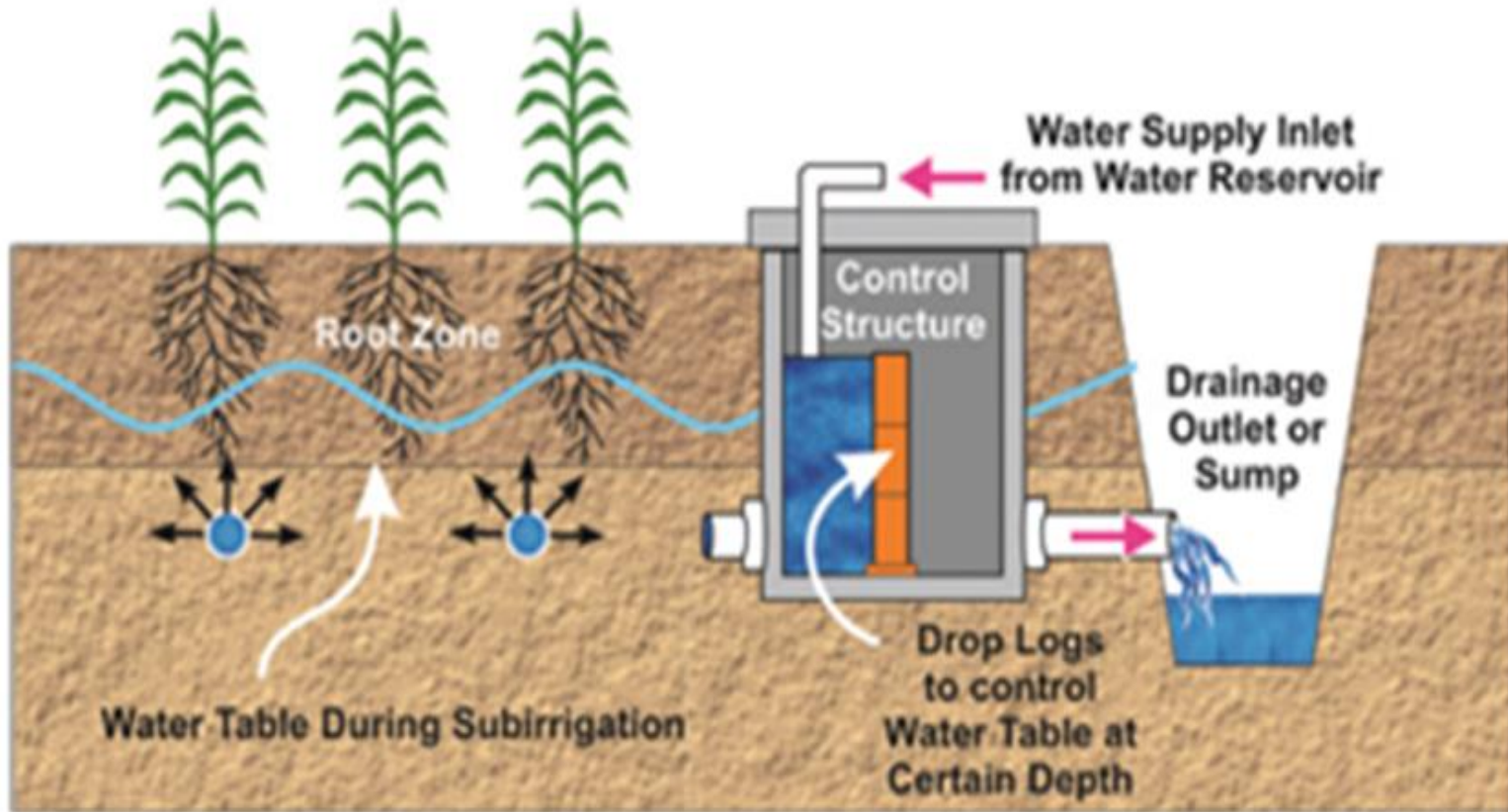


SubSurface Irrigation



I ILLINOIS

**COLLEGE OF AGRICULTURAL, CONSUMER
& ENVIRONMENTAL SCIENCES**

THE GRAINGER COLLEGE OF ENGINEERING

Department of Agricultural & Biological Engineering
338 Agricultural Engineering Sciences Building, MC-644
1304 W. Pennsylvania Ave.
Urbana, IL 61801

File Home Insert Page Layout Formulas Data Review View Developer Acrobat Tell me what you want to do... Cooke, Richard Share

=SoilFileName

	A	B	C	D	E	F	G	H	I	J	K	L	M	N																																															
1		Download Database																																																											
2				Illinois		Adams		Drummer																																																					
3		Simulation		<p>Relative Overall Yield (%) for Soybean</p> <table border="1"> <caption>Estimated Data from Graph</caption> <thead> <tr> <th>Spacing (ft)</th> <th>Illinois (%)</th> <th>Adams (%)</th> <th>Drummer (%)</th> </tr> </thead> <tbody> <tr> <td>20</td> <td>88.5</td> <td>88.2</td> <td>88.5</td> </tr> <tr> <td>30</td> <td>88.5</td> <td>88.5</td> <td>88.5</td> </tr> <tr> <td>40</td> <td>88.5</td> <td>88.5</td> <td>88.5</td> </tr> <tr> <td>50</td> <td>88.5</td> <td>88.5</td> <td>88.5</td> </tr> <tr> <td>60</td> <td>88.5</td> <td>88.5</td> <td>88.5</td> </tr> <tr> <td>70</td> <td>88.0</td> <td>88.5</td> <td>88.5</td> </tr> <tr> <td>80</td> <td>86.8</td> <td>88.0</td> <td>88.0</td> </tr> <tr> <td>90</td> <td>85.0</td> <td>87.0</td> <td>87.5</td> </tr> <tr> <td>100</td> <td>83.8</td> <td>85.0</td> <td>86.5</td> </tr> <tr> <td>110</td> <td>81.5</td> <td>84.0</td> <td>84.8</td> </tr> <tr> <td>120</td> <td>79.5</td> <td>82.0</td> <td>83.2</td> </tr> </tbody> </table>										Spacing (ft)	Illinois (%)	Adams (%)	Drummer (%)	20	88.5	88.2	88.5	30	88.5	88.5	88.5	40	88.5	88.5	88.5	50	88.5	88.5	88.5	60	88.5	88.5	88.5	70	88.0	88.5	88.5	80	86.8	88.0	88.0	90	85.0	87.0	87.5	100	83.8	85.0	86.5	110	81.5	84.0	84.8	120	79.5	82.0	83.2
Spacing (ft)	Illinois (%)	Adams (%)	Drummer (%)																																																										
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120	79.5	82.0	83.2																																																										
4		Time Period																																																											
5		<input checked="" type="radio"/> 1980 -2010 (Observed)																																																											
6		<input type="radio"/> 1980 to 2010																																																											
7		<input type="radio"/> 2040 to 2069																																																											
8		<input type="radio"/> 2070 to 2099																																																											
9		Run New Simulation																																																											
10		Change Simulation Parameters																																																											
11		View Report																																																											
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17																																																													

Infiltration Evapotranspiration

Drained Volume Runoff

Dry Days Work Days

SEW

CORN	SOYBEAN
<input type="radio"/> SDI Excess	<input type="radio"/> SDI Excess
<input type="radio"/> Stress Drought	<input type="radio"/> Stress Drought
<input type="radio"/> Yield Excess	<input type="radio"/> Yield Excess
<input type="radio"/> Yield Drought	<input type="radio"/> Yield Drought
<input type="radio"/> Overall Crop Yield	<input checked="" type="radio"/> Overall Crop Yield

Economic Analysis

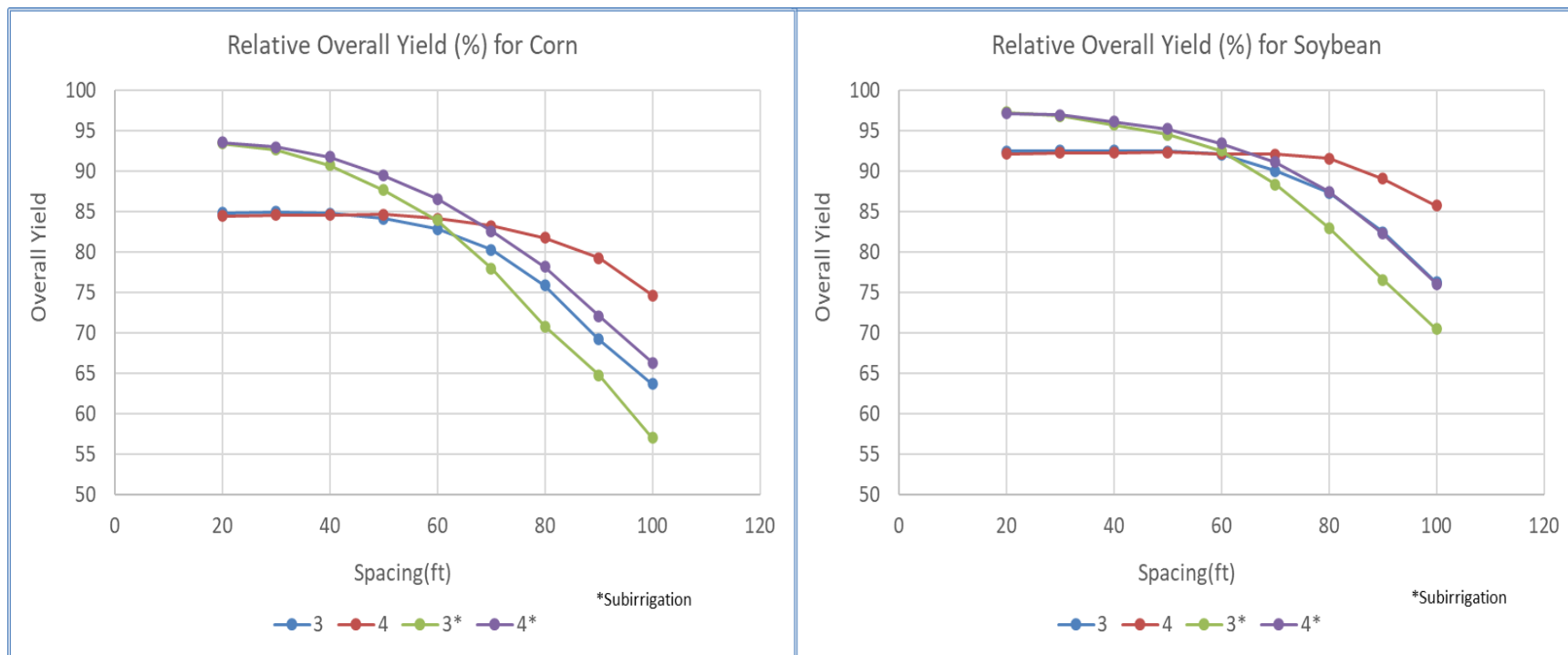
Main Model Description

Applied Engineering in Agriculture 36(3): 303-319



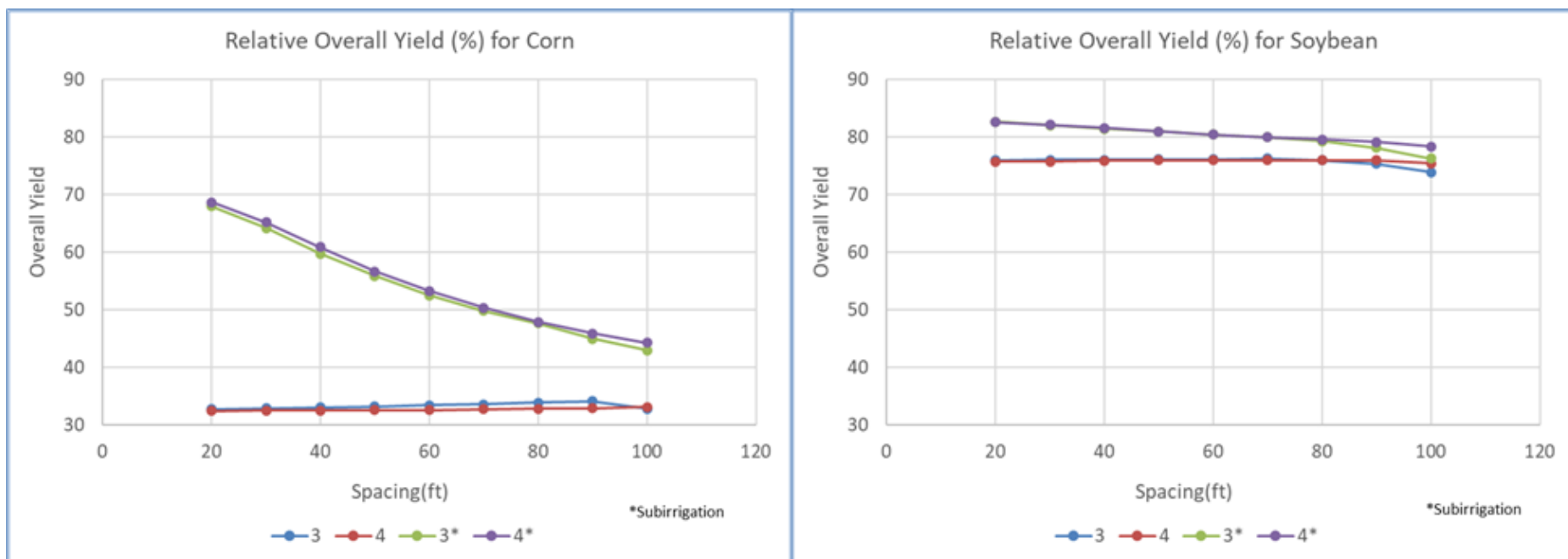
Climate Change and Crop Productivity

DRAINMOD simulated relative yields for corn and soybean grown on Ipava soil in Fulton County using historical climate data for 1981-2010.



Climate Change and Crop Productivity

DRAINMOD simulated relative yields for corn and soybean grown on Ipava soil in Fulton County using projected climate data for 2041-2070.




Other Voices

I project biophysically driven shifts in cultivation geographies to 2100 under low, moderate, and high emissions scenarios and find that these geographies will shift strongly north, with **the Corn Belt becoming unsuitable to the cultivation of corn by 2100**. These results indicate that significant agricultural adaptation will be necessary and inevitable in the Central and Eastern U.S.

ENVIRONMENTAL RESEARCH LETTERS

LETTER • OPEN ACCESS

Shifting cultivation geographies in the Central and Eastern US

Emily K Burchfield¹ 

Published 16 May 2022 • © 2022 The Author(s). Published by IOP Publishing Ltd

[Environmental Research Letters](#), Volume 17, Number 5

Citation Emily K Burchfield 2022 *Environ. Res. Lett.* 17 054049

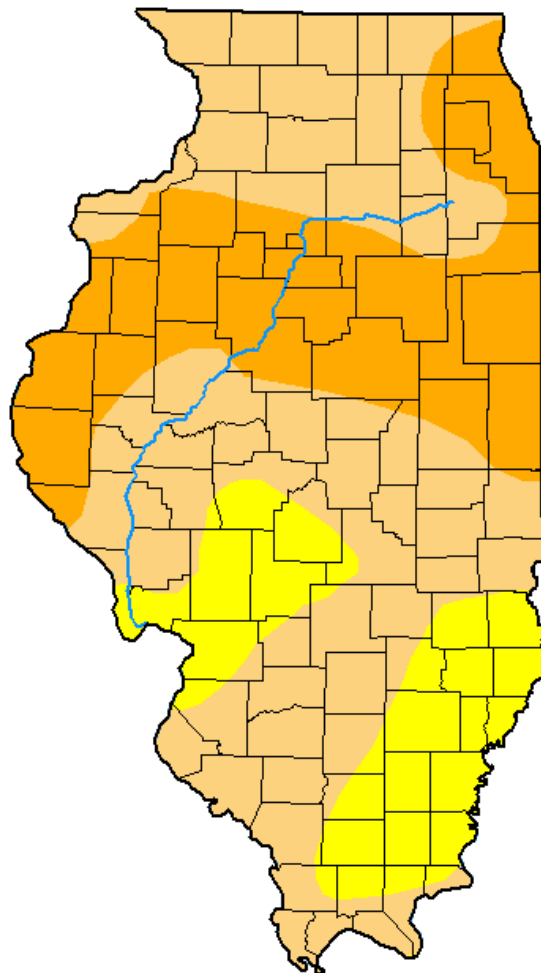


[Figures](#) ▾ [References](#) ▾ [Open science](#) ▾

[+ Article information](#)

**U.S. Drought Monitor
Illinois**

June 20, 2023
(Released Thursday, Jun. 22, 2023)
Valid 8 a.m. EDT



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	82.02	30.67	0.00	0.00
Last Week <i>06-13-2023</i>	0.88	99.12	64.99	14.68	0.00	0.00
3 Months Ago <i>03-21-2023</i>	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year <i>01-03-2023</i>	35.34	64.66	3.98	0.00	0.00	0.00
Start of Water Year <i>09-27-2022</i>	65.33	34.67	8.15	0.00	0.00	0.00
One Year Ago <i>06-21-2022</i>	53.02	46.98	6.38	0.00	0.00	0.00

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Adam Hartman
NOAA/NWS/NCEP/CPC



What is Irrigation

- ◆ controlled application or distribution of water
- ◆ associated with applying supplemental water to cropland to supply needed moisture not supported by natural rainfall

History

- ◆ **6000 BCE:** Irrigation began at about the same time in Egypt and Mesopotamia (present day Iraq and Iran) using the water of the flooding Nile or Tigris/Euphrates rivers.

History

- ◆ **3100 BCE:** The first major irrigation project was created under King Menes during Egypt's First Dynasty. He and his successors used dams and canals (one measuring 20 km) to use the diverted flood waters of the Nile into a new lake called lake "Moeris."

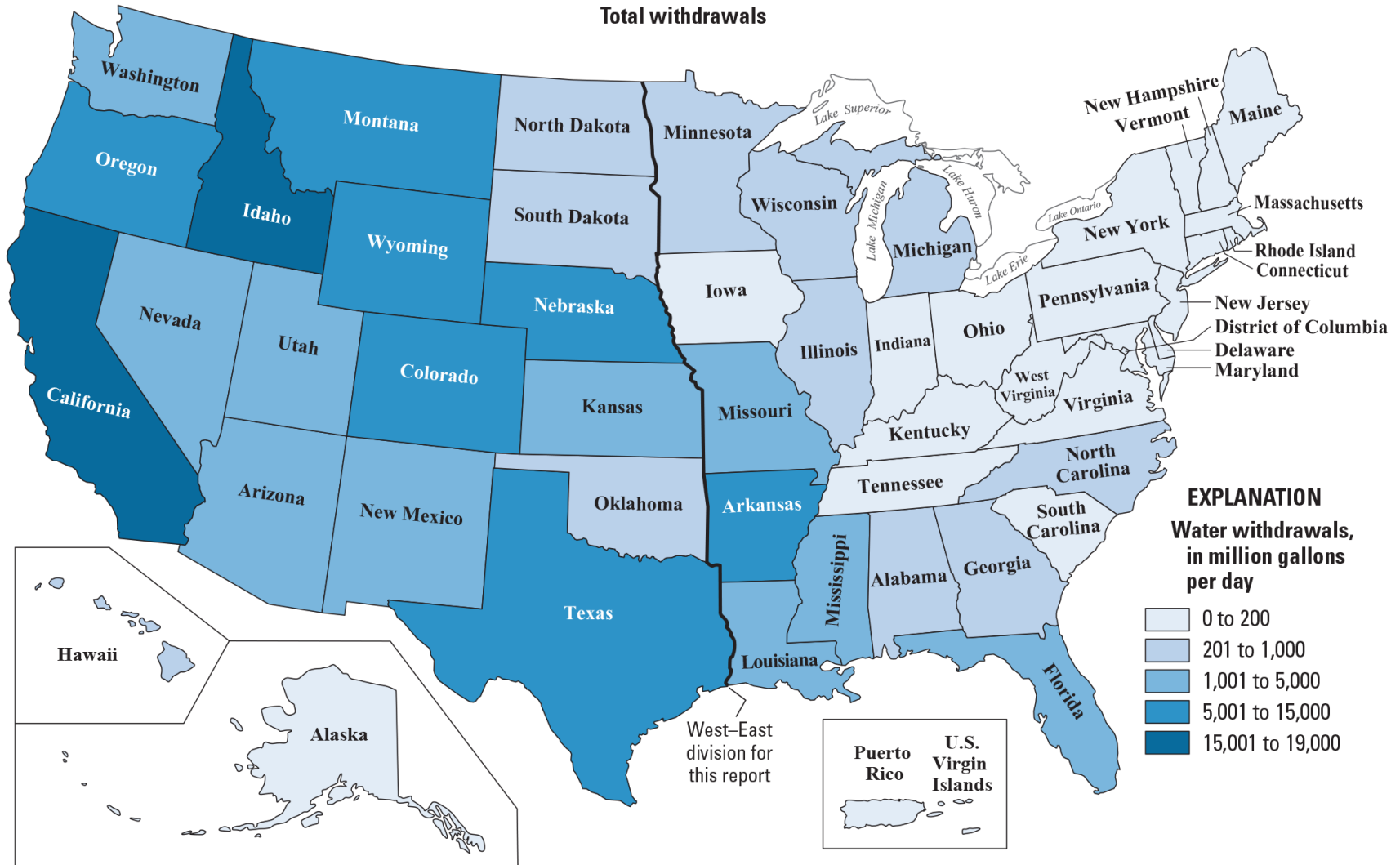
History

- ◆ **1800 CE:** Irrigated acreage worldwide reaches 19,760,000 acres. This compares with an estimated 600,000,000 acres today.

Irrigation in USA

Irrigation 2015

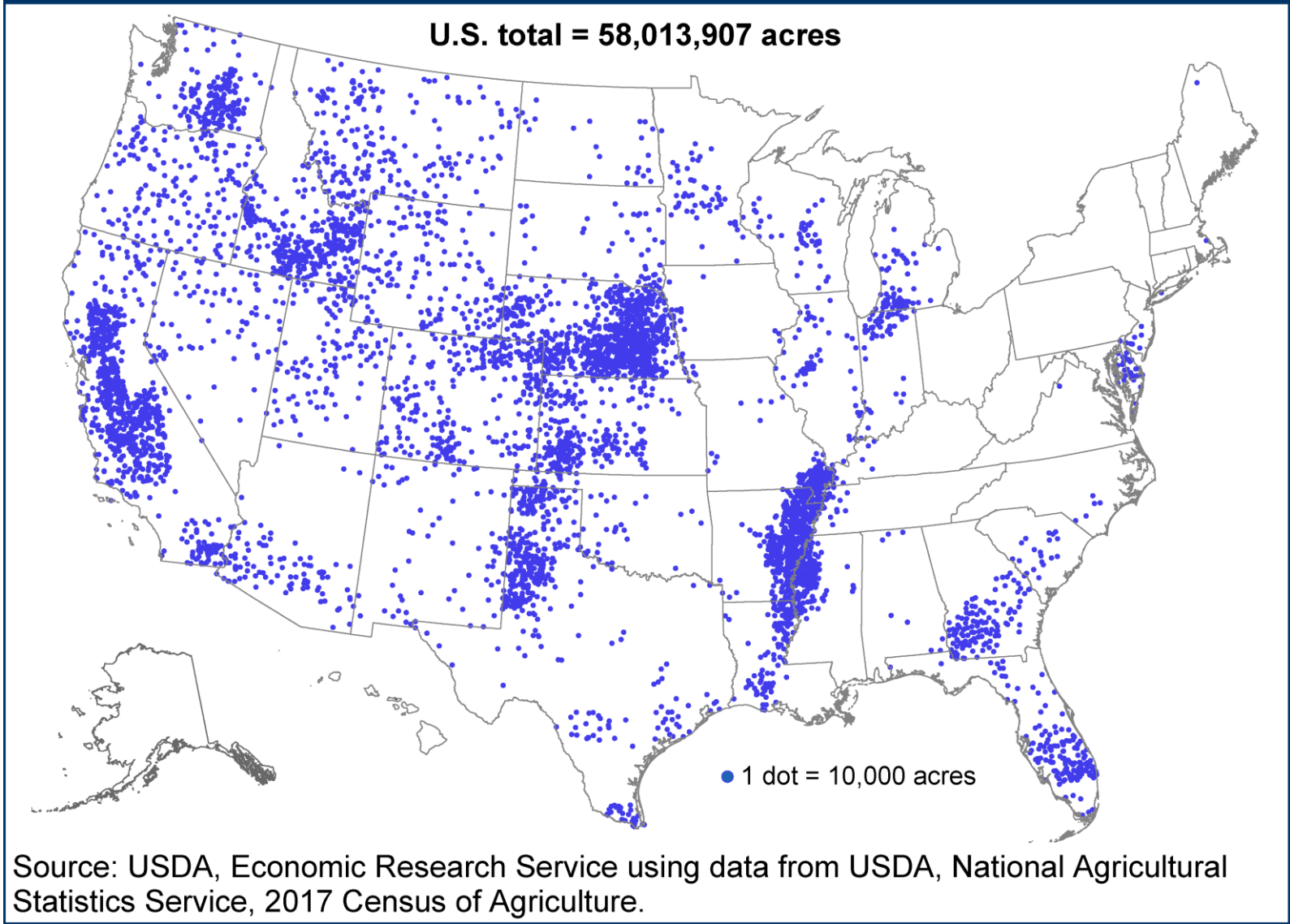
Total withdrawals



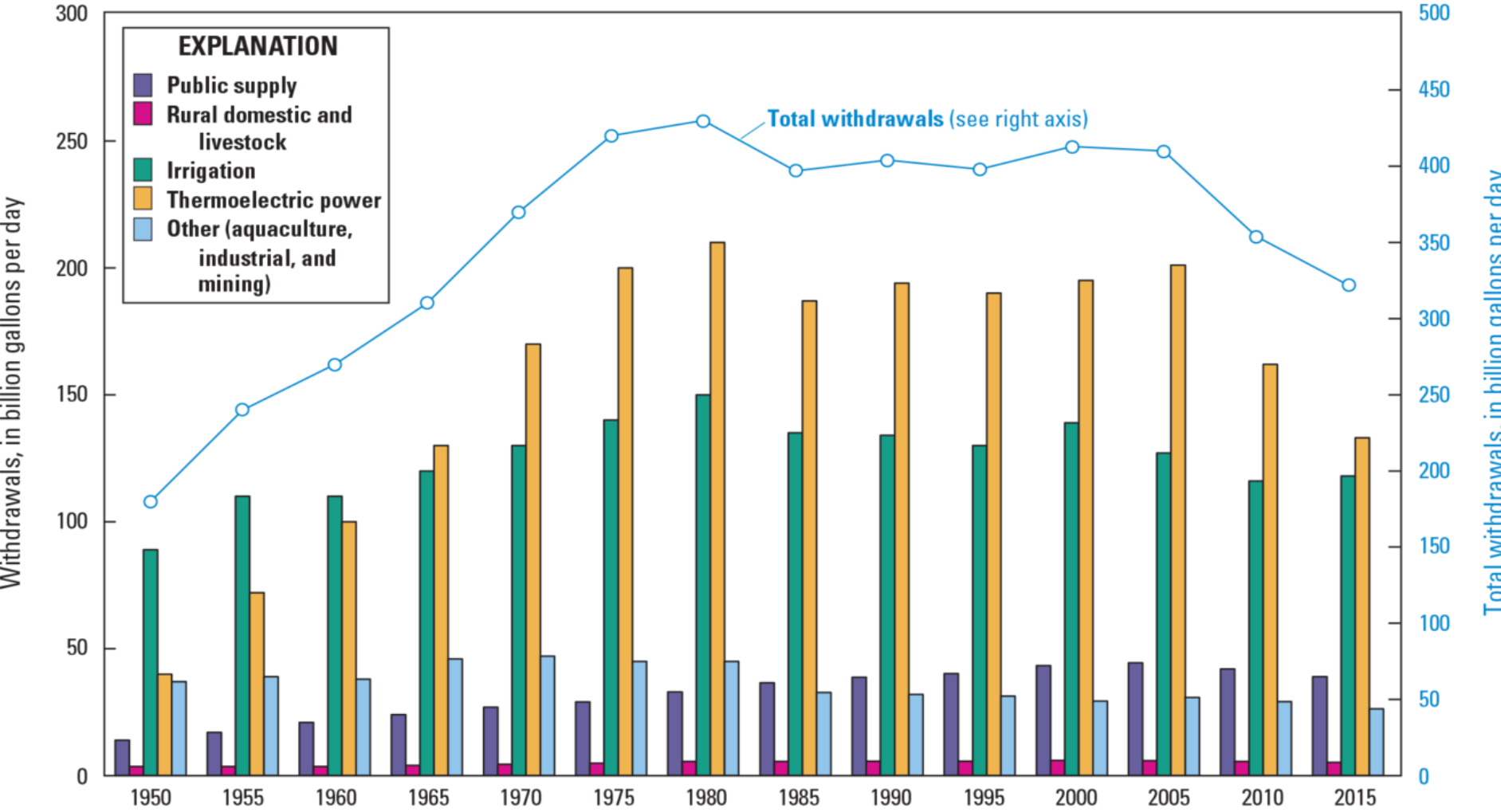
EXPLANATION
Water withdrawals,
in million gallons
per day

- 0 to 200
- 201 to 1,000
- 1,001 to 5,000
- 5,001 to 15,000
- 15,001 to 19,000

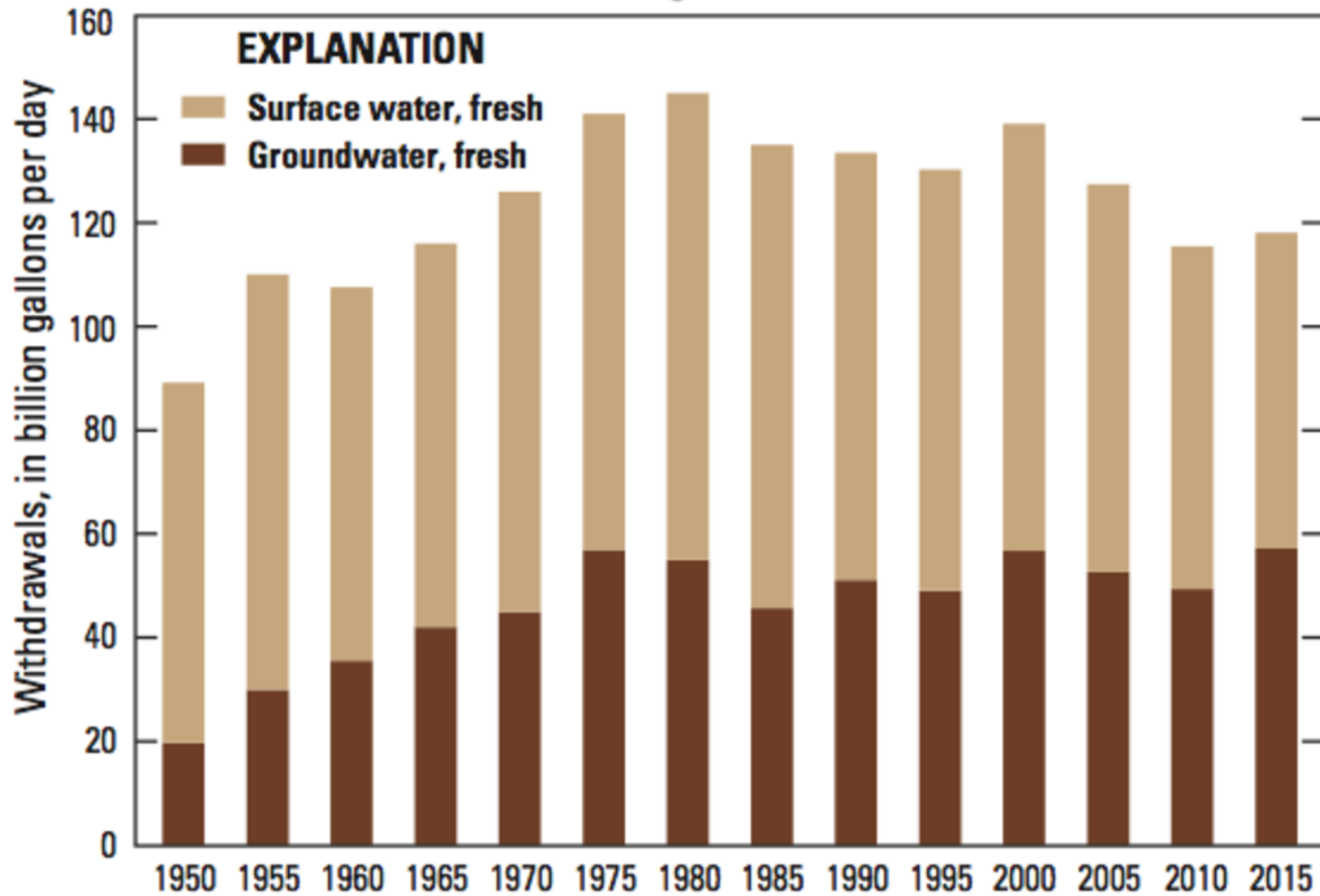
U.S. acres of irrigated land by county, 2017



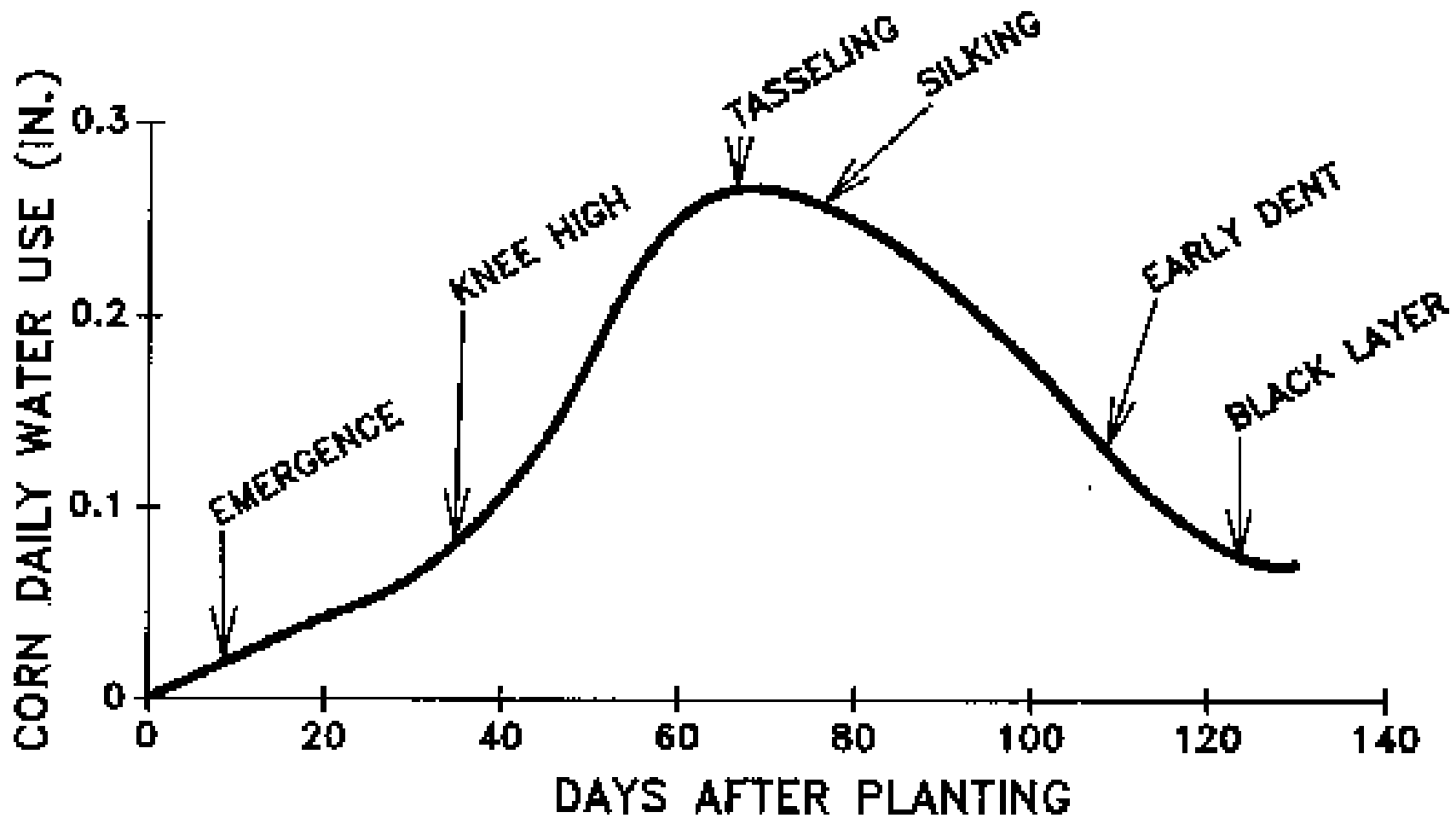
Trends in total water withdrawals by water-use category, 1950-2015



Irrigation



Crop Water Demand (Corn)



Crop Water Demand (Soybean)

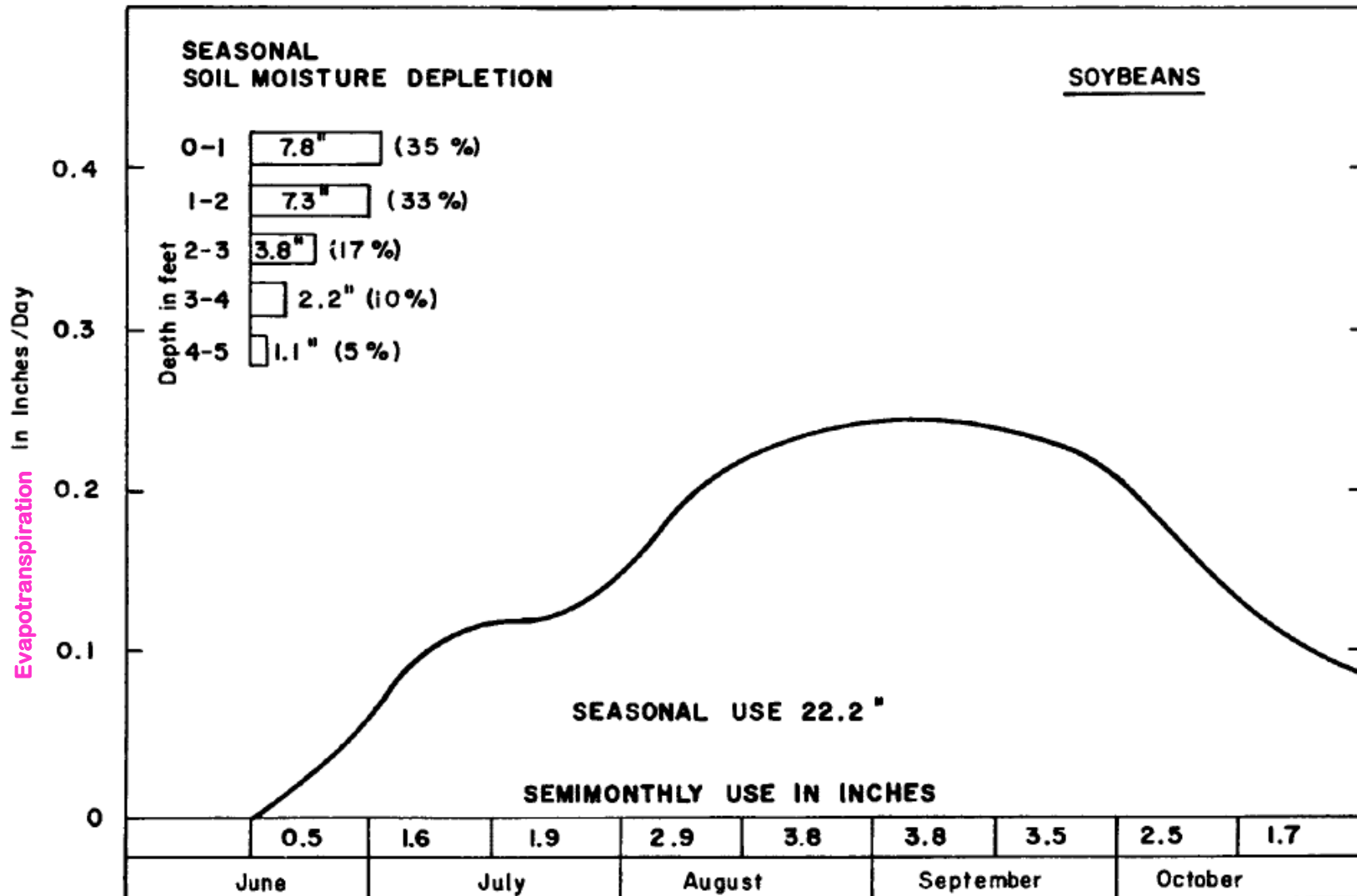


Figure 5.—Mean consumptive use for soybeans at Mesa, Ariz., 1944.

Crop Water Demand (Wheat)

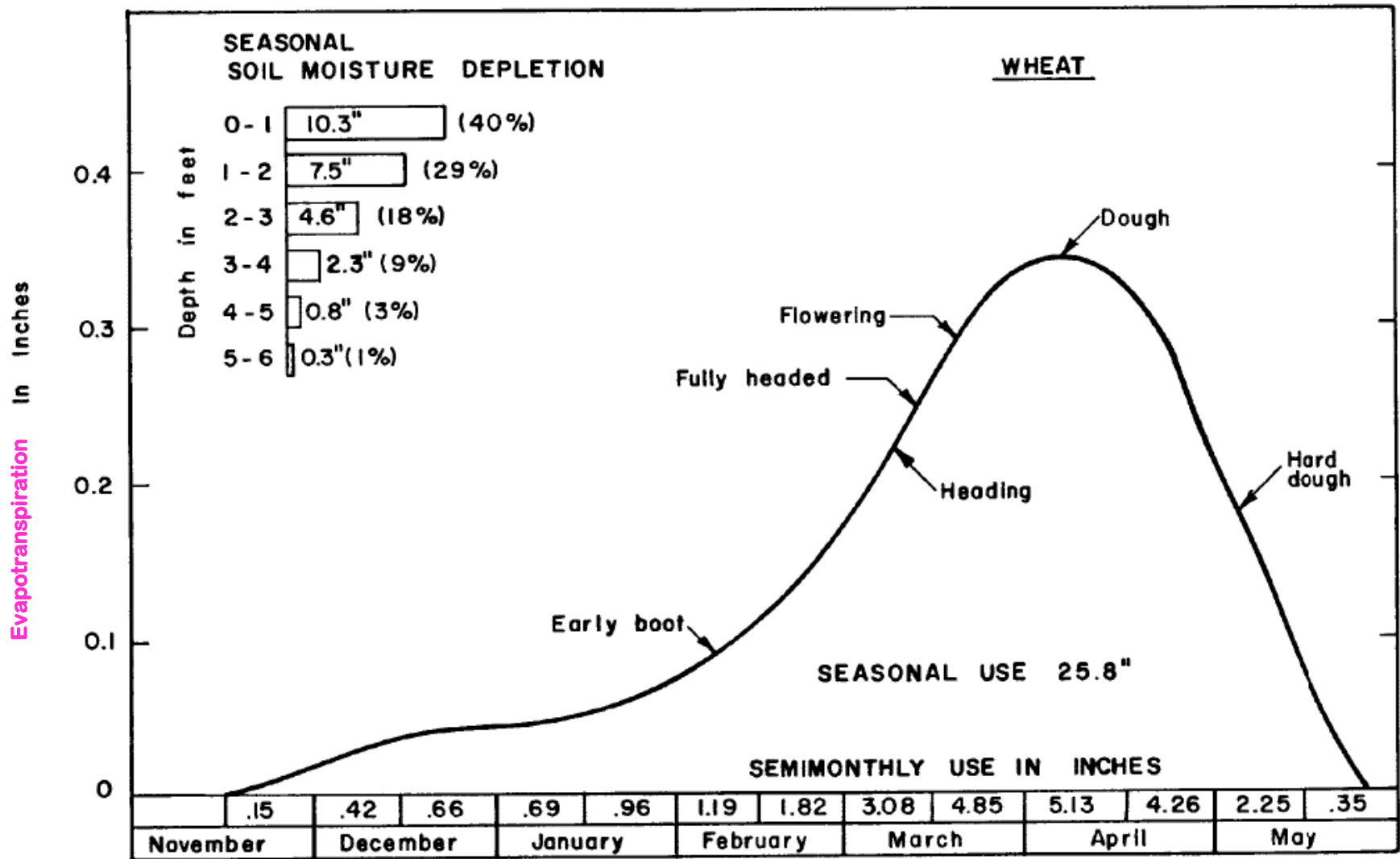


Figure 14.—Mean consumptive use for high-yielding wheats at Mesa, Ariz., 1969-70.

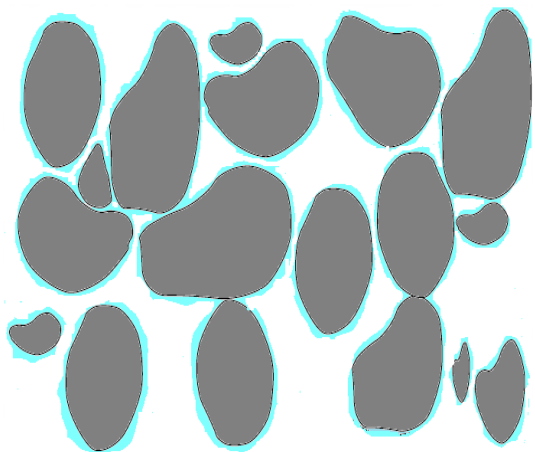
Effective rainfall

- ◆ Rainfall must be considered when determining the crop water needs that must be supplied by irrigation.
- ◆ Not all rainfall is effective, but only that portion which contributes to evapotranspiration.
- ◆ For example, rainfall on a wet soil is ineffective in meeting evapotranspiration but may contribute to the leaching requirement.

Soil Moisture Reservoir

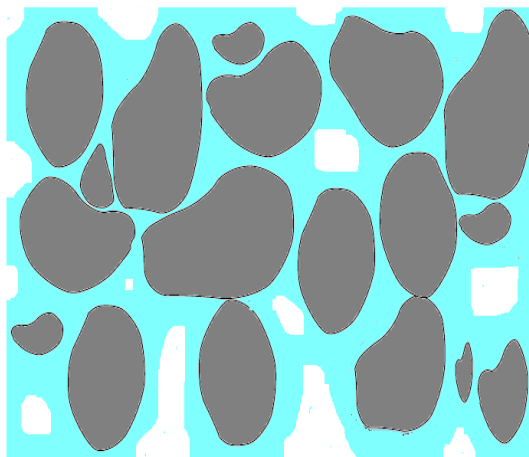
- ◆ In planning and managing irrigation, it is helpful to think of the soil's capacity to store available water as the soil water reservoir.
- ◆ The reservoir is filled periodically by applications of water: rainfall, irrigation.
- ◆ Water is slowly depleted by evapotranspiration.
- ◆ Water application in excess of the reservoir capacity is wasted unless it is used for leaching.
- ◆ Irrigation is usually scheduled to prevent the soil water reservoir from becoming so low as to cause plant stress.

Hydroscopic Water



Water adheres to soil particles

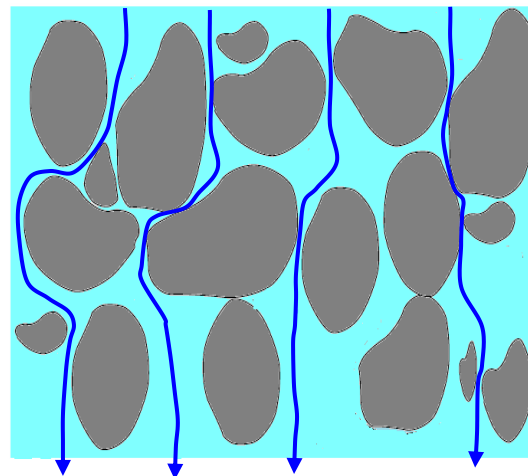
Capillary Water



Water held in large pores

Available for crop use

Gravitational Water



Water drains through soil profile

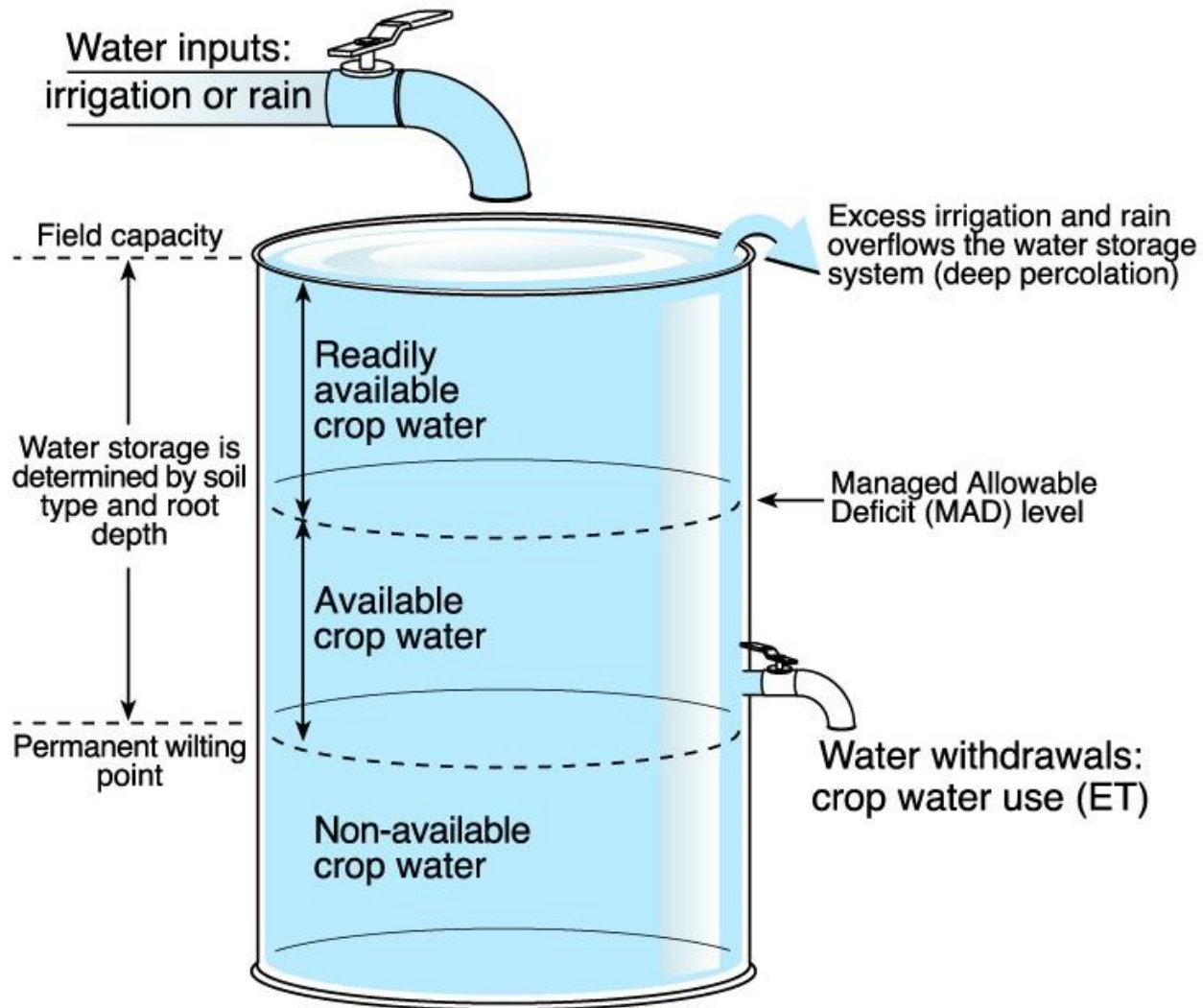
Irrigate

Drain

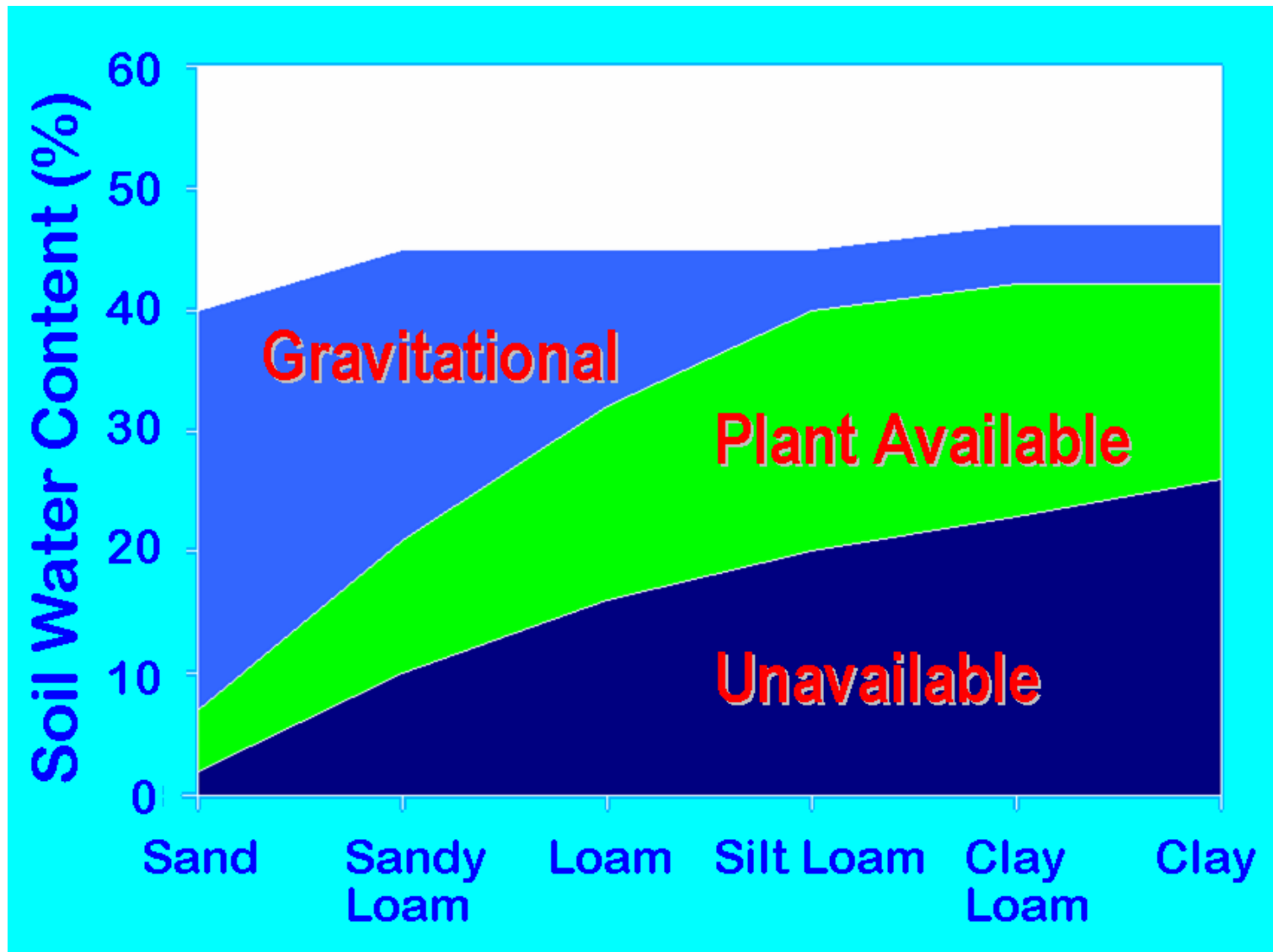
Permanent Wilting

Field Capacity

Summing up.....



Water States by Soil Texture







Water Supply
Water Conveyance
Water Distribution
Economics

Economic Analysis of Drainage Systems

Straight Line Depreciation

Calculate
Clear
Quit

Income to Break Even (\$/Acre)

Cost of Drainage Practice (\$/acre) []
Depreciation Schedule (Years) [10]
Interest Rate (%) [6]
Marginal Tax Rate (%) [28]
Life of Drainage System (Years) [50]

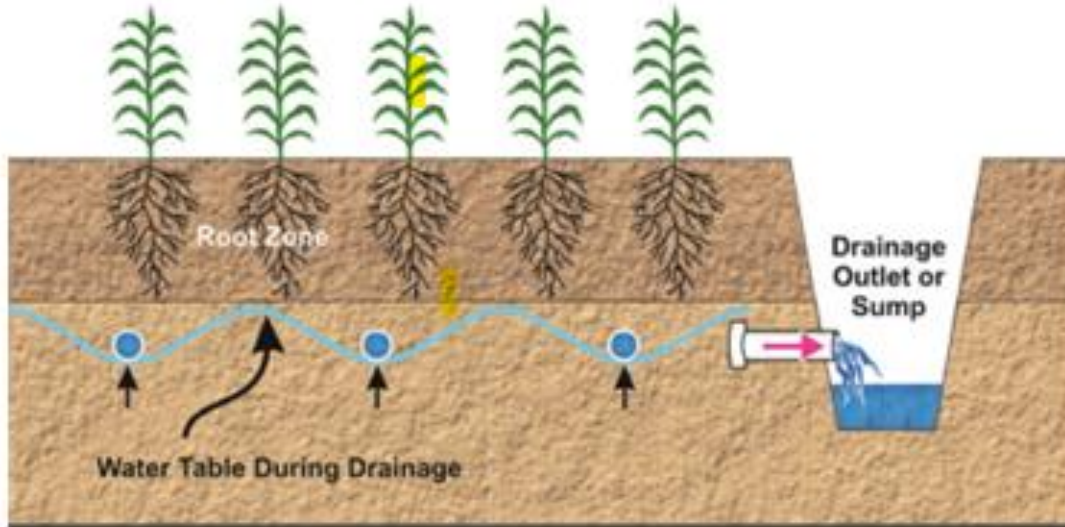
Break Even Income Return on Specified Yield

Increase in Crop 1 Yield (bu/acre) [15]
Price for Crop 1 (\$/bu) [2.25]
Increase in Crop 2 Yield (bu/acre) [5]
Price for Crop 2 (\$/bu) [6.25]
Additional Costs (\$/acre) [50]
Additional Savings (\$/acre) [1.25]

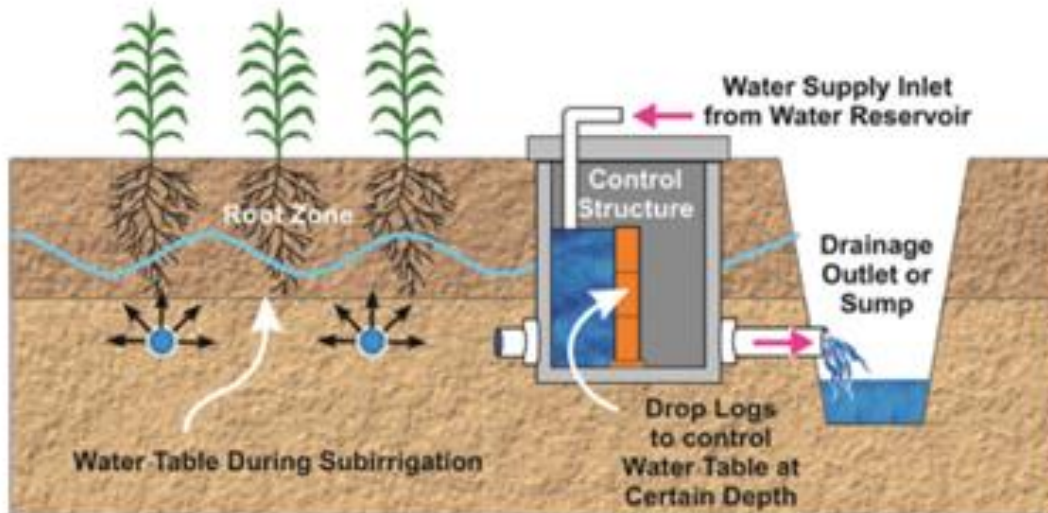
Net Increase in Income (\$/Acre) []
Net Present Value (\$) []
Undiscounted Years to Payback []
Discounted Years to Payback []
Internal Rate of Return (%) []

The Future of Irrigation in
Illinois – Evaluating Center-
Pivot and Combination
Drainage/Subirrigation Systems

Drainage Mode



Subirrigation Mode



Land Suitability: Soils

The most important factor in determining soil suitability is the **Ability to Sustain an Elevated Water Table.**

Soils classified as being hydric typically require drainage, and for the most part, are suitable for subirrigation.

List of Hydric Soils in Illinois

Land Suitability: Major Soil Components

All of the soils in a field may not be suitable for subirrigation. A parcel meets the components criterion if the **majority of the soils** are suitable.

Example of an Unsuitable Field

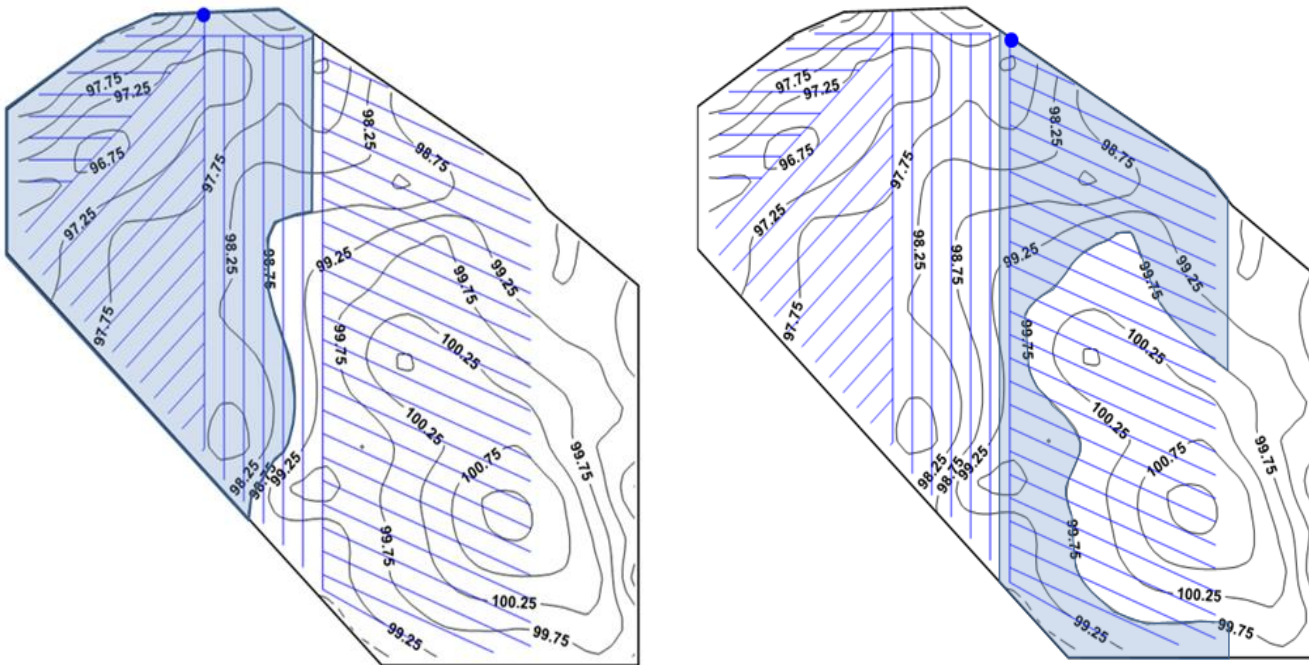
Toggle Fields



Soil 331A is not suitable for sub irrigation as it drains quickly and will not sustain an elevated water table. Soil 415A is suitable, but it covers a small section of the field. Therefore, this field is not suitable for implementing subirrigation. If this were a large field, and each of the 415A sections were larger enough and able to sustain an elevated water table, then it might be possible to implement subirrigation in those sections, depending on the layout of the drainage system.

Land Suitability: Slope

Fields, or sections of a field, with an average slope of **1% or less** are more likely to be suitable for the implementation of Subirrigation.



Flatter fields have higher treated areas for each control structure

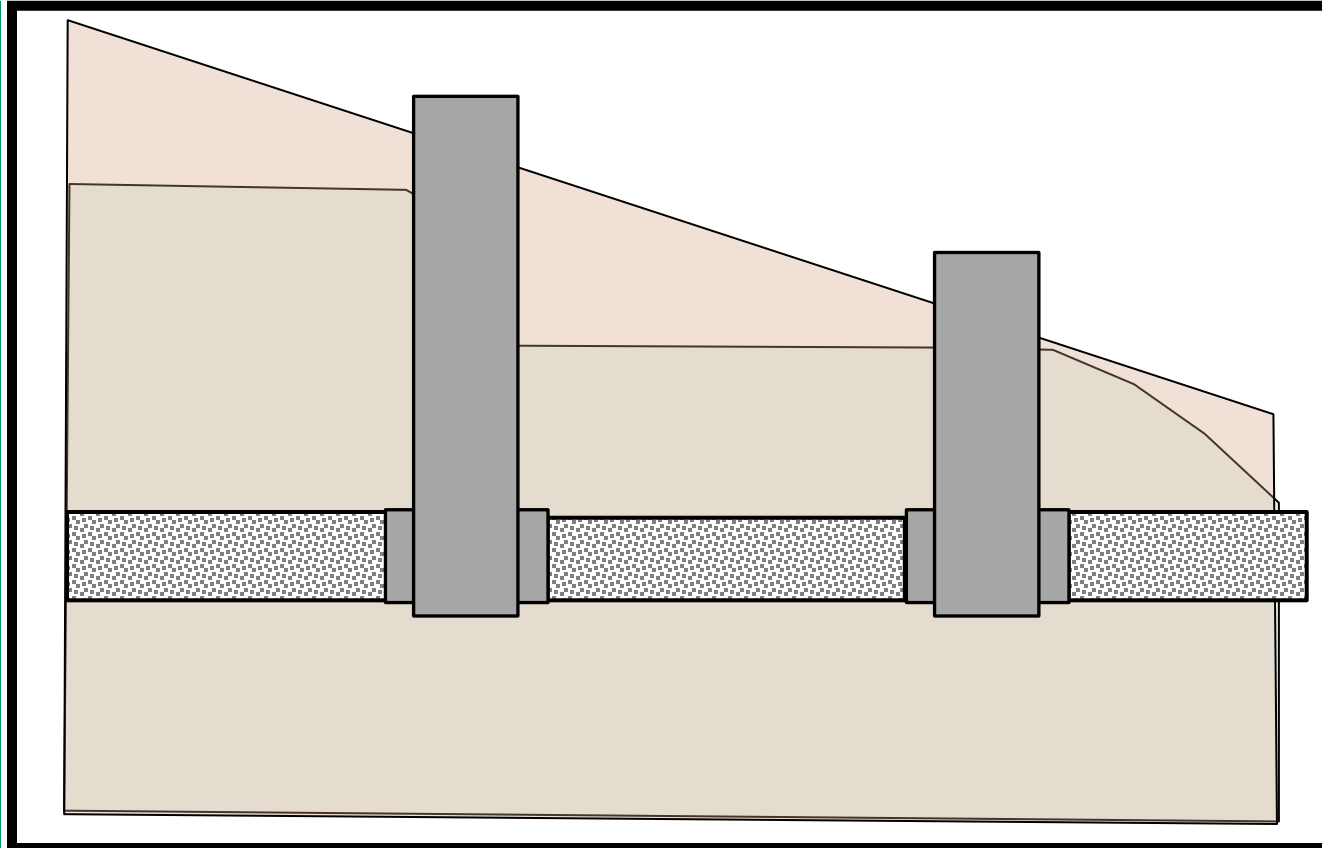
Mitigating the Effects of Slope

On steeper slopes, the effective treated area can be increased by using multiple structures. Multiple structures are most suited for fields in which the laterals are parallel, or near parallel, with the contour lines.

Click the toggle button below to see systems laid out free and managed drainage

Toggle Layouts

Clear Layouts



Multiple structures being used to increase treated area in a steeper field. One drawback to multiple structures is that structures may have to be located inside a field. Producers may find it inconvenient to work around them.

Mitigating the Effects of Slope: Watergate

The water gate was designed to provide an increase in hydraulic head in tile lines without the inconvenience of above ground structure inside a field. It was designed to produce 12 inches of static head difference between the upstream and downstream ends.



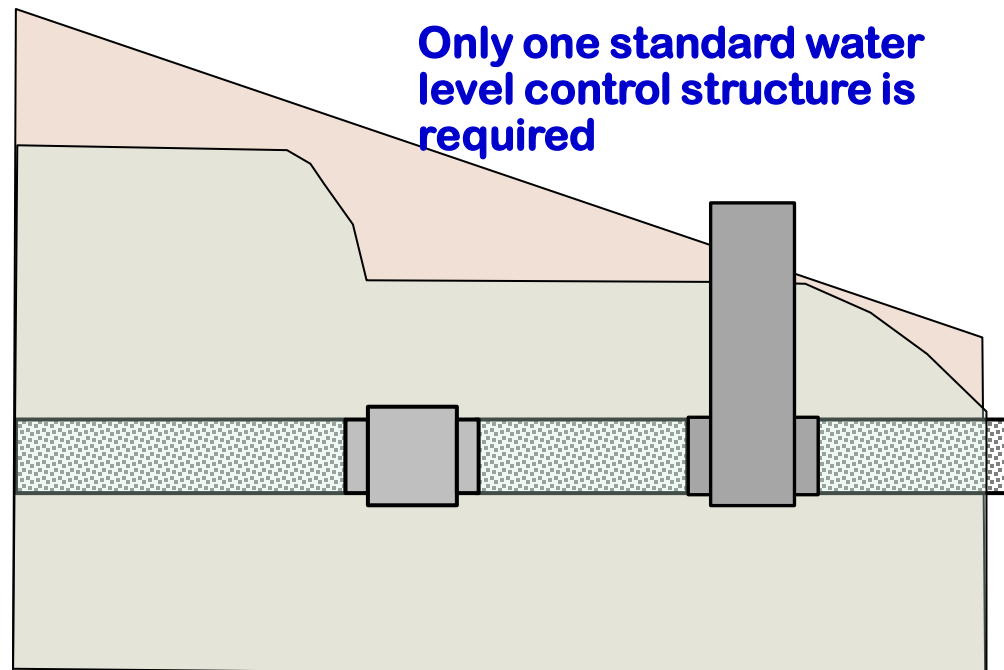
Schematic of Installed Water Gate

Water Gate Performance:
Free Flow Conditions

Water Gate Performance:
Design Table

Water Gate Performance:
Submerged Outlet Flow

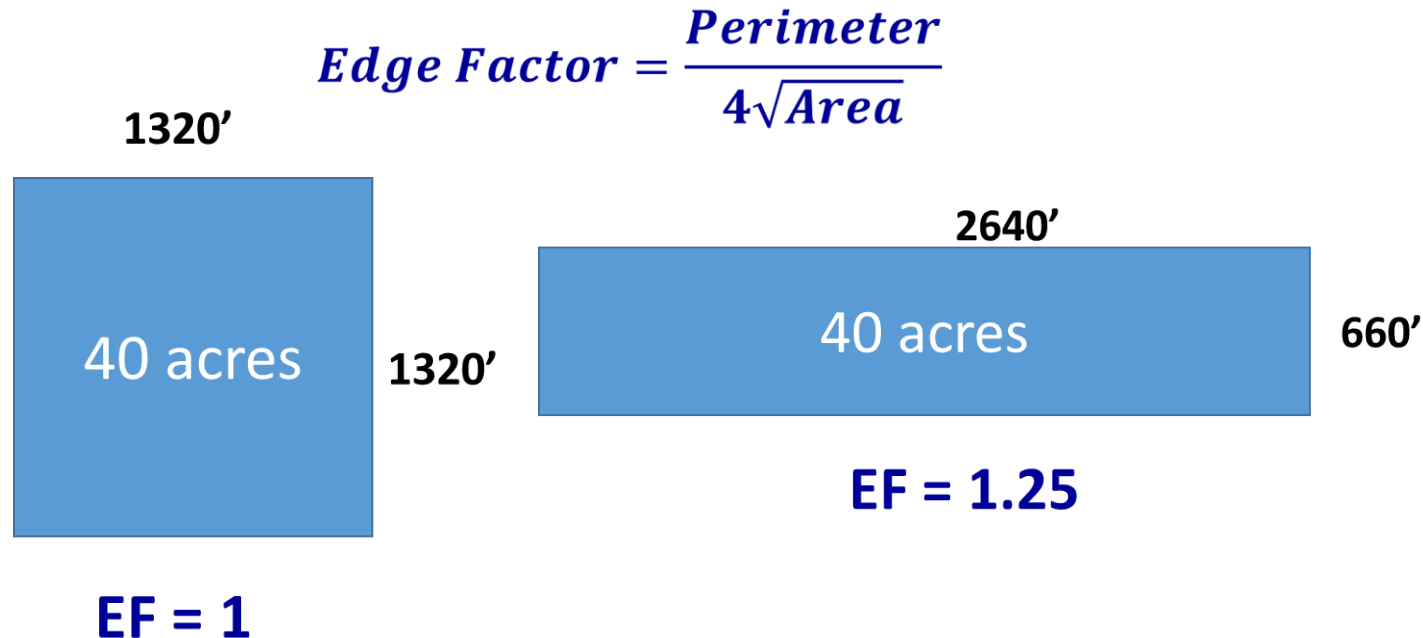
State Position on Use of
Water Gates



Land Suitability: Parcel Contiguity

The Edge Factor (EF) of a field may be defined as the ratio of the perimeter of the field to the perimeter of a square of equal area.

The smaller the EF, the more suitable the field is for sub-irrigation.



Subirrigation Water Control: NRCS Practice Standard 443

Within each managed subunit, the water level control structure shall be of sufficient size to allow adequate flow to meet water requirements of that subunit. The control structures should be set on elevation intervals not to exceed 1 foot.

Subirrigation Drain Spacing: NRCS Practice Standard 443

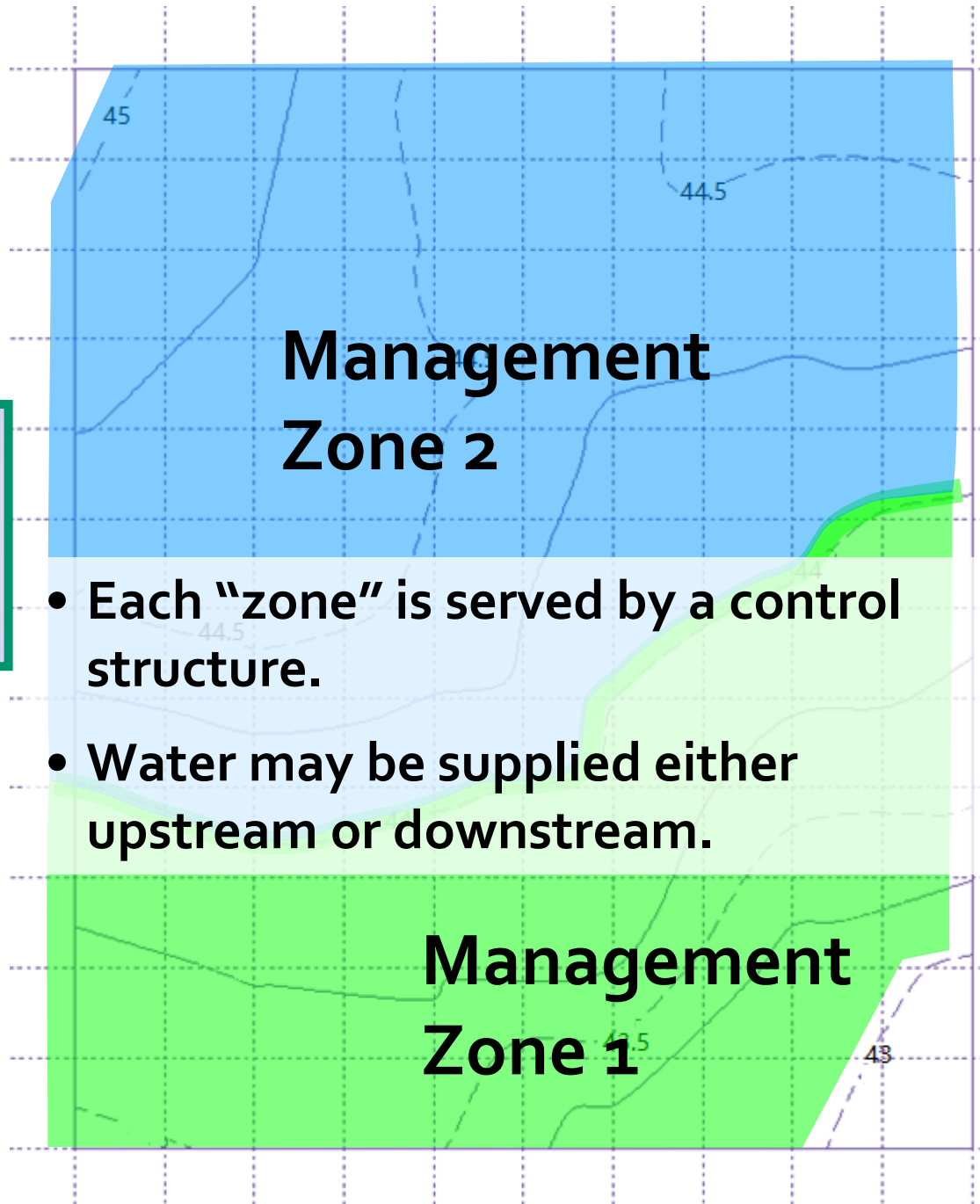
Laterals shall be equally spaced in each subunit.
Maximum spacing of irrigation tiles shall be no more than **one-half the lateral or ditch spacing specified in local drainage guides**

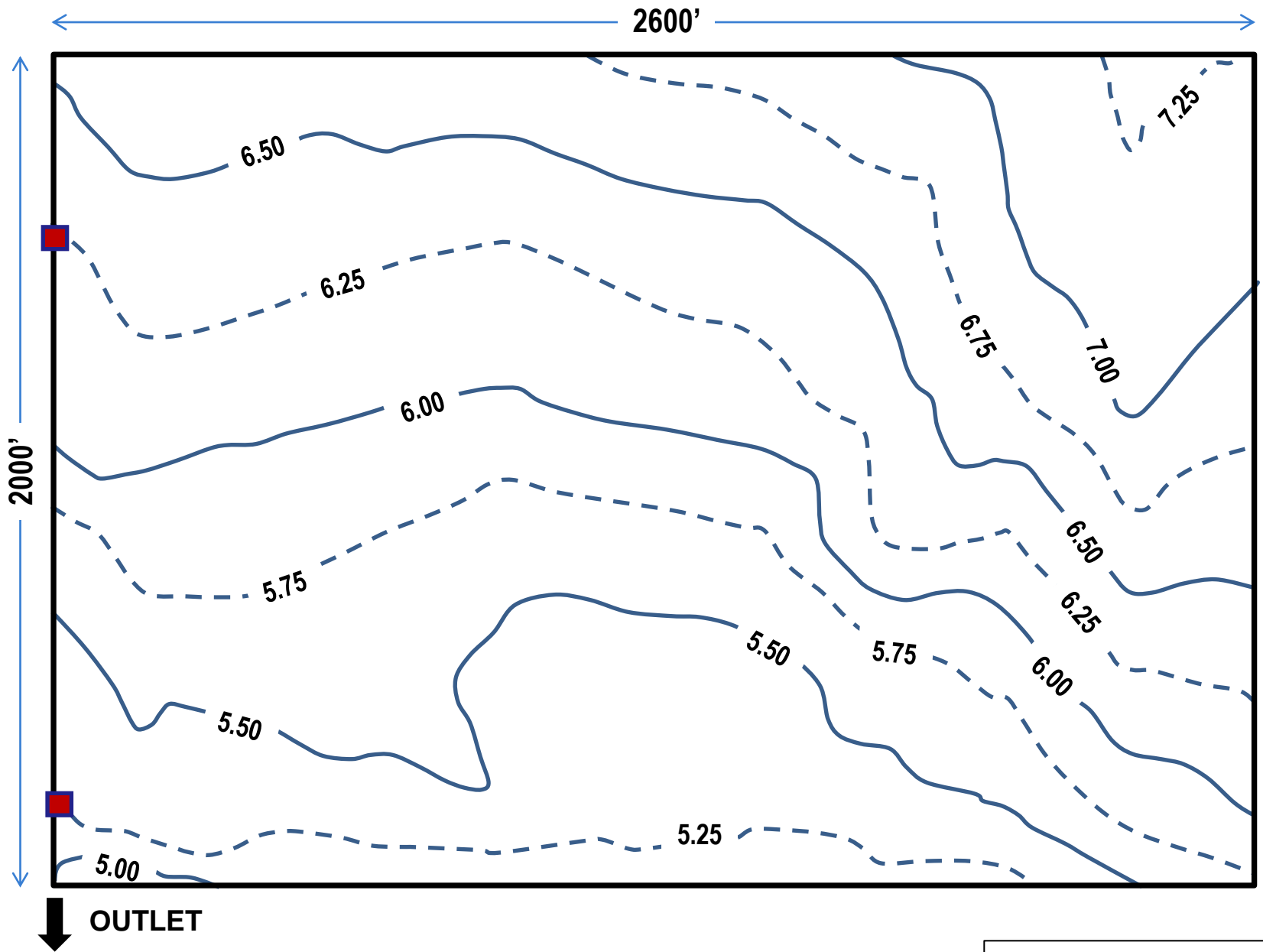
Subirrigation Zones

Management Zone 2

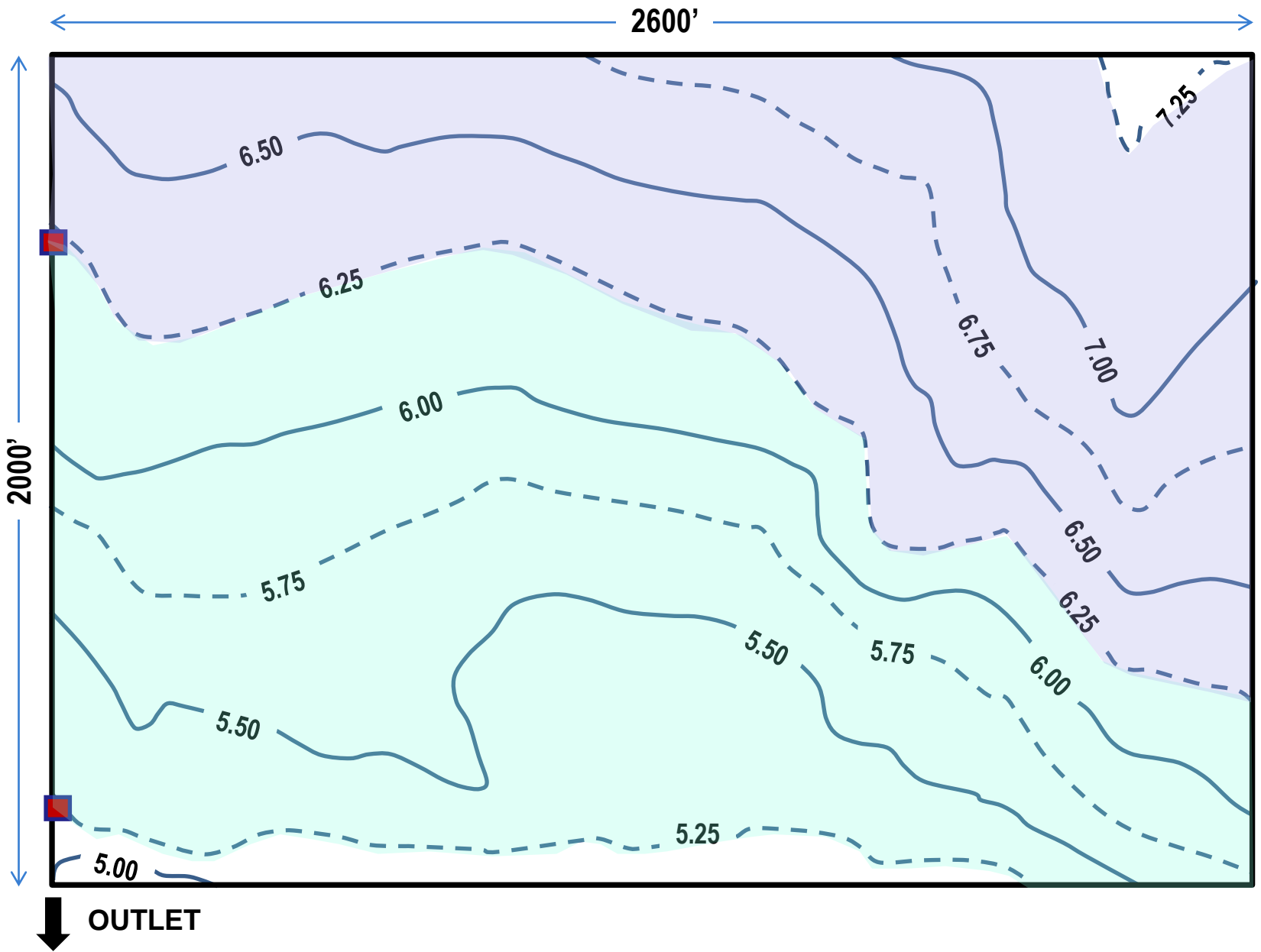
- Each “zone” is served by a control structure.
- Water may be supplied either upstream or downstream.

Management Zone 1





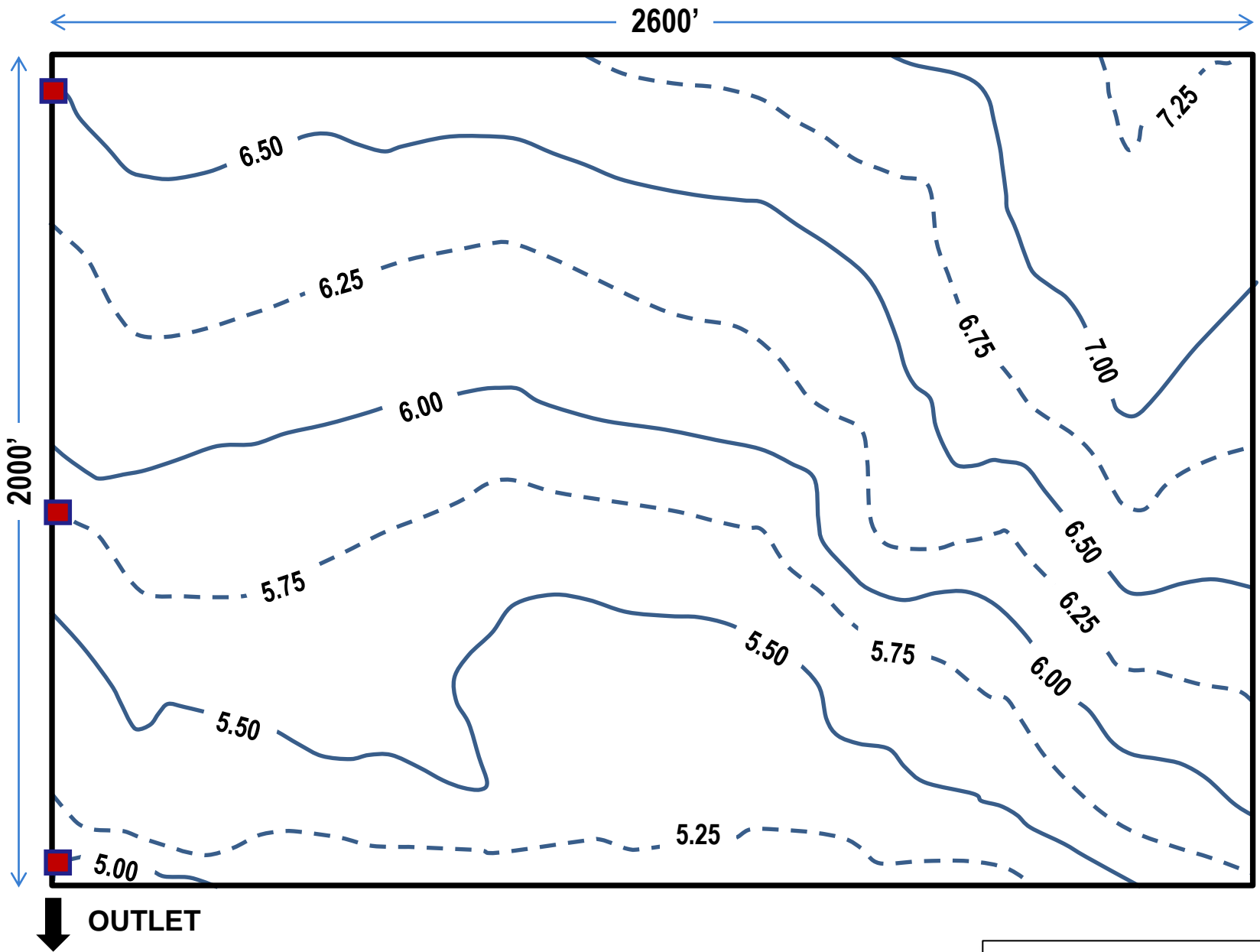
0.25-ft contours
120 acres



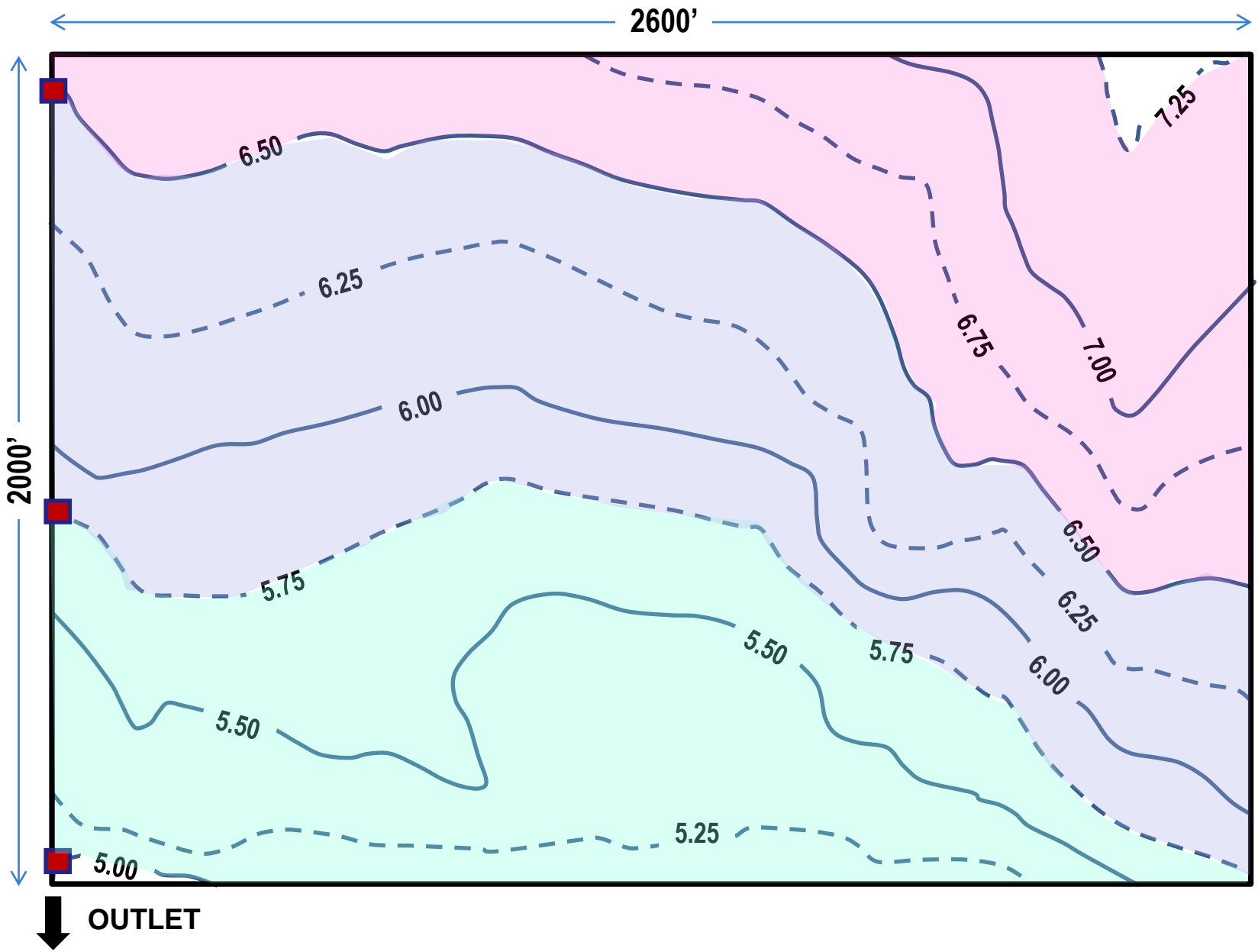
2600'

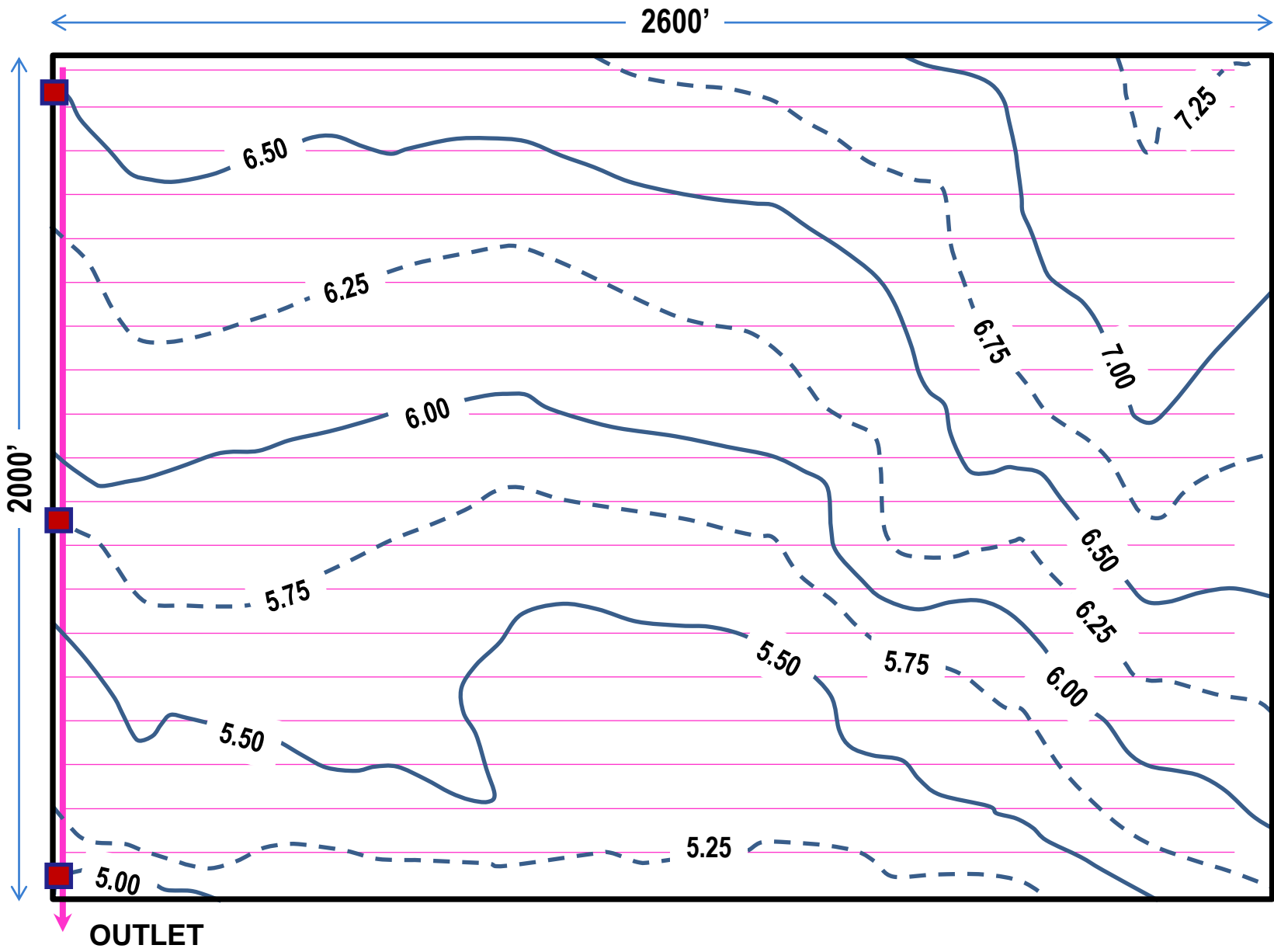
2000'

OUTLET

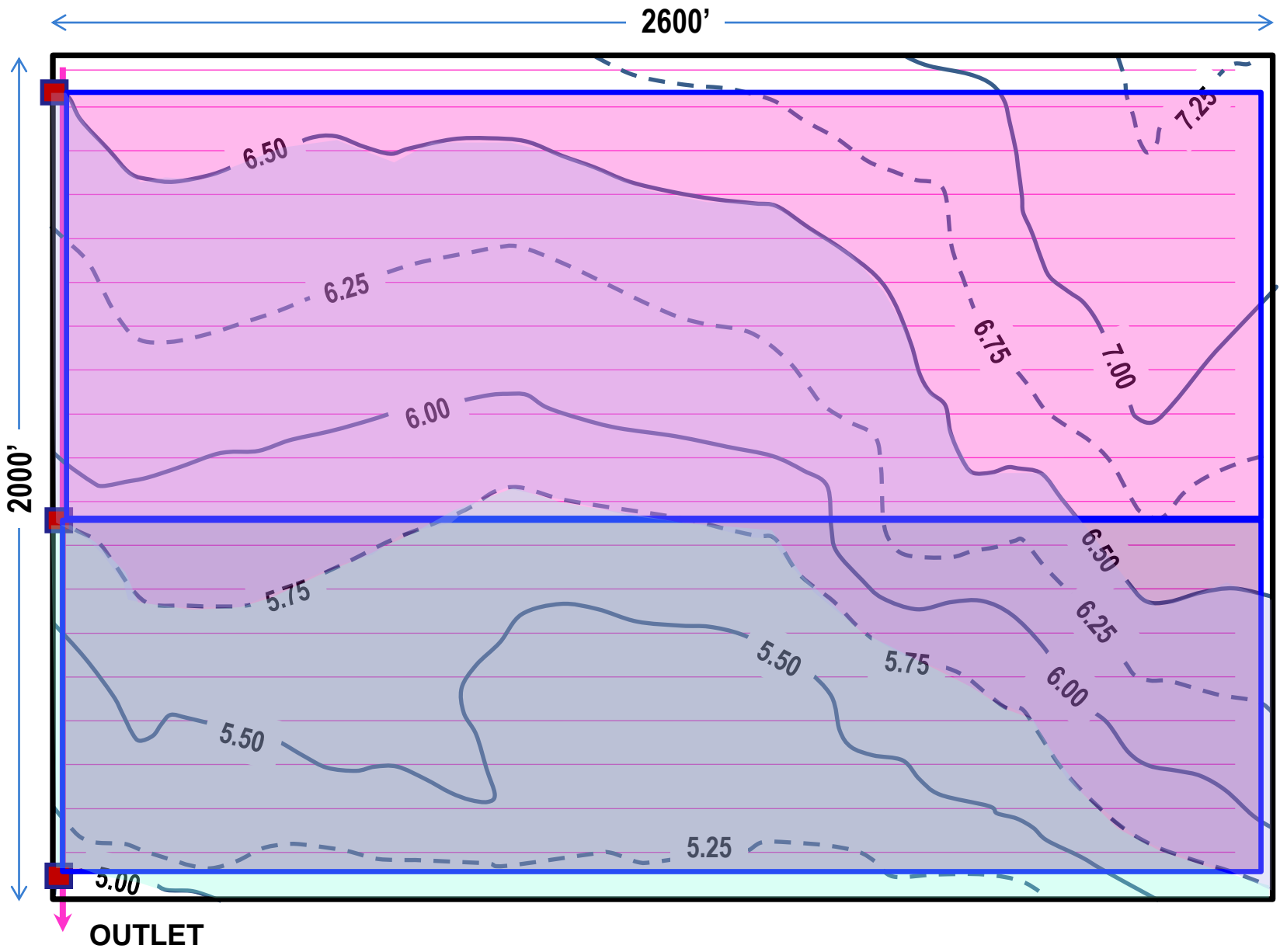


0.25-ft contours
120 acres

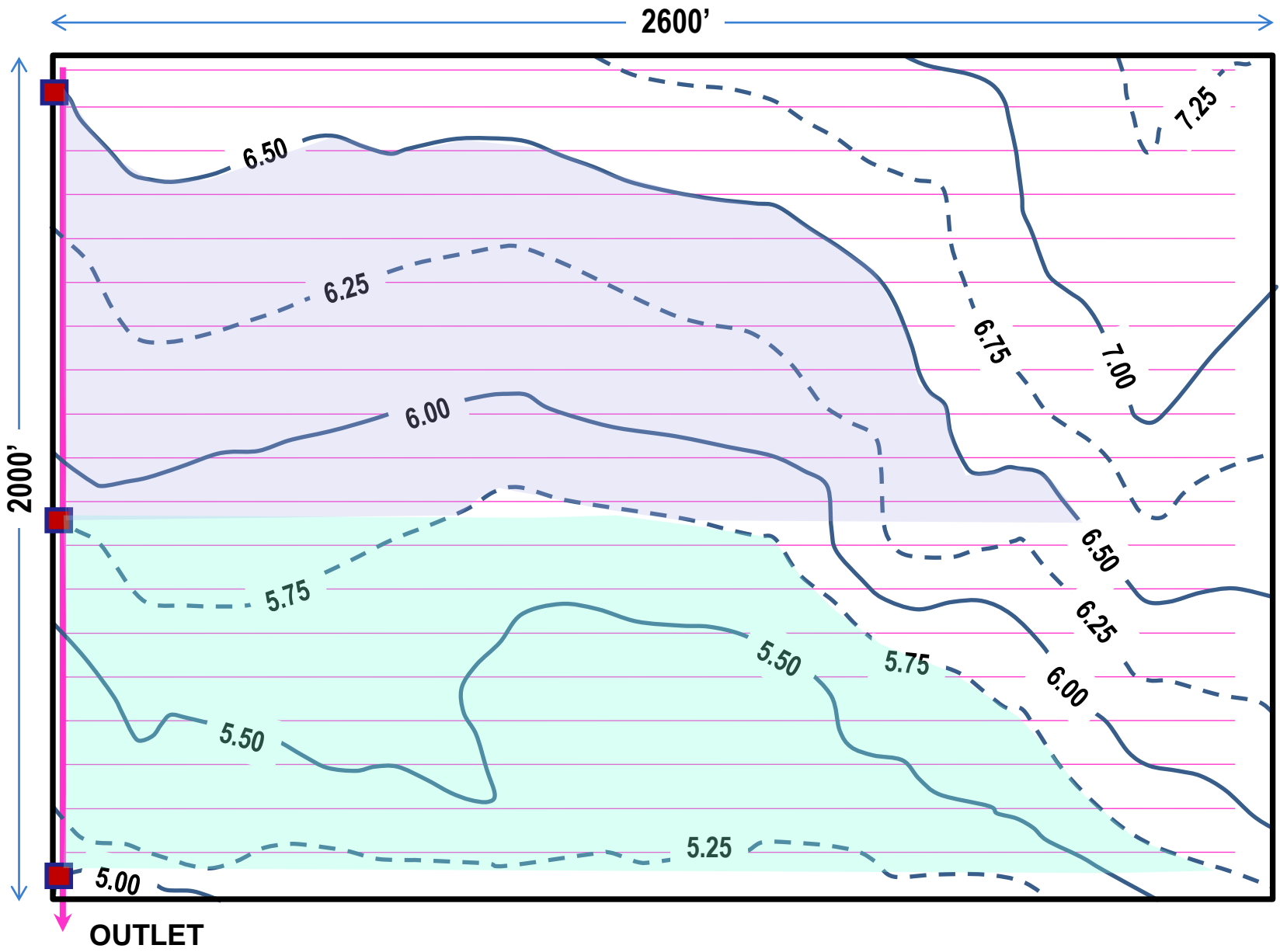




0.25-ft contours
120 acres

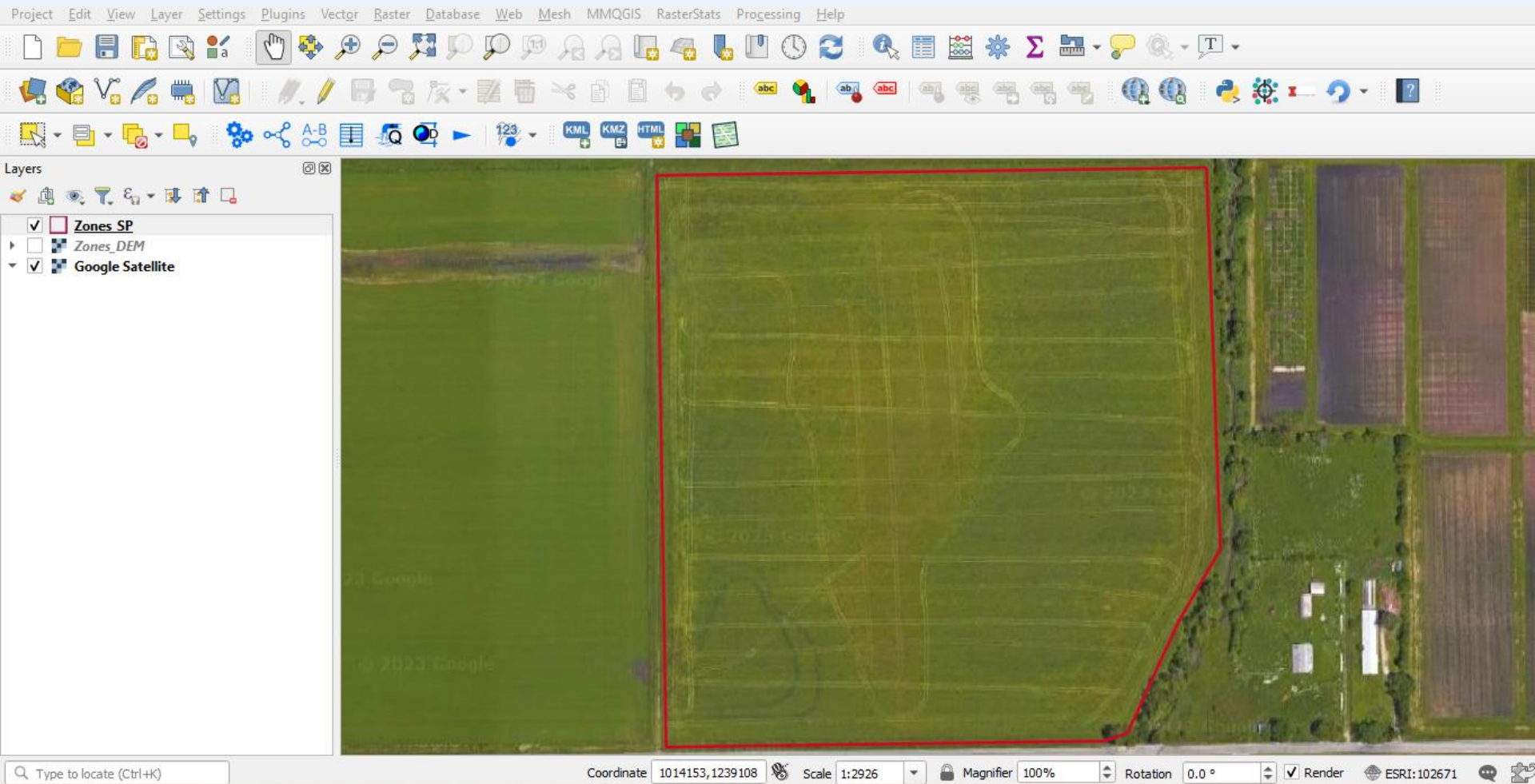


0.25-ft contours
120 acres



0.25-ft contours
120 acres

Doubleclick to load the SI_Zones.qgz Project



Load the Reclassify by Table Plugin

Processing → Toolbox → Reclassify by table



The screenshot displays the QGIS interface with the 'Reclassify by Table' dialog box open. The dialog box has two tabs: 'Parameters' and 'Log'. The 'Parameters' tab is active, showing the following settings:

- Raster layer:** [Empty dropdown]
- Band number:** 1
- Reclassification table:** Fixed table (0x3)
- Advanced Parameters:**
 - Output no data value:** -9999.000000
 - Range boundaries:** min < value <= max
 - Use no data when no range matches value
 - Output data type:** Float32
- Reclassified raster:** [Save to temporary file]

The 'Log' tab is empty. The 'Processing Toolbox' is visible on the right side of the screen, showing a search for 'table' and a list of tools. The 'Reclassify by table' tool is highlighted in the list.

Processing Toolbox

Search: table

- Recently used
 - Reclassify by table
- Database
 - Export to PostgreSQL
 - Export to Spatialite
 - PostgreSQL execute and load SQL
- Raster analysis
 - Reclassify by table
- Vector analysis
 - Basic statistics for fields
 - Statistics by categories
- Vector creation
 - Create points layer from table
- Vector general
 - Create attribute index
 - Create spatial index
 - Flatten relationship
 - Join attributes by field value
 - Join attributes by nearest
 - Truncate table
- Vector table
 - Add autoincremental field
 - Add field to attributes table
 - Add unique value index field
 - Add X/Y fields to layer

Reclassify the Zones_DEM to show the region between 698' and 699'

Reclassify by Table

Parameters Log

Raster layer
Zones_DEM [ESRI:102671]

Band number
Band 1 (Gray)

Reclassification table
Fixed table (3x3)

Advanced Parameters

Output no data value
-9999.000000

Range boundaries
min < value <= max

Use no data when no range matches value

Output data type
Float32

Reclassified raster
[Save to temporary file]

Open output file after running algorithm

0%

Run as Batch Process... Run



Reclassify by Table

Parameters Log

Reclassification table

	Minimum	Maximum	Value
1	0	698	0
2	698	699	1
3	699	800	0

Add Row
Remove Row(s)
Remove All
OK
Cancel

0%

Run as Batch Process... Run

Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh MMQGIS RasterStats Processing Help



Layers

- Reclassified raster
- Zones_SP
- Zones_DEM
- Google Satellite



Processing Toolbox

table

- Recently used
 - Reclassify by table
- Database
 - Export to PostgreSQL
 - Export to SpatialLite
 - PostgreSQL execute and load SQL
- Raster analysis
 - Reclassify by table
- Vector analysis
 - Basic statistics for fields
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 - Join attributes by field value
 - Join attributes by nearest
 - Truncate table
- Vector table
 - Add autoincremental field
 - Add field to attributes table
 - Add unique value index field
 - Add X/Y fields to layer

Type to locate (Ctrl+K)

Coordinate 1015293,1239082 Scale 1:2926 Magnifier 100% Rotation 0,0 ° Render ESRI:102671

Experiment with different 1' zones

698.25 – 699.25 , for example