Basics of Drip Irrigation Systems

by
Bob Schultheis
Natural Resource Engineering Specialist

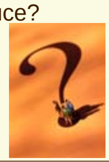
UNIVERSITY OF MISSOURI Extension

Site Considerations

- Labor & layout
- Light
- Elevation & slope
- Trees & buildings
- Size
- Soil
- Water
- Utilities
- Roadway access

Site Considerations

- Labor & layout
  - Who will be doing the work?
    - Tractor & vehicle access?
    - Disability access?
  - What do you & your family like to eat?
  - How do you plan to use the produce?
    - Eat fresh vs. preservation
  - Don't plant more than you can manage



Site Considerations

- Light - at least 6 hours sunlight per day
  - Needed for healthy plants & maximum yield
  - Leafy vegetables & root crops tolerate some shade
  - 8-10 hours best for beans, okra, tomatoes, peppers, melons, cucumbers, squash and other fruiting vegetables
- Do surrounding trees or buildings cast shadows?
- Run rows N-S for best sun exposure & air circulation; low-growing plants on South end

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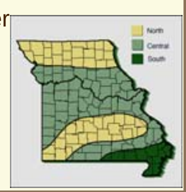
Site Considerations

- Elevation & slope
  - Good air drainage for frost prevention
  - South slopes warm first in spring
  - Affects planting dates
  - Affects cost of getting water to site & distributing it



Site Considerations

- Trees & buildings
  - Affects air currents downwind at least 10X tree height
  - Can block cold winter wind from N or W; moderate hot summer wind from S or W
  - Tree roots can stunt or kill vegetables (walnut)

Site Considerations

- Size
  - Allow enough space for plants at maturity
  - See MU Guides
    - G6201 Vegetable Planting Calendar
      extension.missouri.edu/explorepdf/agguides/hort/g06201.pdf
      for space requirements, amounts to plant, recommended varieties, planting & maturity dates
    - G6005 Fruit & Nut Cultivars for Home Plantings
      extension.missouri.edu/explorepdf/agguides/hort/g06005.pdf
  - Rotation schedule to reduce diseases
  - Room to expand?

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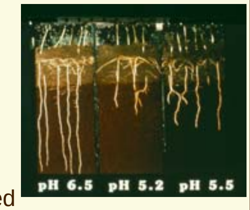
Site Considerations

- Soil
  - Good drainage; high organic matter
  - Adapted to plants to be grown, i.e. pH
  - Soil test to find modifications needed
  - Adequate time for modifications to work
  - Soil temperature near 60°F for warm-season crops



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Soil & Climate Properties

- Soils store 1.5”-2.5” of water per foot of depth (check county NRCS Soil Survey)
- Intake rate = 0.3”-2.0” per hour, rest is runoff
- Available water = 75% of total water in soil
- Summer E.T. rate is 0.25” per day
- A 2-ft. deep soil holds 9-15 day supply of moisture
- Southwest Missouri historical weather:
  - Rainfall = 41”-42” per year
  - Evaporation = 40” per year
- Ozarks has 3-4 week summer dry spell

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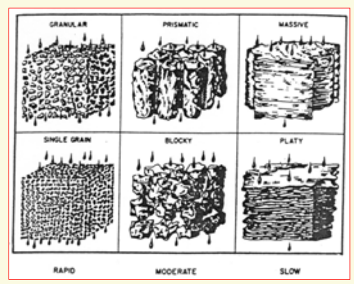
USDA Soil Structure Classes

Soil structure influences infiltration rate of water



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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

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Soil Drainage Classification

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

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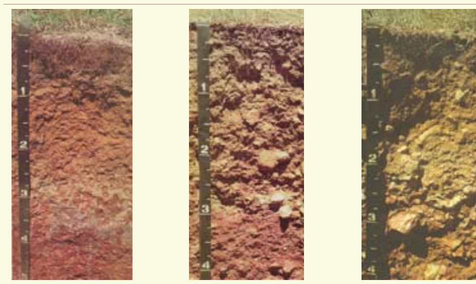
Color Indicates Drainage & Pans



Captina Silt Loam | Tonti Silt Loam | Scholten Gravelly Silt Loam

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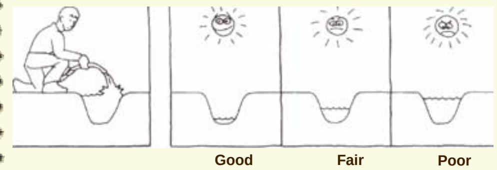
Testing Soil Drainage

- Dig & fill with water several 12" deep holes
  - Good drainage = water drains in 2 hours
  - Fair drainage = water drains in several hours
  - Poor drainage = water still there after 8-10 hours



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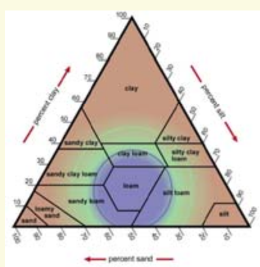
USDA Soil Texture Classes

- 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



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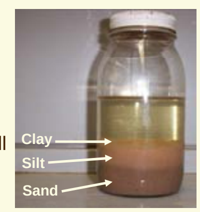
Determining Soil Texture

- 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



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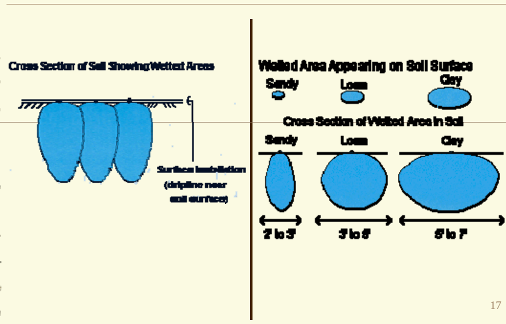
Wetting Patterns (Drip)



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Site Considerations

- Water
  - Easy access to reliable water source
  - Adequate volume for duration of plants
  - Avoid areas that accumulate runoff from rain or irrigation
  - Beware of "fragipan" on upland soils
    - Most plants don't like "wet feet"

Site Considerations

- Utilities
  - Overhead electrical wires
  - Underground electrical or communication wires, gas or water lines, septic systems
  - Easements

Red	ELECTRIC
Yellow	GAS-OIL-STEAM
Orange	COMMUNICATION-CATV
Blue	WATER
Green	SEWER
Pink	TEMPORARY SURVEY MARKINGS
White	PROPOSED EXCAVATION
Purple	RECLAIMED WATER

Site Considerations

- Roadway access
  - All-weather durability
  - Adequate parking
  - Security (vandals, food defense)

The Two Major Factors in Irrigation System Planning

1. How much water do you need?

2. How much time do you have?

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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”

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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

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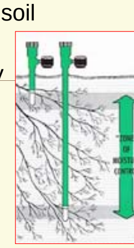
Moisture Measurement 1

- “Feel” method - handful of soil
- Screwdriver method – force into soil
- Appearance of plants - wilt
- Calendar method - daily, 3rd day
- “Checkbook” method
  - Tally total rainfall + irrigation against daily water use of plants
- Tensiometers
  - Read scale of 0 (wet) to 100 (dry)
- Moisture resistance blocks
  - Buried at depths in soil, check with meter



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Measuring Water Needs

Catch cans

4-cycle timer

Rain gauge

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Plant Water Requirements 1

(Estimated design rates for southwest Missouri)

Vegetable Crop (mature)	*Gallons per 100 Feet of Row per Week*
Minimum for plant survivial	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

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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

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Plant Water Requirements 3

(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

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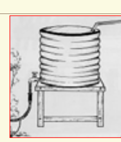
Water Sources

Good ↕ Poor

- Well = check pH & hardness
- Municipal = may be expensive
- Spring or stream
- Pond water = sand filters
- Pump to tank on hill
  - Elevation dictates pressure (2.3 feet of head = 1 psi pressure)
  - Watch for tank corrosion
- Rain barrel
  - Limited volume & pressure



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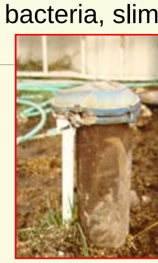
Water Quality Analysis

- Inorganic solids = sand, silt
- Organic solids = algae, bacteria, slime
- Dissolved solids
  - Iron & Manganese
  - Sulfates & Chlorides
  - Carbonates (calcium)
- pH
- Hardness



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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

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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

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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

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Pump Cycling Rate, Max.

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

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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

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Pressure Tanks

Larger tank

OR

variable pump speed controller

Multiple tanks

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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!!

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Pond Water Quality

- Grass filters sediment & nutrients

- Copper sulfate controls algae & slime

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Drip Irrigation 1

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

Drip Irrigation 2

- 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

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Drip Irrigation 3

- Can automatically control
- Susceptible to clogging
- Must design system to carefully match equipment to elevation
- Requires diligent management
- Cost = $900 - $1200 for 1st acre; $600 - $800/acre for rest

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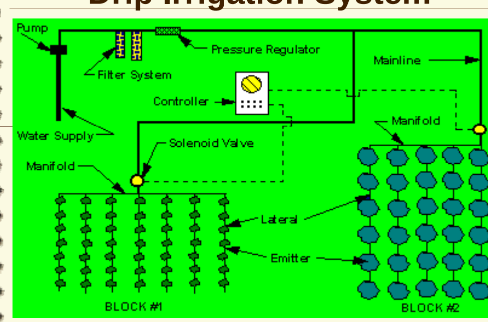
Example Layout of Larger Drip Irrigation System



Drip Irrigation Components 1

- Power Supply
  - Electric = 1st choice
  - Gas, diesel, propane = 2nd choice
  - Gravity = ram pumps
- Pump system
  - Higher elevation = lower horsepower
  - Size to elevation & system pressure
  - Pressure tank vs. throttling valve control

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Drip Irrigation Components 2

- Check valve(s)
  - Stop backflow into water source
  - Critical if fertigating
- Filter system
  - 100-150 mesh screen
  - Manual or automatic backflushing
  - If you can see particles, the system can plug

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Filter Selection 1

- Cartridge filter
  - Best with well water on very small systems
  - Made of paper or spun fiber
  - Disposable or washable
  - Install in pairs to avoid service downtime
  - Clean when pressure loss exceeds 5-7 psi

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Filter Selection 2

- Screen filter
  - 150-200 mesh, 3/4” to 6” dia.
  - Slotted PVC, perf. or mesh stainless steel or nylon mesh
  - Manual or automatic flush

- Disc filter
  - Stack of grooved wafers
  - Provides more filter area than screen of same size

Filter Selection 3

- Sand media
  - 14” to 48” diameter
  - Use swimming pool filter for smaller systems
  - Use pairs of canisters for larger systems
  - Work best at < 20 GPM flow per square foot of media
  - Follow with screen filters
  - Backflush to clean

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Drip Irrigation Components 3

- Pressure regulation
  - Depends on field slope & pipe layout
  - In-line regulators
  - Pressure tank(s) = match to pump cycle rate to avoid pump burnout
- Solenoid valves
  - Low-voltage water control valves
  - Mount above ground for easy service

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Solenoid Valves

- Low-voltage water control valves
- Mount above ground for easy service



Drip Irrigation Components 4

- Controller
  - Time clock switches solenoid valves
- Mainline
  - Carry water to each irrigation block
  - Buried 1.5" - 3" dia. PVC pipe
- Manifolds
  - Meter water from mainlines to laterals
  - Buried 3/4" - 2" PVC or PE pipes

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Controller

- Protect controllers from weather & pests
- Use proper wiring (Type UF or USE)


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Drip Irrigation Components 5

- Laterals
  - Carry water down rows to the plants
  - Surface or buried 3/8" - 3/4" PE pipe
  - Thin-wall "tape" for close-growing crops
- Emitters
  - Deliver water to the plants
  - 0.5 - 2 GPH "in-line" or "on-line" units
  - Pressure-compensating or not

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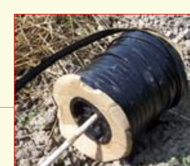
Laterals & Emitters 1

- Operating pressure in laterals
  - Thin-wall “tape” = 4-8 psi
  - Non-P.C. emitters = 8-15 psi
  - P.C. emitters = 10-60 psi
- Max. pressure variation in plant block = 20 psi (+/- 10 psi)


Drip Tape

- Low pressure
  - 4-8 psi
- Inexpensive
  - Lasts 1-2 years
- Needs flat sites
- Needs filter
- Good for gardens
- Prone to animal damage




Laterals & Emitters 2

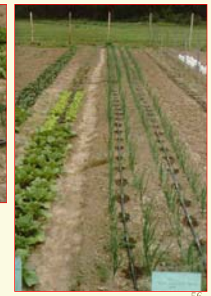
- Extend laterals 10-20 ft. past row end to serve as debris trap

- Use air relief valve at high point of each plant block to stop shutoff suction

Laterals & Emitters 3

Split water flow for low-use plants

Roll up & store laterals at end of season



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Pumping Head Calculations

- Total head in feet is the sum of:
  - Elevation from water source to high point
  - Pipe friction loss
  - Discharge pressure
  - Miscellaneous friction loss of elbows, risers, valves, etc.
- Remember conversion of:
  2.31 feet = 1 psi

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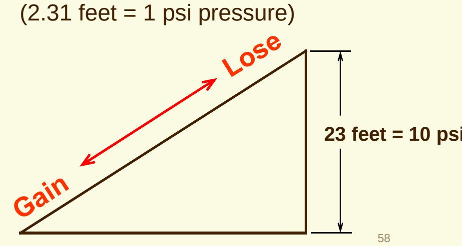
Pipeline Design – Elevation

Elevation from pump to field
(2.31 feet = 1 psi pressure)



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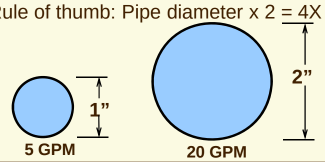
Pipeline Design – Friction Loss

- Gravity systems
  - Limit head to 1.5 ft. per 100 ft. of pipe
  - Minimum pipe size = 1¼-inch diameter
- Pressure systems
  - Limit head to 2.3 ft. (1 psi) per 100 ft. of pipe
  - Rule of thumb: Pipe diameter x 2 = 4X flow rate



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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

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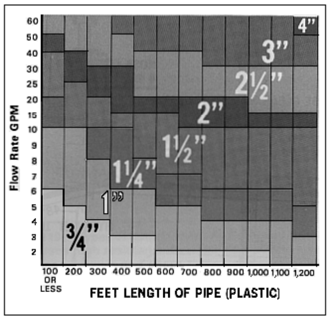
Plastic Pipe Friction Loss



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Design Considerations 1

- Water supply capacity
- Hours of operation per day
- Field size, shape & elevation
  - 2.3 feet elevation change = 1 psi pressure change
  - Design for +/- 10% or less flow variation
- Plant spacing
- Row spacing

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Design Considerations 2

- Emitter selection & location
- Clogging control - air relief valve
- Burial and draining
  - Frostline depth = 24"- 30"
  - Flush with air
- Pipe protection under roadways
- Animal damage
- Expansion

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Planning Your System 1

- Make a field plan
  - Show field size, shape, elevation contours
  - Show distance to water source, electricity
  - Note soil type, climate, air drainage
  - Example: Two acres apples
    a. 290' x 300' field, 4.0% slope across rows, 2.3% along row
    b. 20 rows 14' o.c., 50 plants per row 6' o.c.

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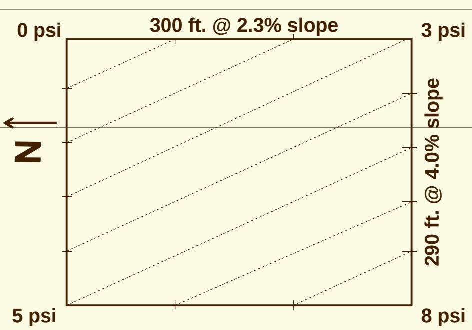
Sample Field Plan 1



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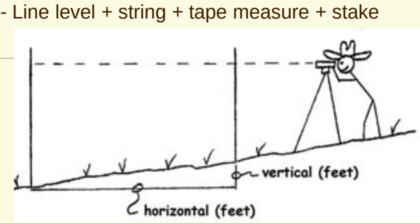
Slope Measurement by Elevation Change

Two types of instruments
- Builder's level and measuring rod
- Line level + string + tape measure + stake



Slope in % = (vertical / horizontal) x 100

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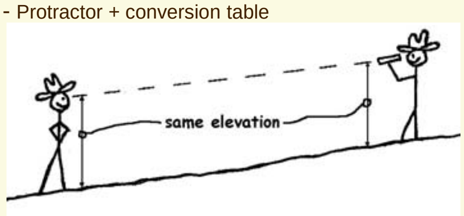
Slope Measurement by Direct Reading

Three types of instruments
- Clinometer (Abney level)
-"Smart" level (electronic)
- Protractor + conversion table



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Planning Your System 2

- Calculate minimum pumping capacity needed & compare to water source
  - GPD = Gallon/plant/day x # of plants
    or
  - GPD = Gallon/100' of row/day x # of rows x (row length/100)
  - Example: Two acres 6' x 14' apples
    8 GPD x 1036 plants = 8288 GPD
    = 345 GPH
    = 5.8 GPM

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Planning Your System 3

- Calculate area irrigated at once
  - # of plants = Well capacity / GPH applic. rate
  - Allow for home water demand
  - Balance well cap. to row length & block size
  - Example: 3 BR, 1.5 bath home & 19 GPM well
    a. Home needs 10 GPM, so field gets 9 GPM
    b. (9 GPM well cap. x 60 min/hr) / 2 GPH/plant = 270 plants
    c. 270 plants / 50 plants/row = 5.4 rows at once
    d. 20 total rows / 5 rows/block = 4 blocks
    e. 4 blocks x 8 GPD/plant / 2 GPH/em. = 16 hrs.

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Friction Loss Design

- Size piping for 1 psi or less pressure loss per 100 feet
- 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

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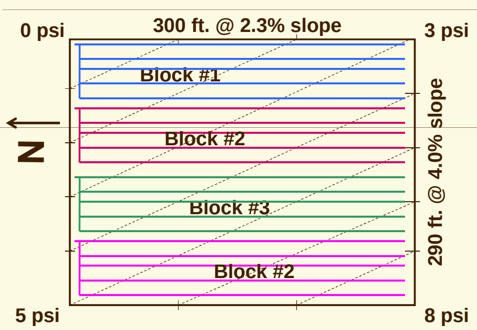
Sample Field Plan 2



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Troubleshooting Guide

Symptom	Possible Causes
Reddish-brown slime or particles near emitters	Bacteria feeding on iron
White stringy masses of slime near emitters	Bacteria feeding on sulfur
Green or slimy matter in surface water	Algae or fungi
White film on tape or around emitters	Calcium salts or carbonates
Presence of silt or clay	Inadequate filtration

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Chemical Injection 1

- Kill bacteria & slime
  - Chlorine needs "contact time"
  - Powdered HTH can plug emitters

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Chemical Injection 2

- Control pH with acid
  - Help acidify soil for plants (blueberries)
  - Dissolve Mn, Fe, Ca precipitates
  - Make chemicals work better

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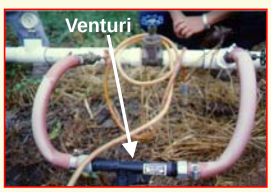
Chemical Injection 3

- Apply fertilizer
  - Be sure it's 100% water-soluble
  - Always inject it two elbows before the filter for good mixing



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Resources

- Irrigation resources & equipment suppliers
  extension.missouri.edu/webster/irrigation
- Water analysis (University of Missouri)
  soilplantlab.missouri.edu/soil/water.aspx
- MU Extension Publications
  extension.missouri.edu/publications
- Farmers' market resources
  extension.missouri.edu/webster/farmersmarket
- Fruit tree and small fruit resources
  extension.missouri.edu/webster/new/homegarden.shtml

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UNIVERSITY OF MISSOURI Extension

Questions?

Robert A. (Bob) Schultheis
Natural Resource Engineering Specialist
Webster County Extension Center
800 S. Marshall St.
Marshfield, MO 65706
Voice: 417-859-2044
Fax: 417-468-2086
E-mail: schultheisr@missouri.edu
Web: extension.missouri.edu/webster

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

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