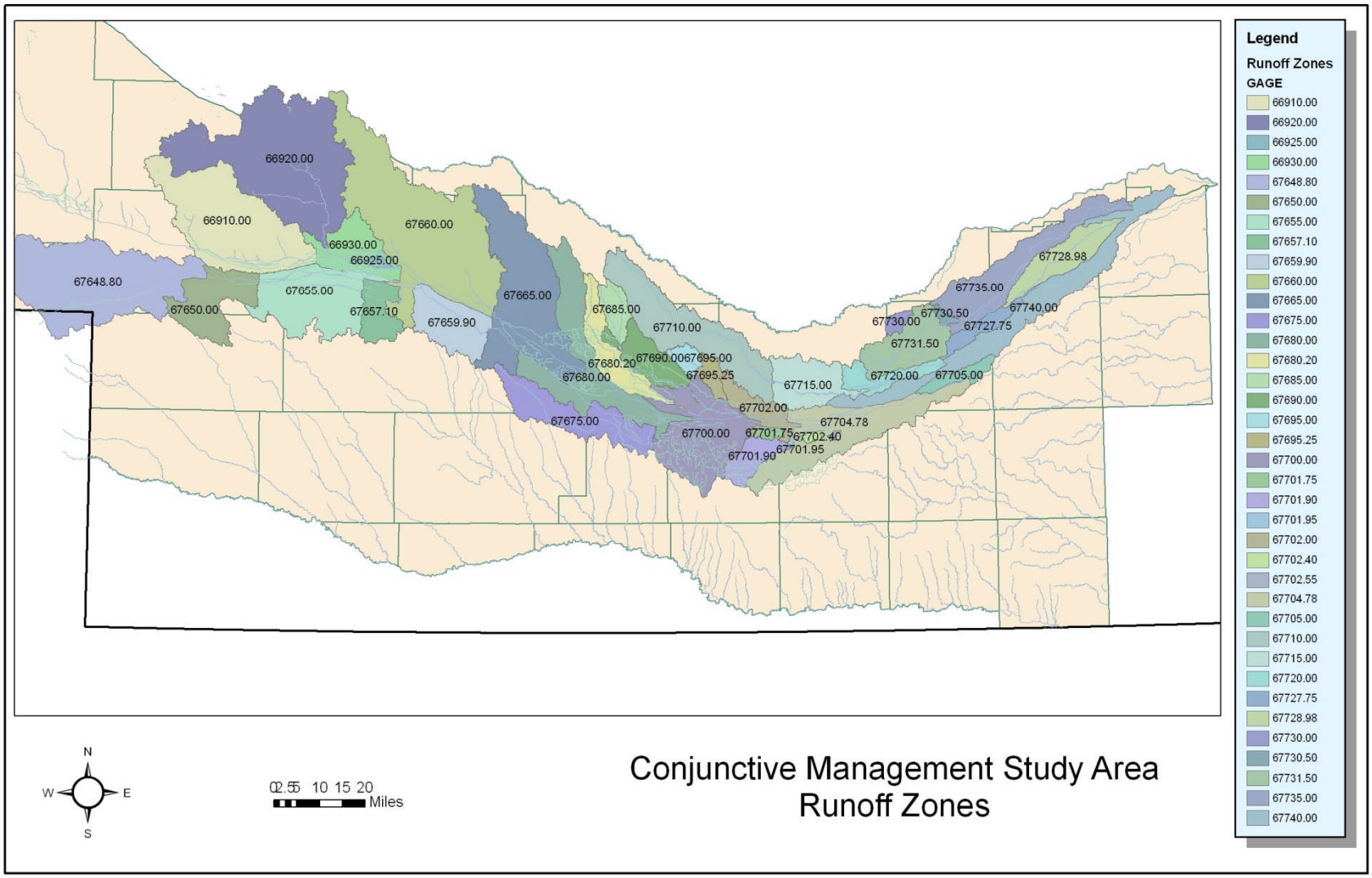
Derrel Martin,
Biological Systems Engineering

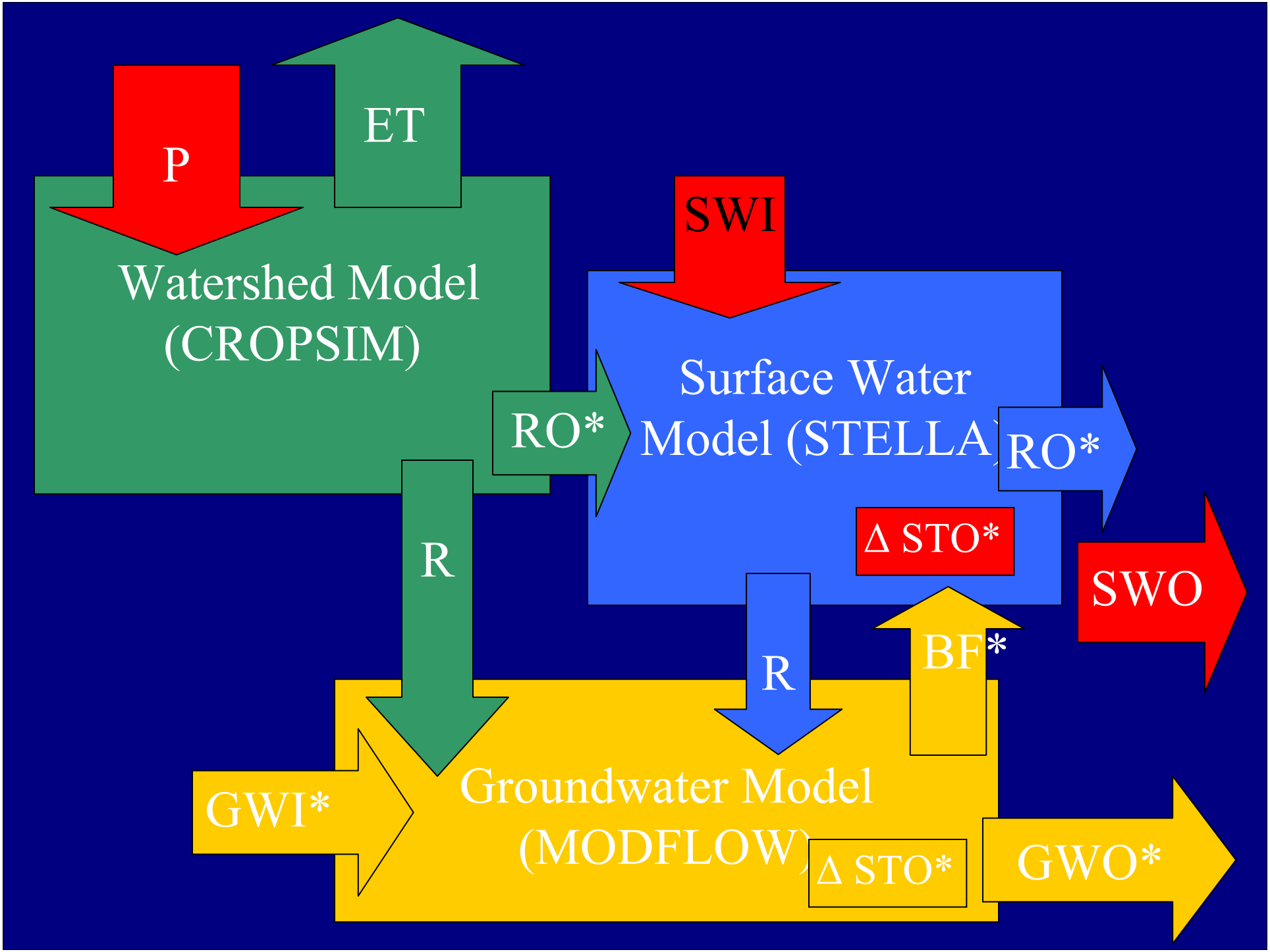
University of Nebraska Lincoln

PRODUCTION FUNCTION



Overland Runoff Values to STELLA

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THANK YOU
QUESTIONS