Irrigation and Water for Gardening

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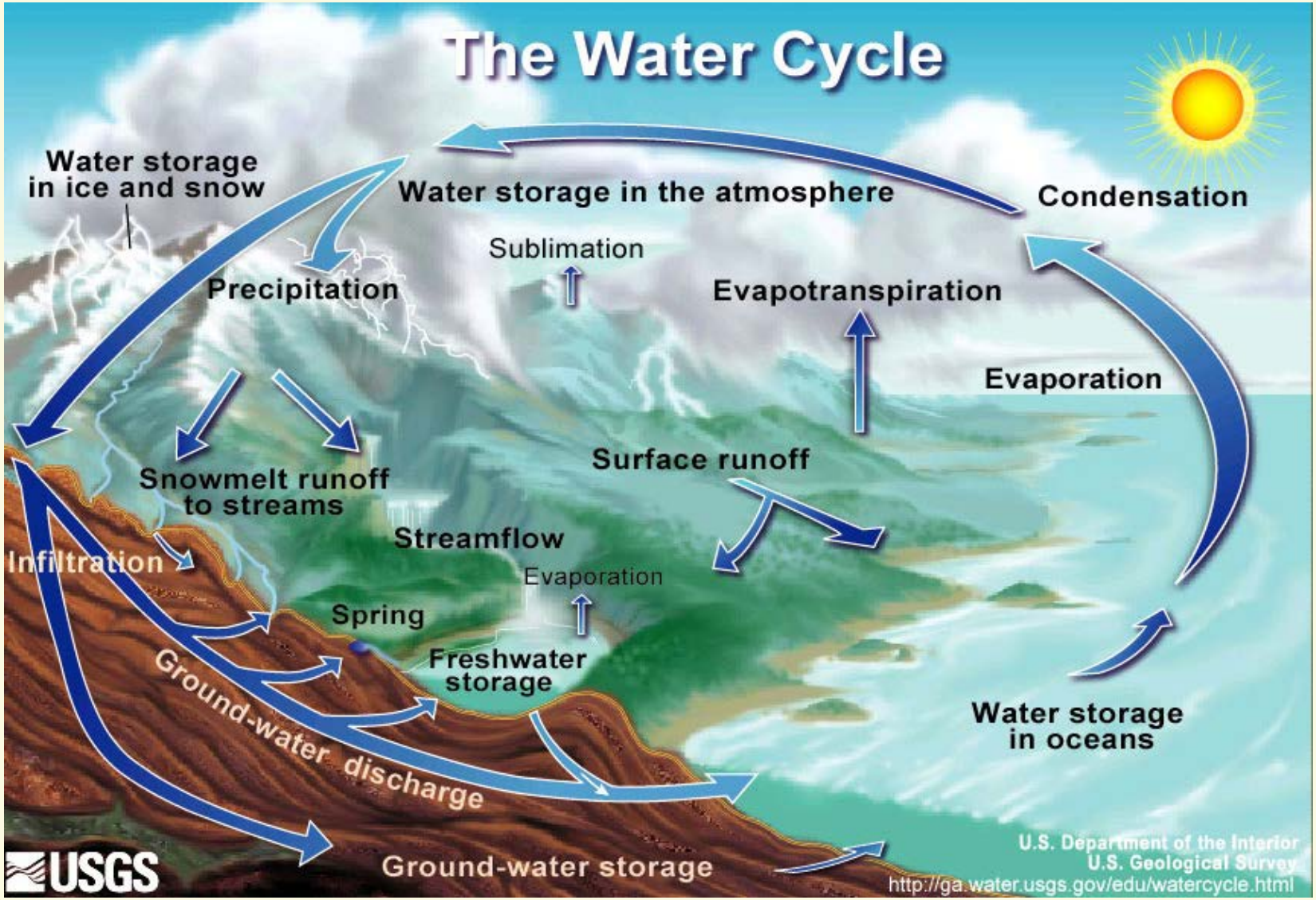
UNIVERSITY OF MISSOURI Extension

What We'll Cover….

- Planting efficiently
- Water use and water saving factors
  - Amounts of water needed
  - Methods of watering
  - Water problems
    - Water quality and quantity
    - Water bans
- Current water issues

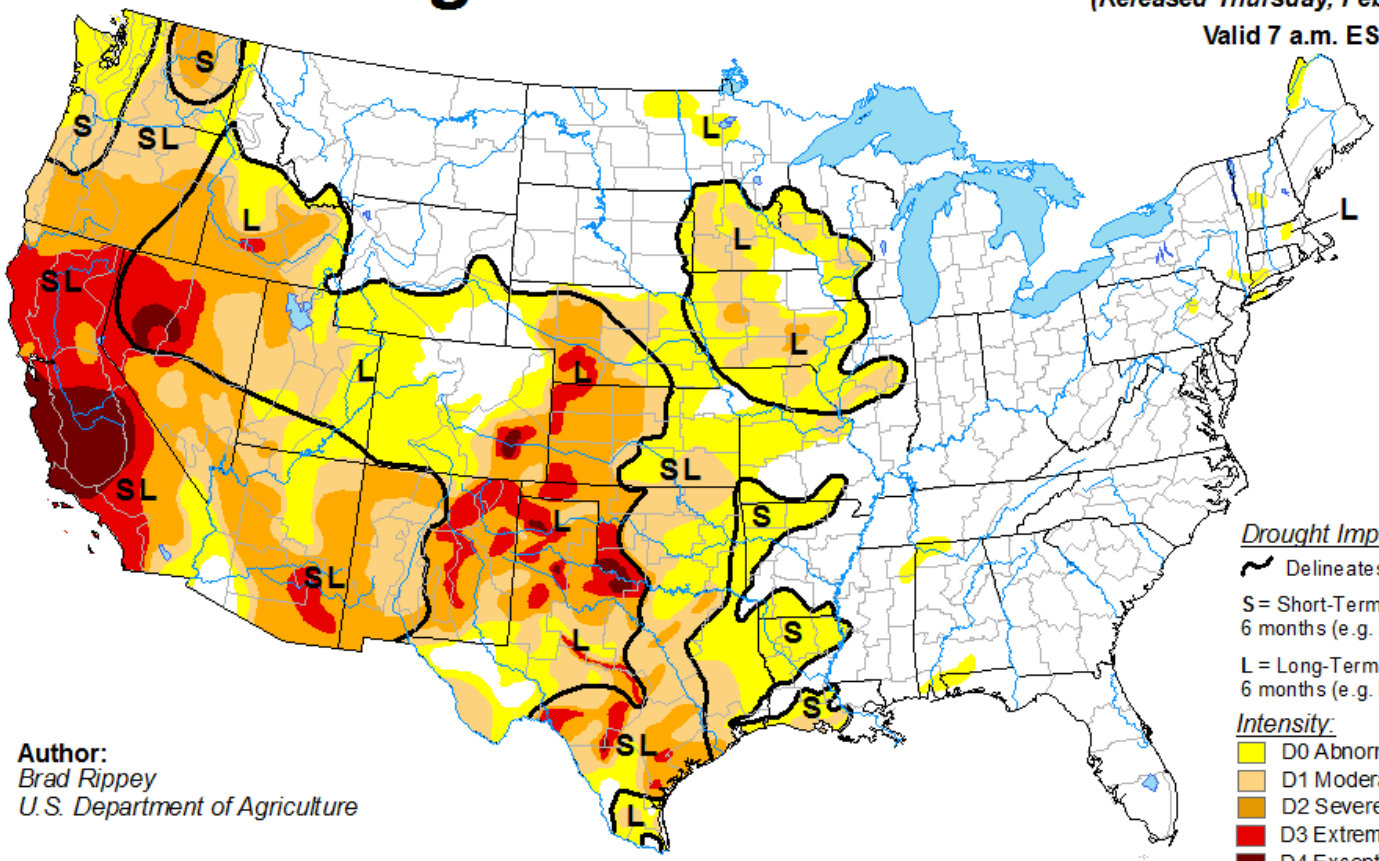

The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Surface runoff
Snowmelt runoff to streams
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Ground-water discharge
Water storage in oceans
Ground-water storage
USGS
U.S. Department of the Interior
U.S. Geological Survey
http://ga.water.usgs.gov/edu/watercycle.html

U.S. Drought Monitor

February 25, 2014

(Released Thursday, Feb. 27, 2014)

Valid 7 a.m. EST



Author:
Brad Rippey
U.S. Department of Agriculture

Drought Impact Types:

Delineates dominant impacts

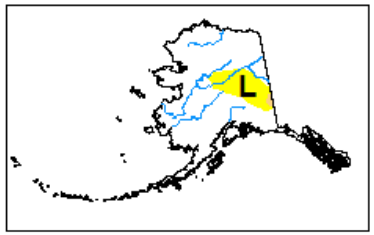
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

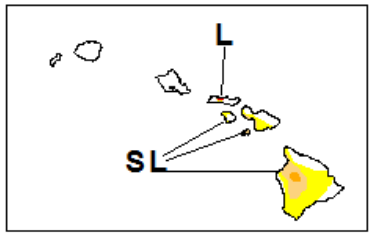
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

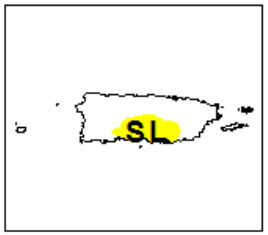
Intensity:

- 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. See accompanying text summary for forecast statements.





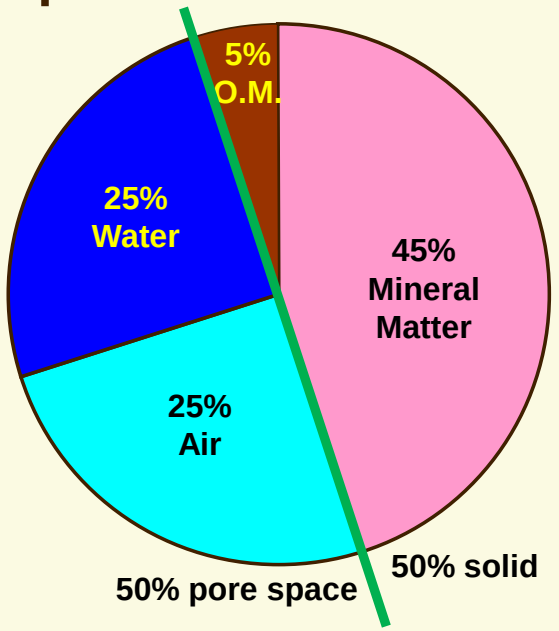


USDA National Drought Mitigation Center

http://droughtmonitor.unl.edu/

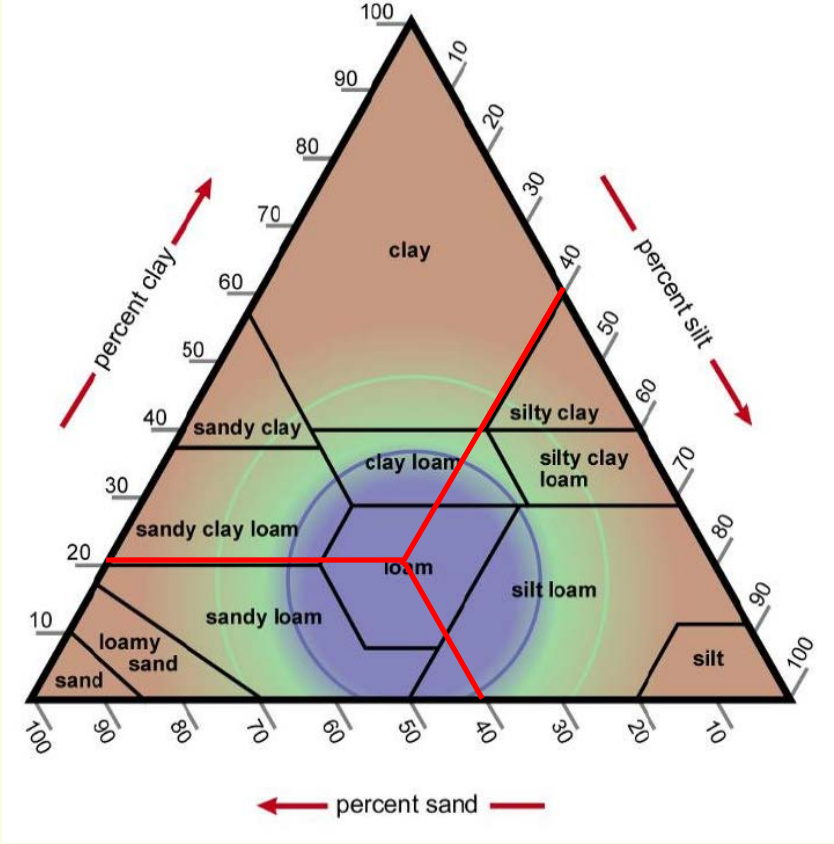
If you take care of your soil, the soil will take care of your plants.

- Plant available water depends on:
  - Soil structure & texture
  - Water infiltration rate
  - Soil organic matter
  - Soil type
  - Plant rooting depth



USDA Soil Texture Classes

- Particle size
  - Sand = 2.0-0.05 mm
  - Silt = 0.05-0.002 mm
  - Clay = <0.002 mm
- Characteristics
  - Sand adds porosity
  - Silt adds body to the soil
  - Clay adds chemical & physical properties



Determining Soil Texture

- By feel
  - Gritty, smooth, sticky
- Using the jar method
  - Fill a 1-quart jar ¼ full of soil
  - Fill the jar with water to ¾ full
  - Add 1 teaspoon of dishwashing detergent
  - Shake very well to suspend soil
  - Place on a flat surface and allow soil to settle for 2 days
  - Measure % thickness of each layer relative to all

Checking Soil Drainage

- Perched water table
- Fragipan on upland soils
- Standing water after a rain


Photo credit: truebluesam.blogspot.com/2011/05/clay-pan-soils.html

Benefits of Using Compost

- Improves drainage & aeration of heavy clay soils
- Increases moisture-holding ability of sandy soils
- Increases earthworm & soil microbial activity that benefit plant growth
- Improves soil structure & makes it easier to work
- Contains nutrients needed for plant growth

Soil Properties

- Soils store 1.5”-2.5” of water per foot of depth (check county NRCS Soil Survey)
- Intake rate = 0.2”-2.0” per hour, rest is runoff
- Available Soil Moisture* = % of soil water between field capacity & permanent wilting point = ranges by crop from 25% to 75%
- Summer E.T. rate can be 0.25”+ per day
  - E.T. affected by radiation, humidity, air temperature, wind speed
- A 2-ft. deep soil at best holds a 9-15 day supply of available moisture for plants

References: * websoilsurvey.nrcs.usda.gov/app/
** www.ces.ncsu.edu/depts/hort/hil/hil-33-e.html

Available Water Holding Capacity for Several Soil Types

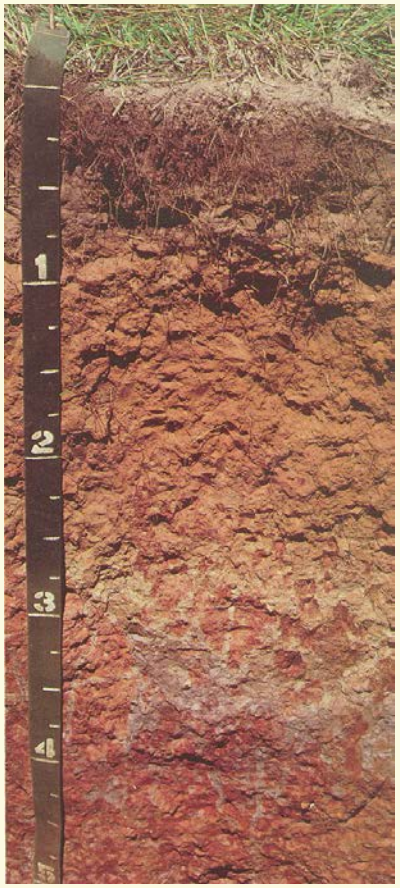
Soil Texture	Available Water Holding Capacity	
	In Inches per Inch of Soil	In Inches per Foot of Soil
Loamy fine sand	0.08-0.12	0.96-1.44
Sandy loam	0.10-0.18	1.20-2.16
Loam	0.14-0.22	1.68-2.64
Silt loam	0.18-0.23	2.16-2.76
Clay loam	0.16-0.18	1.92-2.16

Reference: Midwest Vegetable Production Guide for Commercial Growers
http://www.btny.purdue.edu/pubs/id/id-56/

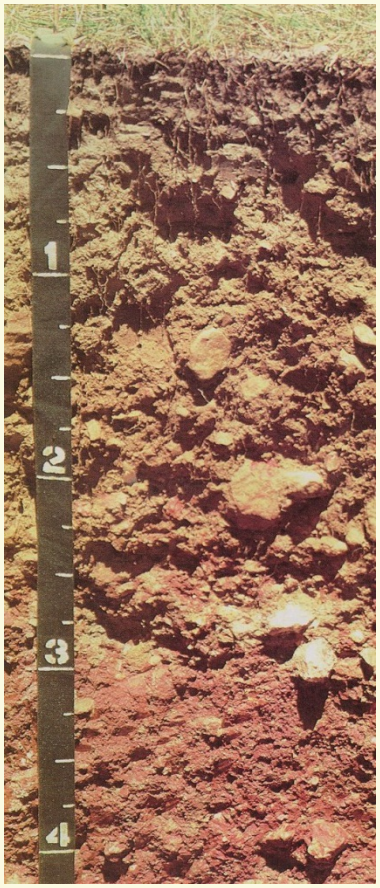
Soil Drainage Classification

Drainage Class	Matrix	Mottle
Well	Bright red	None
Moderately well	Red	Gray
Somewhat poorly	Dull	Red
Poorly		All gray

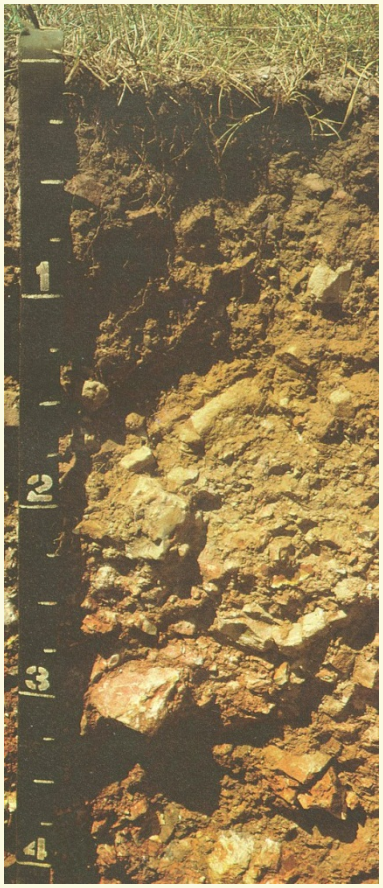
Color Indicates Drainage & Pans



Captina
Silt Loam



Tonti
Silt Loam



Scholten Gravelly
Silt Loam

Table 6. Effective Rooting Depth of Selected Vegetables

Shallow (6-12″)	Moderate (18-24″)	Deep (> 36″)
Beet	Cabbage, Brussels Sprouts	Asparagus
Broccoli	Cucumber	Lima Bean
Carrot	Eggplant	Pumpkin
Cauliflower	Muskmelon	Sweet Potato
Celery	Pea	Watermelon
Greens & Herbs	Potato	Squash, Winter
Onion	Snap Bean	
Pepper	Squash, Summer	
Radish	Sweet Corn	
Spinach	Tomato	

Table 7. Vegetable Crops and Growth Period Most Critical for Irrigation Requirements

Crop[1]	Most Critical Period
broccoli, cabbage, cauliflower, lettuce	head development
carrot, radish, beet, turnip	root enlargement
sweet corn	silking, tasseling, and ear development
cucumber, eggplant, pepper, melon, tomato	flowering, fruit set, and maturation
bean, pea	flowering, fruit set, and development
onion	bulb development
potato	tuber set and enlargement

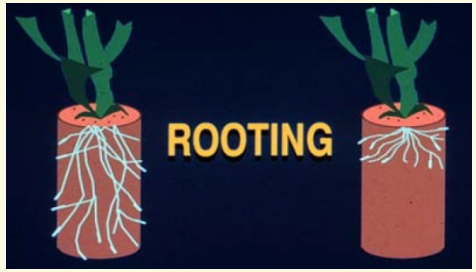
[1]For transplants, transplanting and stand establishment represent a most critical period for adequate water.

Most of the active root system for water uptake may be between 6”-12”

Reference: irrigationtraining.tamu.edu/docs/irrigation-training/south/crop-guidelines/estimatedwaterrequirementsvegetablecrops.pdf

Basic Watering Facts

- Plants need 1”-1.5” of water per week
  - 624-935 gallons (83-125 cu.ft.) per 1,000 sq.ft.
- Can survive drought on half that rate
- Deep infrequent waterings are better than several light waterings
- Deeper roots require less supplemental irrigation
- Taller plants have deeper roots
  - Lowers tendency to wilt
  - Shades soil surface
  - Controls weeds by competition
  - Makes water “go farther”

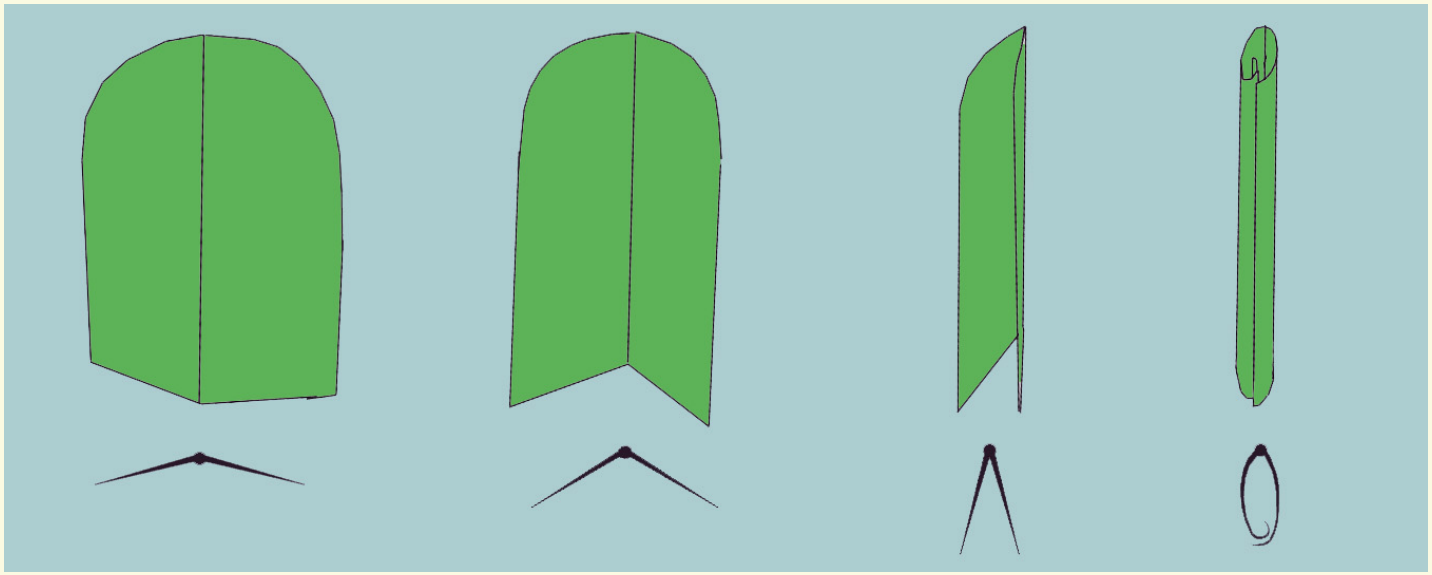


When to Water 1

- Rainfall less than 1” per week
  - Keep a record of rainfall received
  - Check soil moisture with long screwdriver
- Water in early morning. Let plant leaves dry before evening to prevent diseases

When to Water 2

- Your plants will tell you when they need water
  - Purple-blue wilting leaves
  - Grass that leaves footprints
  - Folded or rolled leaves



Just rained **Getting dry** **Time to water** **Drought**

What to Water

- Irrigate highly visible & intensively-managed areas first
- High priority to drought-sensitive plants
- Low priority to turf (less costly to replace)

Measuring Water Needs

Catch cans

4-cycle timer

Rain gauge

The Two Major Factors in Irrigation System Planning

1. How much <u>water</u> do you need?

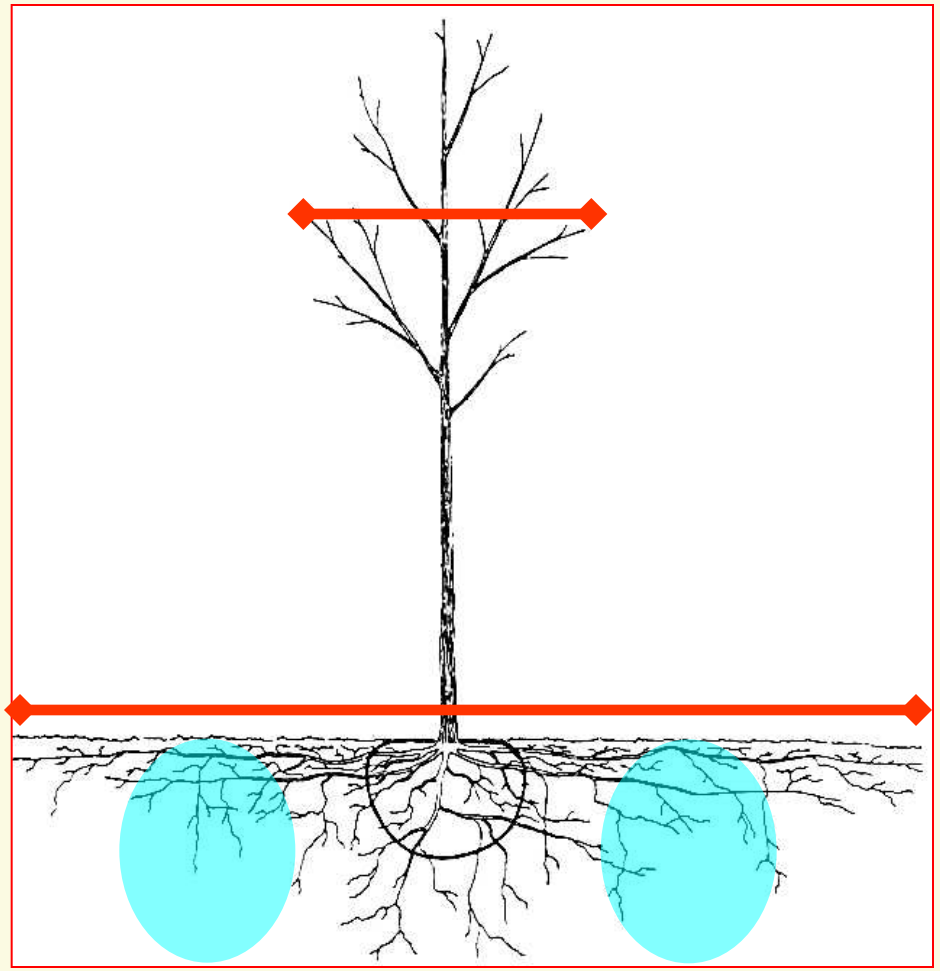
2. How much <u>time</u> do you have?

Is a Rain Barrel Enough?

- 1” of rain from a 1,600 sq. ft. house roof = 1,000 gallons
- Elevation dictates pressure
  - 2.3 feet of head = 1 psi pressure

Watering Mature Trees and Shrubs

- Most roots in top 12” of soil
- Root spread up to 4X tree crown spread
  - Varies by tree species
- Saturate 20% of root zone 12” deep



How Much Water for Trees?

- Gallons needed for 1” water per week =

$$\frac{\text{Diameter x Diameter}}{2}$$

- Example #1:

$$\frac{\text{6 ft. x 6 ft.}}{2} = \textbf{18 gal./wk.}$$

- Example #2:

$$\frac{\text{20 ft. x 20 ft.}}{2} = \textbf{200 gal./wk.}$$

Formula: (Dia.’ x Dia.’ x 0.7854 ÷ 43,560 sq.ft./ac.) x 27,154 gal./ac.-in.)

Watering Trees

Soaker hose around drip line of tree

“Gender bender” to improve uniformity of water flow

Bucket & Jug Irrigation

- Labor-intensive
- Efficient water use
- Point-source application
- 0-2 psi system operating pressure
- Rates:
  - 2 GPH = 5/64” hole (put in bottom of bucket)
  - 5 GPH = 1/8” hole

Soaker Hose

- “Sweaty” hose
- Low pressure
- 1/2” - 5/8” dia.
- 0.1 - 1.0 GPH per foot
- Lasts 7-10 years
- Good for gardens, shrub beds
- Expensive on large areas

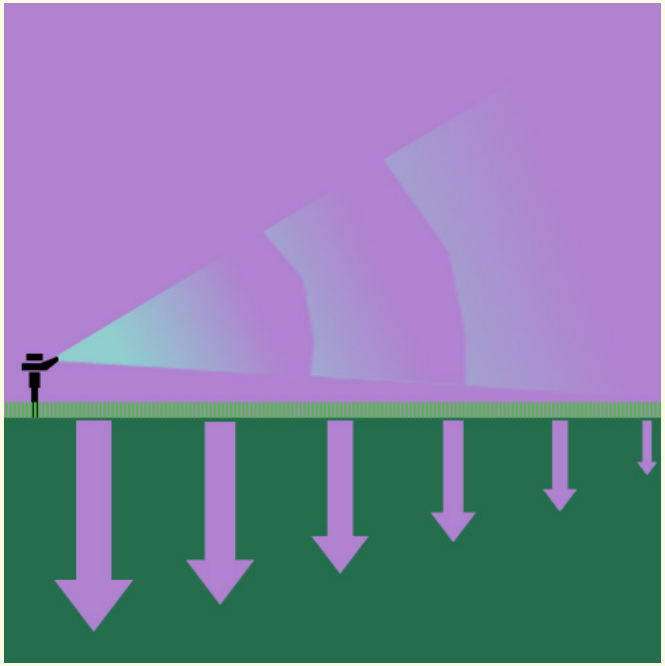
Micro-Sprinkler

- Good for landscape beds
- Uses more water than soaker hose
- More evaporation
- Wide range of spray patterns
  - Spray range is 1.5-6 ft.
- Not effective for frost control

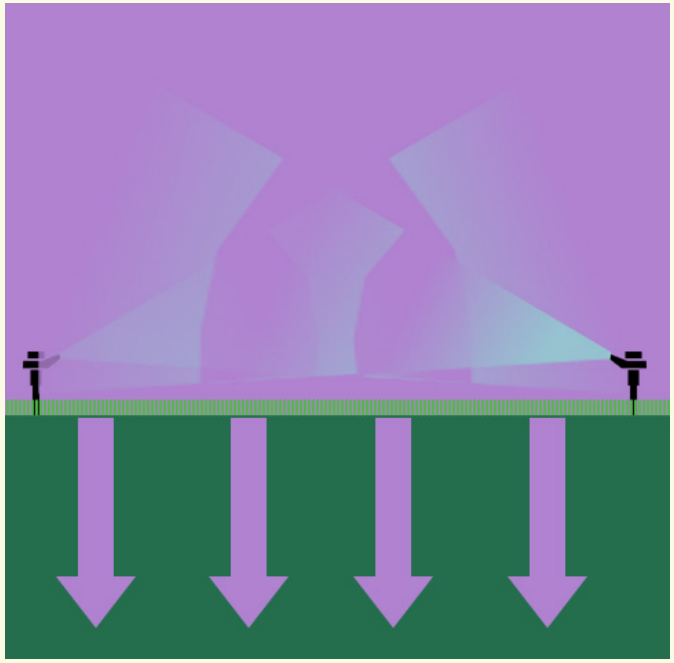
Sprinkler Irrigation [1]

- 1.5-8.5 GPM flow rate
- 4-7 GPM water supply/acre for irrigation
- 45-60 GPM/acre for frost control from 25°F-20°F.
- 25-45 psi system operating pressure
- Wind can disrupt coverage
- Equipment & labor tradeoff
- Cost = $500-$700/acre (?)

How a Sprinkler Waters

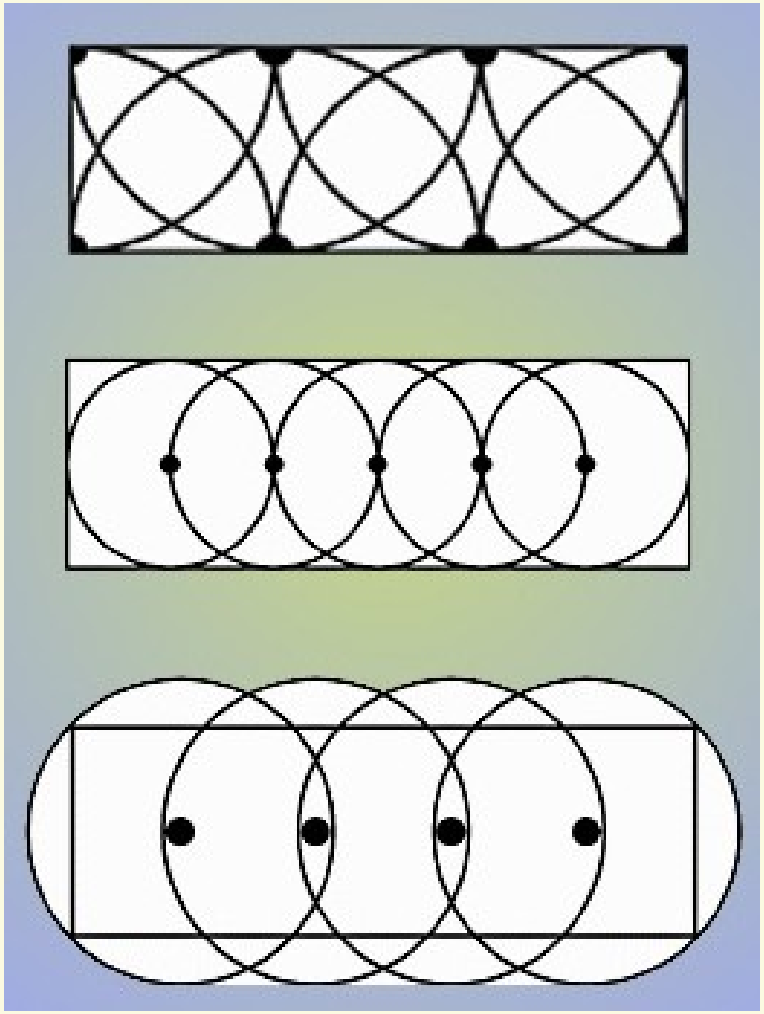


One sprinkler applies a lot of water close in and less water farther away, so watering is uneven.



When sprinklers are set so that patterns overlap, the entire area gets an even amount of water.

Check Sprinkler Overlap



CORRECT
- High uniformity
- No waste

INCORRECT
- Poor uniformity
- Inadequate irrigation

INCORRECT
- Poor uniformity
- Wasted water

Sprinkler Irrigation 2

Oscillating sprinkler covers 3,500 sq.ft. rectangle

Traveling sprinkler covers 16,500 sq.ft. variable path

Sprinkler Irrigation 3

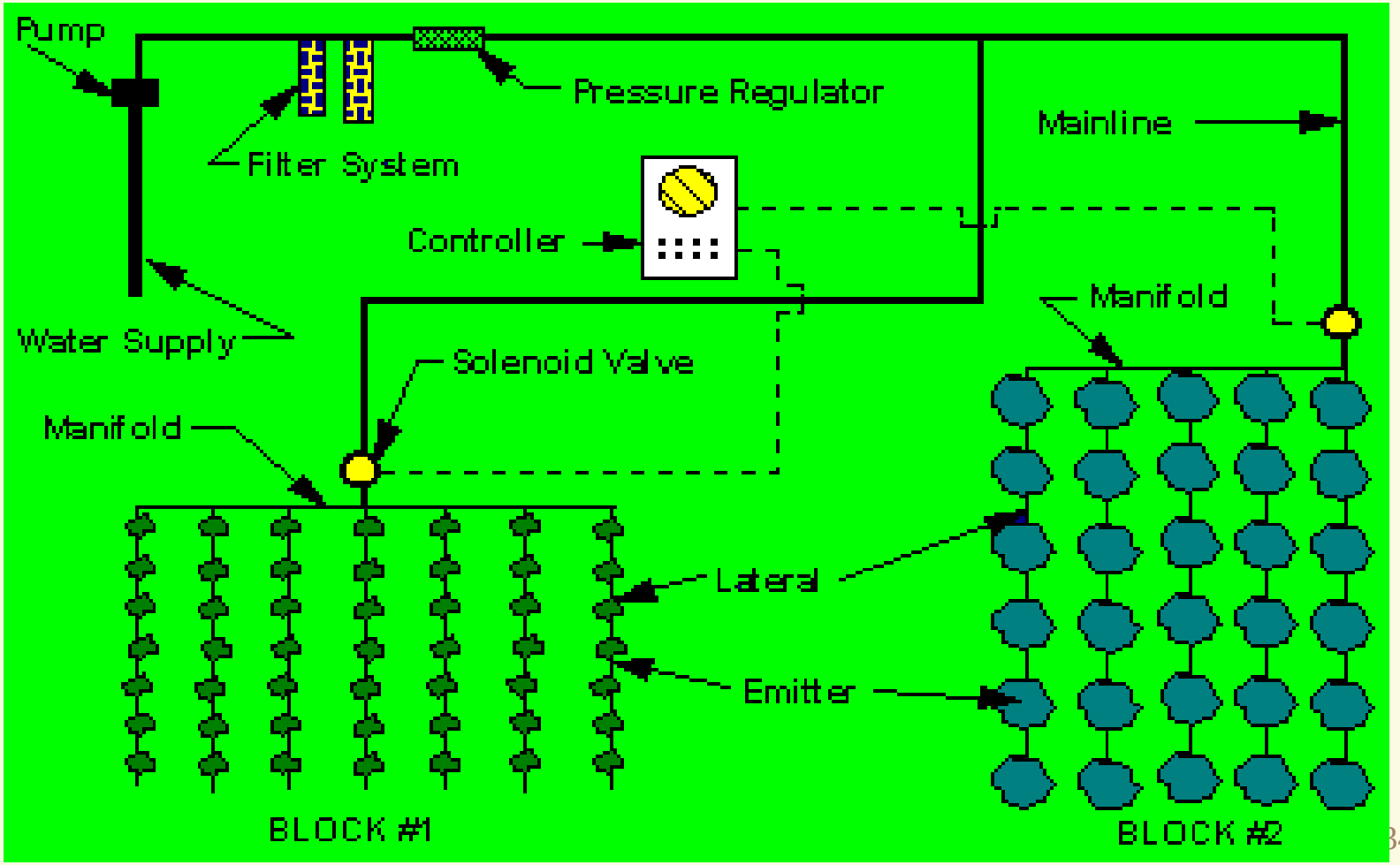
Whirling-head sprinkler covers 5 to 50 ft. diameter

Rotary or impulse sprinkler covers partial to full circles

Drip Irrigation [1]

- Also known as:
  - Trickle irrigation
  - Micro-irrigation
  - Low-volume irrigation

Example Layout of Drip Irrigation System



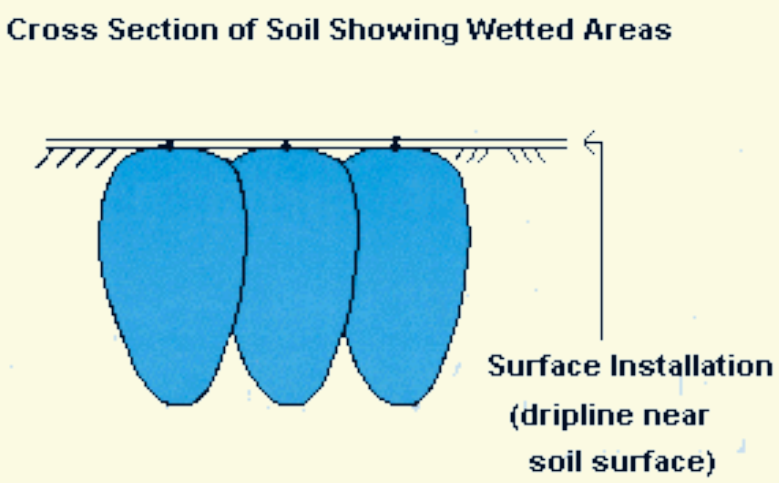
Drip Irrigation 2

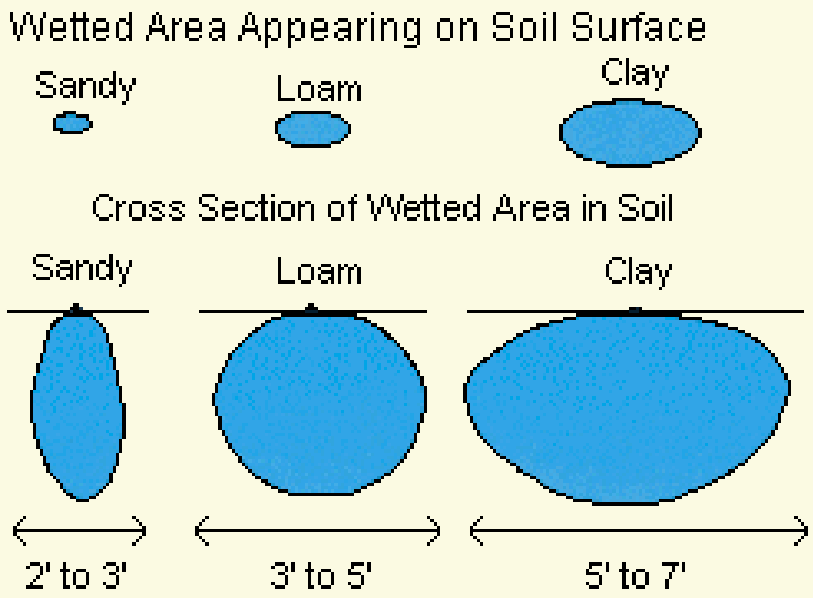
- 0.5-2.0 GPH flow rate per emitter
- 2-5 GPM/acre for water supply
- Point use gives less runoff, less evaporation, easier weed control, saves 30%-50% water
- Low pressure of 6-20 psi means smaller pumps & pipes
- Can fertilize through system
- Do field work while irrigating

Drip Irrigation 3

- Can automatically control
- Susceptible to clogging
- Must design system to carefully match equipment to elevation
  - 2.3 feet of head = 1 psi pressure
- Requires diligent management
- Cost = $1100 - $1500 for 1st acre;
  $750 - $1000/acre for rest

Wetting Patterns (Drip)





Drip Laterals & Emitters

Split water flow for low-use plants

Roll up & store laterals at end of season

Home Garden Drip Irrigation

Home Garden Drip Irrigation

Supply, pressure regulator & filter

Layout & Connect

Push barbed valve into hole

Push tape on & tighten collar nut

Plant Water Requirements [1]

(Design rates for southwest Missouri assuming no effective rainfall for >60 days.)

Fruit Crop	Plant x Row Spacing, Ft.	Sq.Ft./ Plant	Plants/ Acre	Gal/Plant/Day Gal/Acre/Day
Apples	6 x 14	84	518	8 4144
	18 x 26	468	93	42 3906
Peaches	15 x 20	300	145	28 4060
	18 x 20	360	121	34 4114
Grapes	8 x 10	80	540	10 5440
	8 x 16	128	340	16 5440
Blueberries	4 x 12	48	908	4 3632

Plant Water Requirements 2

(Design rates for southwest Missouri assuming no effective rainfall for >60 days.)

Fruit Crop	*Gallons per 100 Feet of Row per Day*
Strawberries	50
Raspberries & Blackberries	
With mulch	75
Without mulch	100

Plant Water Requirements 3

(Estimated design rates for southwest Missouri)

Vegetable Crop (mature)	*Gallons per 100 Feet of Row per Week*
Minimum for plant survival	100
Lettuce, spinach, onions, carrots, radishes, beets	200
Green beans, peas, kale	250
Tomatoes, cabbage, peppers, potatoes, asparagus, pole beans	300
Corn, squash, cucumbers, pumpkins, melons	400-600

Calculating Irrigation Water Needs

- 1” of water = 27,154 gallons per acre
- 1 acre = 43,560 sq. ft.
- 0.25”/day pan evaporation rate = 1.75”/week
- Formula for 1.5” of water per week:
  - Gallons/100 ft. of row/day = (66 x 80% of Pan Evaporation Rate x Row width in feet)
- Example for 5 twin rows 100 ft. long x 2 ft. wide
  - GPD/100 ft. = (66 x 0.25 x .80 x 2) = 26.4 gallons
  - Gallons per day = 26.4 x (5 beds x 2 plant rows) = **264 gallons per day = 1,848 gallons per week**
  - 264 GPD ÷ (30 GPH/100 ft. drip tape) x 10 rows = **0.88 hours/day = 53 minutes/day**

Hours Required to Apply 1” of Water to Mulched Raised Bed

Drip Tube Flow Rate		Width of Mulched Bed		
Gallons per Hour per 100 feet run of drip tape	Gallons per Minute per 100 feet run of drip tape	2 feet	2.5 feet	3 feet
16	0.27	8.0	10.0	11.5
18	0.30	7.0	8.5	10.5
20	0.33	6.0	8.0	9.5
24	0.40	5.0	6.5	8.0
30	0.50	4.0	5.0	6.0
36	0.60	3.5	4.5	5.0
40	0.67	3.0	4.0	4.5
42	0.70	3.0	4.0	4.5
48	0.80	2.5	3.0	4.0

Estimating Water Quantity

- Household water demand
  - GPM = Total count of toilets, sinks, tubs, hose bibs, etc. in home
- Excess is available for irrigation
  - Contact pump installer for capacity data
- Is pressure tank large enough?
  - Stay within cycle limits of pump, OR
  - Run the pump continuously

Home Water Flow Rates

	Number of Bathrooms in Home			
	1	1.5	2	3
Bedrooms	Flow Rate (Gallons Per Minute)			
2	6	8	10	--
3	8	10	12	--
4	10	12	14	16
5	--	13	15	17
6	--	--	16	18

Source: MU Guide G1801

Pump Cycling Rate, Max.

Horsepower Rating	Cycles/ Hour
0.25 to 2.0	20
3 to 5	15
7.5, 10, 15	10

Pressure Tank Selection

	Average Pressure, psi*		
Tank Size, gallons	**40**	**50**	**60**
	Pumping Capacity, GPM		
42	5	4	3
82	11	8	6
144	19	14	10
220	29	21	15
315	42	30	22

* Cut-in pressure + 10 psi = Avg. Pressure = Cut-out pressure - 10 psi

Pressure Tanks

Larger tank

OR

Variable speed pump controller

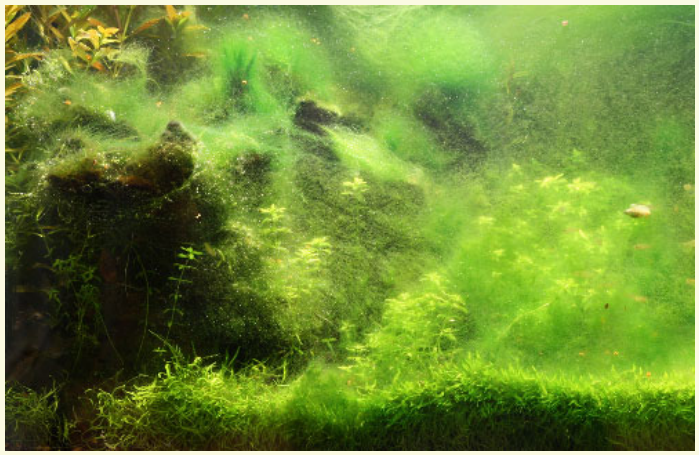
Multiple tanks

Water Source Quality

Good

Poor

- Well = check pH & hardness
- Municipal = may be expensive
- Spring = may not be dependable
- River or stream = depends on runoff
- Lake or pond water = sand filters
- Pump to tank on hill = limited use



Using Ponds for Irrigation

- Pond 8' deep, 100' dia. holds 280,000 gallons of water.
- One-half of water volume is usable for irrigation. Rest is seepage & evaporation.
- 20 GPM demand for 20 hrs/day uses 24,000 gal/day.
- Pond holds about 6-day water supply.
- Water is least available when most needed!!

Pond Water Quality

- Grass filters sediment & nutrients

- Copper sulfate controls algae & slime
- No overhead irrigation on vegetables or fruits

Water Quality Analysis

- Inorganic solids = sand, silt
- Organic solids = algae, bacteria, slime
- Dissolved solids (<500 ppm)
  - Iron & Manganese
  - Sulfates & Chlorides
  - Carbonates (calcium)
- pH (5.8-6.8 preferred)
- Hardness (<150 ppm)
- E. coli bacteria

Resources:
soilplantlab.missouri.edu/soil/water.aspx
https://utextension.tennessee.edu/publications/Documents/SP740-B.pdf

PVC Casing

Steel Casing

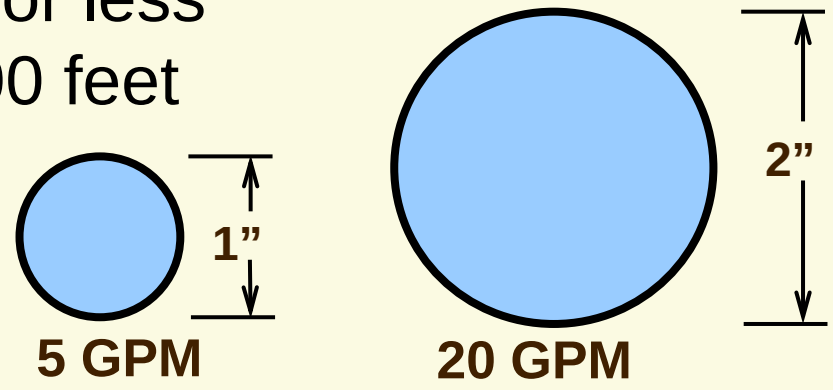
Plugging Potential of Drip Irrigation Systems

Factor	Moderate (ppm)*	Severe (ppm)*
Physical		
Suspended solids	50-100	>100
Chemical		
pH**	7.0-7.5	>7.5
Dissolved solids	500-2000	>2000
Manganese	0.1-1.5	>1.5
Iron	0.1-1.5	>1.5
Hardness***	150-300	>300
Hydrogen sulfide	0.5-2.0	>2.0

* ppm = mg/L ** pH is unitless *** Hardness: ppm = gpg x 17

Friction Loss Design

- Size piping for 1 psi or less pressure loss per 100 feet
  - Pipe diameter x 2 = 4X flow rate



- Pipe friction may replace pressure regulators on downhill runs
- Vary flowrate no more than 20% (+/- 10%) within each block of plants
- Manifolds attached to mainline...
  - at center if < 3% slope
  - at high point if 3+% slope

Plastic Pipe Friction Loss

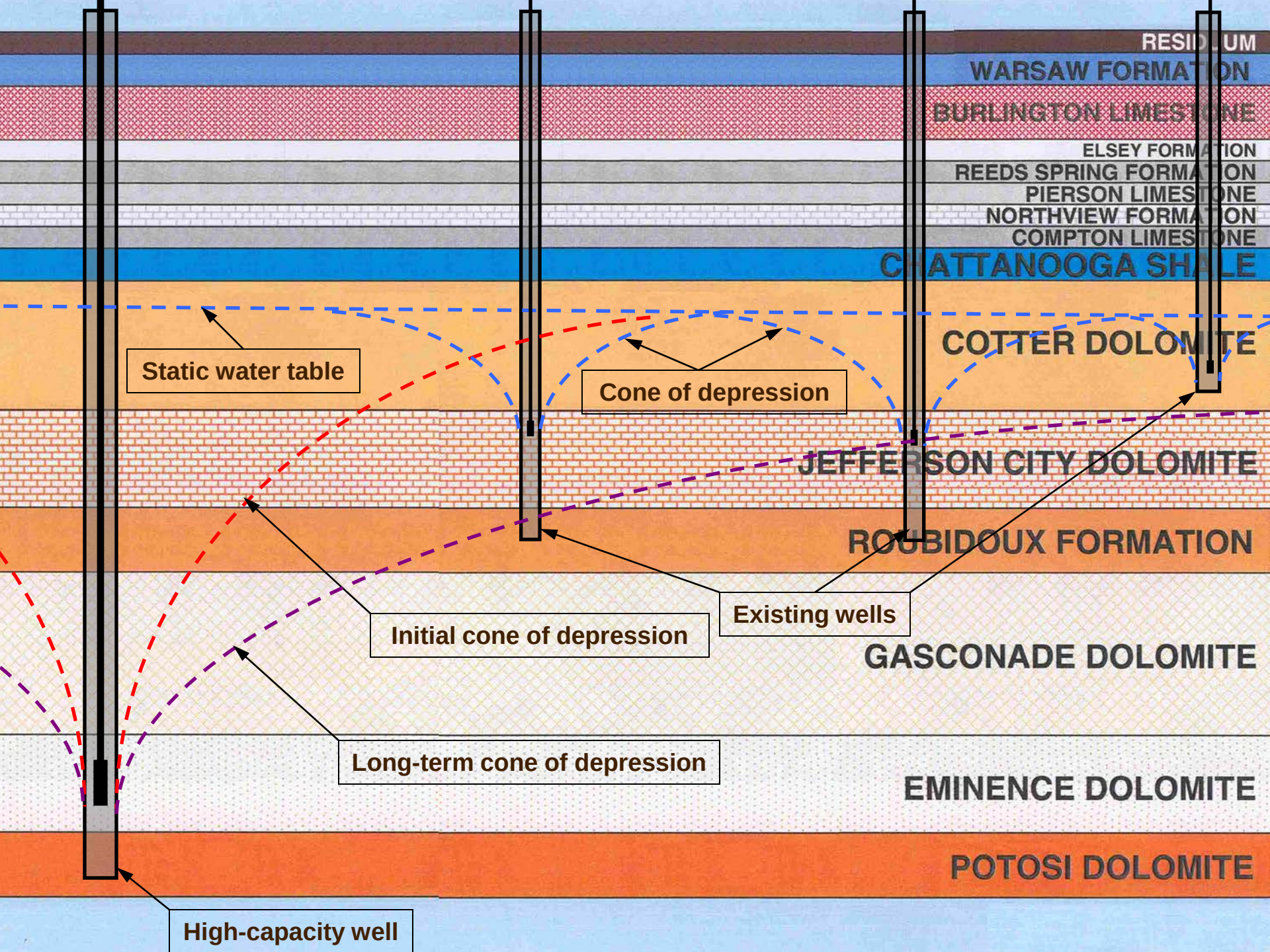
	Pipe Diameter, inches			
	0.75"	1"	1.5"	2"
GPM	PSI Loss per 100 ft. of pipe			
5	2.8	0.8	0.1	--
10	11.3	3.0	0.4	0.1
15	21.6	6.4	0.8	0.2
20	37.8	10.9	1.3	0.4
25	--	16.7	1.9	0.6
30	--	--	2.7	0.8

Current Water Issues
that can affect gardening

- Good Agricultural Practices (GAPs)
  - Food safety
- Major Water Users law
  - File annual report with MoDNR if >100,000 GPD
- Waters of the United States (WOTUS)
  - Under litigation
- Rainwater harvesting
  - Illegal in some states
- Water conservation
  - Local shortages

Good Agricultural Practices - Irrigation Water

- Pathogens that contaminate the surface of produce are difficult to remove
- Irrigation water can be a vehicle for foodborne pathogens
  - E. coli 0157:H7 in spinach
  - Salmonella in peppers
- GAPs program looks at food safety practices
  - Irrigation water quality
  - Manure management
  - Worker hygiene
  - Harvesting, transportation & storage practices

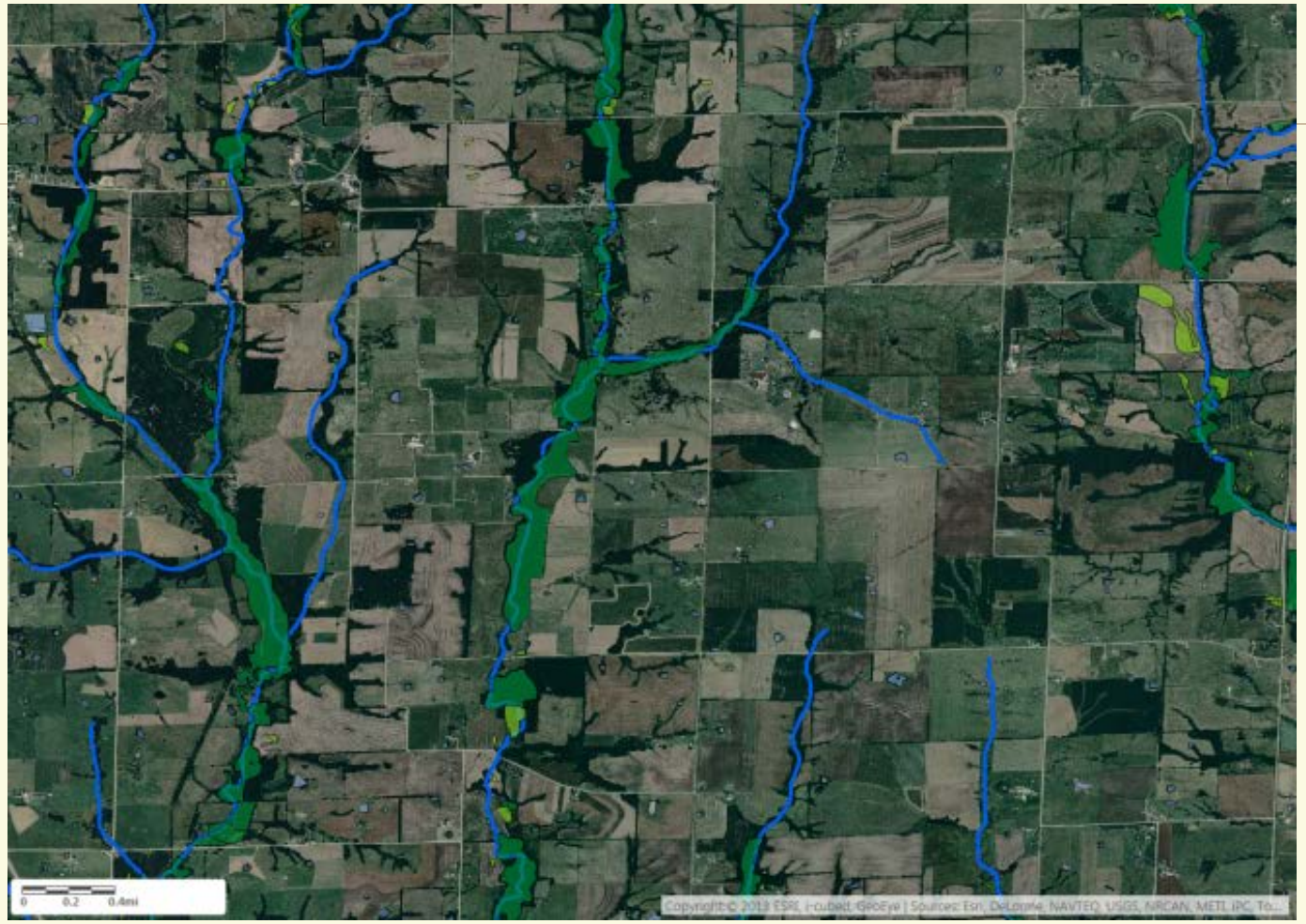

RESIDUUM
WARSAW FORMATION
BURLINGTON LIMESTONE
ELSEY FORMATION
REEDS SPRING FORMATION
PIERSON LIMESTONE
NORTHVIEW FORMATION
COMPTON LIMESTONE
CHATTANOOGA SHALE
COTTER DOLOMITE
JEFFERSON CITY DOLOMITE
ROUBIDOUX FORMATION
GASCONADE DOLOMITE
EMINENCE DOLOMITE
POTOSI DOLOMITE
Static water table
Cone of depression
Initial cone of depression
Existing wells
Long-term cone of depression
High-capacity well

Waters of the United States (WOTUS)

- Clean Water Act of 1972 established regulated waters ("blue line" streams) by EPA and U.S. Army COE
- WOTUS rule blocked by federal court from starting 8/28/2015
  - Greatly differs from the proposed rule provided for public comment
  - COE believes EPA used flawed technical and scientific analysis in crafting the regulation
  - EPA failed to consult with state and local governments, confer with business stakeholders, comply with the requirements of the Regulatory Flexibility Act, or produce an accurate cost-benefit analysis.
  - Puts millions of additional acres of private land under federal control
  - Major parts of the rule remain largely incomprehensible to experts and laypeople
  - Landowners have no reliable way to know which of the water and land within that area will be regulated, yet they must still conform their activities to the new law.

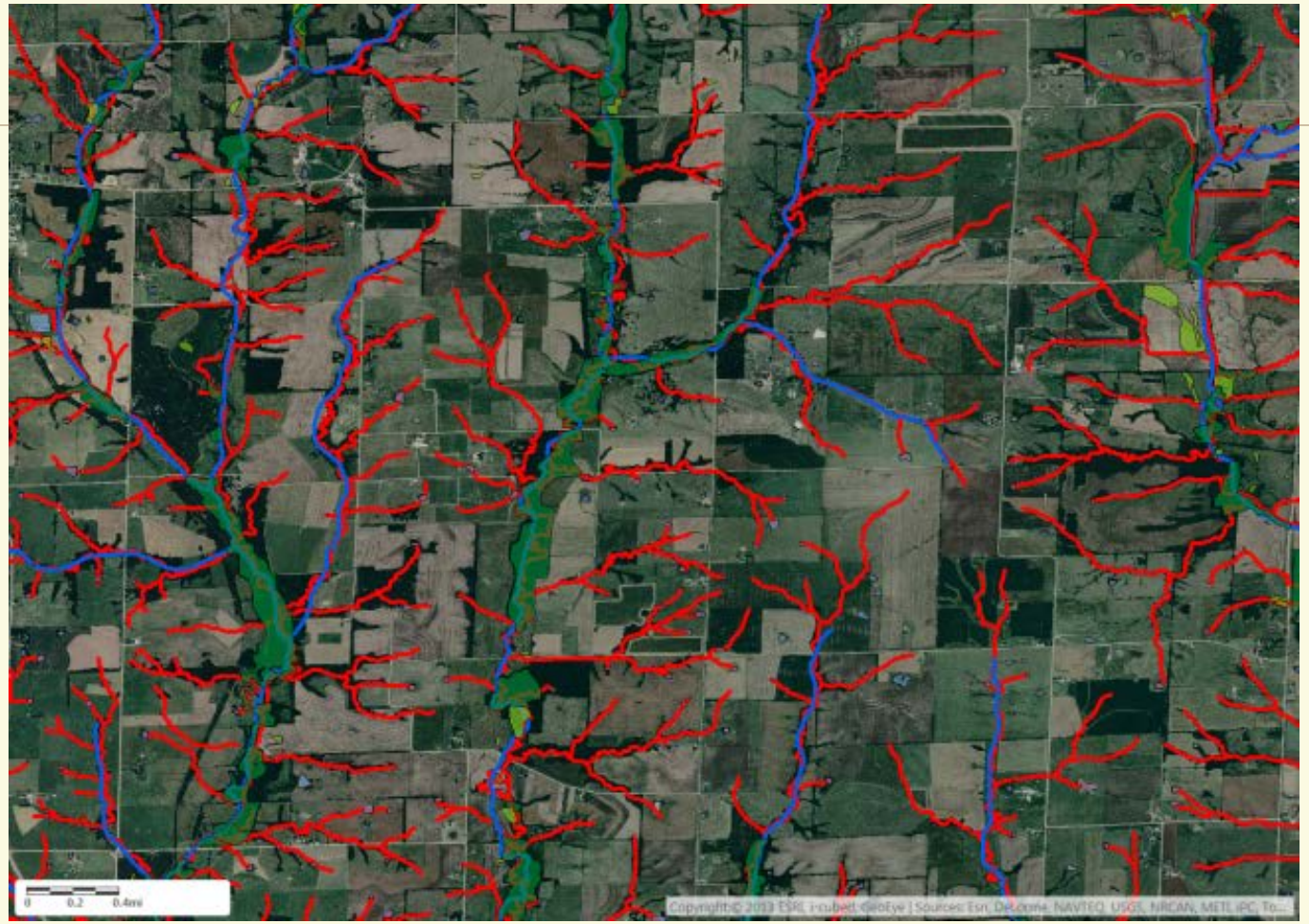
Reference: https://www.washingtonpost.com/news/volokh-conspiracy/wp/2015/08/28/north-dakota-district-court-blocks-controversial-waters-of-the-united-states-rule/

WOTUS example from Missouri



Previous rules/guidance – Tributaries and Adjacent Wetlands
Absent case-specific "significant nexus" finding, only <u>perennial and intermittent tributaries</u> (blue lines) and adjacent wetlands (green shapes) deemed jurisdictional.
(Note: light blue shapes designate freshwater ponds.)

WOTUS example from Missouri

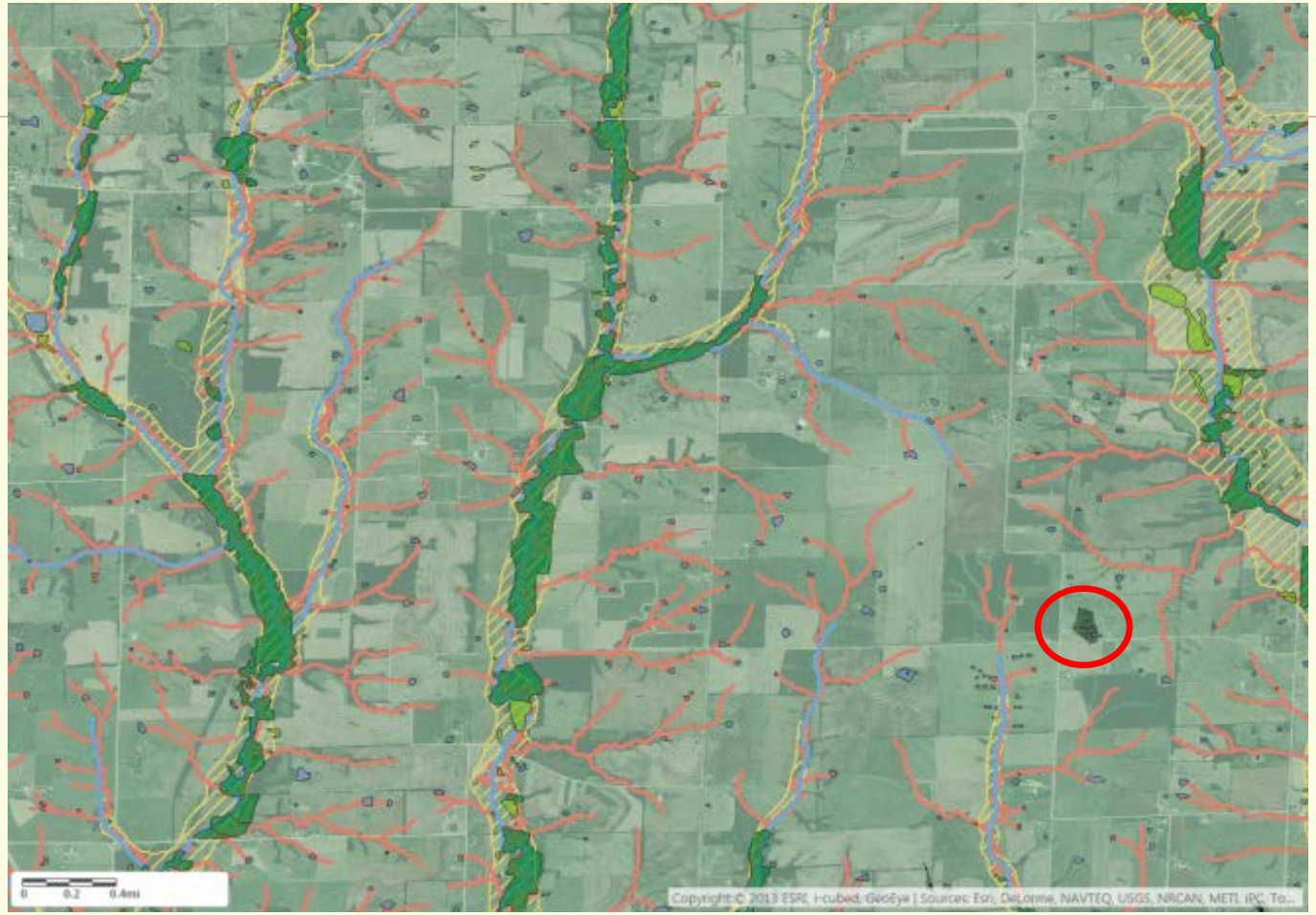


New WOTUS Rule – More Automatically Regulated "Tributaries"
Ephemeral tributaries (red lines) deemed jurisdictional without further analysis.
Ditches also regulated if "excavated in" or "relocated" a tributary.
Note: This map does not show jurisdictional ditches and may not include all ephemeral tributaries

WOTUS example from Missouri

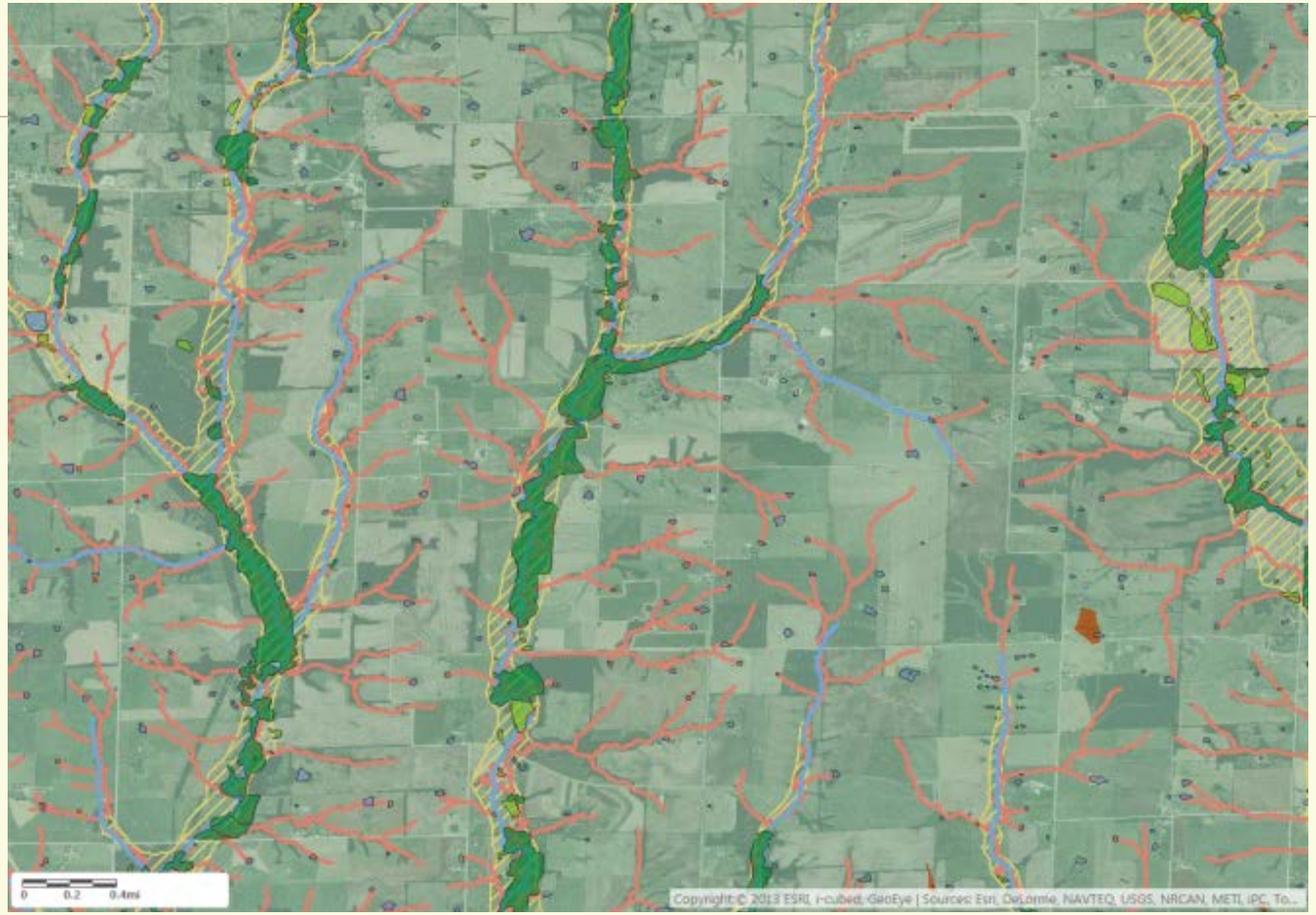
New WOTUS Rule – Automatically Regulated Adjacent Waters
Includes all "waters"—including wetlands—that lie even partially within a 100-foot buffer (pink shading) around all perennial, intermittent and ephemeral streams.

WOTUS example from Missouri



New WOTUS Rule – More Automatically Regulated Adjacent Waters
Includes all "waters"—including wetlands—where <u>any part</u> is within the 100-year floodplain and not more than 1,500 feet from a tributary. Light green shading shows the 1,500-feet zone and hash marks show the known FEMA Flood Zone maps (which may be out-of-date or may not be relied upon by the Corps). Absent definitive flood zone information from the Corps, any water partially within the light green shading is a possible "adjacent water."

WOTUS example from Missouri



New WOTUS Rule – Maybe Regulated "Significant Nexus" Waters
Water/wetlands even partially within 4,000 feet (about ¾ mile) of a tributary can be regulated on a "significant nexus" finding. Orange shading shows land outside the possible adjacency zone but within the 4,000 feet zone.

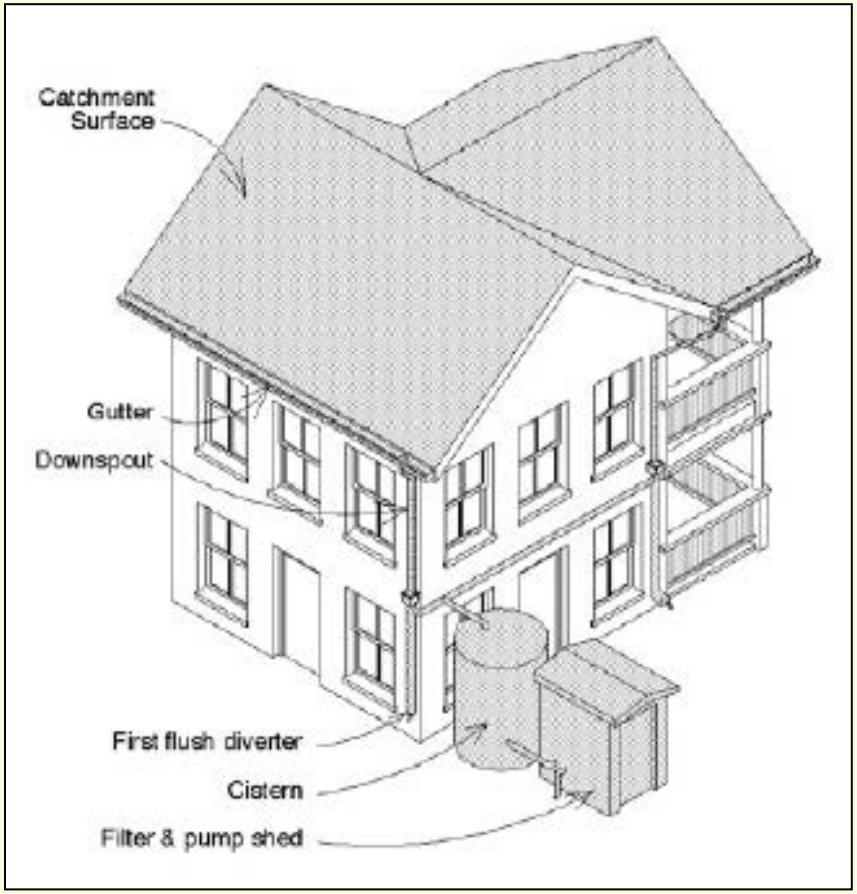
Even without mapping around jurisdictional ditches, the area of possible regulation covers the entire map.

Missouri WOTUS Zones

Missouri	Acres	Share of Total Acres
Total Acres in State	44,692,943	
Acres within 100-ft buffer (adjacent)	3,869,667	7%
Acres within 1,500-ft buffer (possibly adjacent)	4,1172,874	92%
Acres within 4,000-ft buffer (subject to “significant nexus” finding)	44,549,122	99.7%

Water Harvesting

- Illegal in some western states
- Possible in MO
  - 0.62 gal./sq. ft./ inch of rain
  - 41” rain/year
  - 70% efficiency
  - 18 gal./sq. ft / per year



Water Conservation Measures (Indoors) 1

a. Repair faucet & toilet leaks
b. Install toilet dams on older units
c. Avoid unnecessary toilet flushing
d. Take short showers instead of baths
   (8-10 gallons vs. 30-50 gallons)
e. Use low-flow shower head
   (50% less water, with more velocity)

Water Conservation Measures (Indoors) 2

f. Turn off shower when shampooing or soaping
g. Run only full loads in dishwasher & clothes washer (20-50 gallons/cycle)
h. Install faucet aerators (50% less water)
i. Turn off faucet when shaving, brushing teeth, handwashing dishes
j. Limit use of the hot tub/spa/Jacuzzi

Irrigation Resources on the Web

- Irrigation System Planning & Management Links
  extension.missouri.edu/webster/irrigation.aspx

- USDA NRCS Web Soil Survey
  websoilsurvey.sc.egov.usda.gov/App/

Questions??

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UNIVERSITY OF MISSOURI Extension

Program Complaint Information
To file a program complaint you may contact any of the following:

University of Missouri

- MU Extension AA/EEO Office
  109 F. Whitten Hall, Columbia, MO 65211
- MU Human Resources Office
  130 Heinkel Bldg, Columbia, MO 65211

USDA

- Office of Civil Rights, Director
  Room 326-W, Whitten Building
  14th and Independence Ave., SW
  Washington, DC 20250-9410