Basics of Irrigation System Design & Maintenance

by
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What We’ll Cover

✓ The soil → soil & climate factors
✓ The plants → water needs
✓ The water → quality and quantity
✓ The irrigation options
  – Small-scale watering
  – Larger-scale watering
U.S. Drought Monitor

March 5, 2013
Valid 7 a.m. EST

Intensity:
- Yellow: D0 Abnormally Dry
- Light Orange: D1 Drought - Moderate
- Orange: D2 Drought - Severe
- Red: D3 Drought - Extreme
- Dark Red: D4 Drought - Exceptional

Drought Impact Types:
- ~ Delineates dominant impacts
- S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically >6 months (e.g. hydrology, ecology)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

Released Thursday, March 7, 2013
Author: Matthew Rosencrans, NOAA/NWS/NCEP/CPC
If you take care of your soil, the soil will take care of your plants.

✔ Available Water Holding Capacity depends on:
  – Soil texture
  – Organic matter
  – 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
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
Average Annual Precipitation

Legend (in inches)
- Red: Under 36
- Orange: 36 to 38
- Yellow: 38 to 40
- Green: 40 to 42
- Blue: 42 to 44
- Light blue: 44 to 46
- Light green: 46 to 48
- Light yellow: 48 to 50
- Purple: Above 50

Period: 1961-1990

This map is a plot of 1961-1990 annual average precipitation contours from NOAA Cooperative stations and (where appropriate) NRC5 SNOTEL stations. Christopher Daly used the PRISM model to generate the gridded estimates from which this map was derived; the modeled grid was approximately 4x4 km latitude/longitude, and was resampled to 2x2 km using a Gaussian filter. Mapping was performed by Jenny Weisburg. Funding was provided by NRCS Water and Climate Center.
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

*Reference: www.ces.ncsu.edu/depts/hort/hil/hil-33-e.html
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
# Soil Drainage Classification

<table>
<thead>
<tr>
<th>Drainage Class</th>
<th>Matrix</th>
<th>Mottle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well</td>
<td>Bright red</td>
<td>None</td>
</tr>
<tr>
<td>Moderately well</td>
<td>Red</td>
<td>Gray</td>
</tr>
<tr>
<td>Somewhat poorly</td>
<td>Dull</td>
<td>Red</td>
</tr>
<tr>
<td>Poorly</td>
<td></td>
<td>All gray</td>
</tr>
</tbody>
</table>
Color Indicates Drainage

Captina Silt Loam

Tonti Silt Loam

Scholten Gravelly Silt Loam
USDA Soil Structure Classes

Soil structure influences infiltration rate of water
Water Needs Vary Widely

- By species & within species by age of crop
- By soil type and time of year
- By location: outdoors vs. indoors

**Example: Tomatoes in high tunnels**
- 12 oz./plant/day when first set
- Climbs gradually to 75 oz./plant/day upon maturity

**Example: Greenhouses (container production)**
- A general rule is to have available from 0.3 to 0.4 gallons/sq. ft. of growing area per day as a peak use rate

**Size irrigation system for peak use**
# Relative Water Needs of Plants

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium Low</th>
<th>Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinach</td>
<td>Peas, Green</td>
<td>Cabbage</td>
</tr>
<tr>
<td>Lettuce</td>
<td>Beans, Kale</td>
<td>Broccoli</td>
</tr>
<tr>
<td>Radish</td>
<td></td>
<td>Pepper</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td>Sweet Corn,</td>
<td>Muskmelon</td>
</tr>
<tr>
<td>Asparagus</td>
<td>Vine Squash</td>
<td>Watermelon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pumpkin</td>
</tr>
</tbody>
</table>
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
Plants are 80-95% Water

- **Water** shortages early in crop development = delayed maturity & reduced yields
- **Water** shortages later in the growing season = quality often reduced, even if yields not hurt
- Short periods of 2-3 days of stress can hurt marketable yield
- **Irrigation** increases size & weight of individual fruit & helps prevent defects like toughness, strong flavor, poor tipfill & podfill, cracking, blossom-end rot and misshapen fruit
The Two Major Factors in Irrigation System Planning

1. How much **water** do you need?

2. How much **time** 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

Photo credit: rainwaterbarrel.org
55 gal.

Photo credit: www.lakesuperiorstreams.org
850 gal. = 3.5 psi

31,000 gal. = 23 psi
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

- 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
Best Time of Day to Water

✔ Early morning: 4 a.m. to 8 a.m.

- Evaporative losses minimized (no sun, calmer winds)
- Knocks dew and guttation fluid off leaf blades
- Lets plant leaves dry before evening to discourage fungal growth and infection
When to Water

✓ It’s getting too dry when you see:
  – Purple-blue wilting leaves
  – Grass that leaves footprints
  – Folded or rolled leaves

✓ Don’t wait to see wilting before watering
Measuring Water Needs

- “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
Measuring Water Needs

- Catch cans
- 4-cycle timer
- Rain gauge
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 = \( \text{Diameter} \times \text{Diameter} \div 2 \)

✓ Example #1:
6 ft. x 6 ft. = 18 gal./wk.

✓ Example #2:
20 ft. x 20 ft. = 200 gal./wk.

Formula: \((\text{Dia.’} \times \text{Dia.’} \times 0.7854 \div 43,560 \text{ sq.ft./ac.}) \times 27,154 \text{ gal./ac.-in.})\)
Watering Trees

Soaker hose around drip line of tree

“Gender bender” to improve uniformity of water flow
# Plant Water Requirements

(Estimated design rates for southwest Missouri)

<table>
<thead>
<tr>
<th>Vegetable Crop (mature)</th>
<th>Gallons per 100 Feet of Row per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum for plant survival</td>
<td>100</td>
</tr>
<tr>
<td>Lettuce, spinach, onions, carrots, radishes, beets</td>
<td>200</td>
</tr>
<tr>
<td>Green beans, peas, kale</td>
<td>250</td>
</tr>
<tr>
<td>Tomatoes, cabbage, peppers, potatoes, asparagus, pole beans</td>
<td>300</td>
</tr>
<tr>
<td>Corn, squash, cucumbers, pumpkins, melons</td>
<td>400-600</td>
</tr>
</tbody>
</table>
## Plant Water Requirements

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

<table>
<thead>
<tr>
<th>Fruit Crop</th>
<th>Gallons per 100 Feet of Row per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries</td>
<td>50</td>
</tr>
<tr>
<td>Raspberries &amp; Blackberries</td>
<td>75</td>
</tr>
<tr>
<td>With mulch</td>
<td></td>
</tr>
<tr>
<td>Without mulch</td>
<td>100</td>
</tr>
</tbody>
</table>
## Plant Water Requirements

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

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

**Good**
- ✔ 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

**Poor**
- - Elevation dictates pressure (2.3 feet of head = 1 psi pressure)
- - Watch for tank corrosion
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)

Resource: soilplantlab.missouri.edu/soil/water.aspx
# Plugging Potential of Drip Irrigation Systems

<table>
<thead>
<tr>
<th>Factor</th>
<th>Moderate (ppm)*</th>
<th>Severe (ppm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended solids</td>
<td>50-100</td>
<td>&gt;100</td>
</tr>
<tr>
<td><strong>Chemical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH**</td>
<td>7.0-7.5</td>
<td>&gt;7.5</td>
</tr>
<tr>
<td>Dissolved solids</td>
<td>500-2000</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.1-1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Iron</td>
<td>0.1-1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Hardness***</td>
<td>150-300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>0.5-2.0</td>
<td>&gt;2.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Bedrooms</th>
<th>Number of Bathrooms in Home</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow Rate (Gallons Per Minute)</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>--</td>
<td>13</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>--</td>
<td>--</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

Source: [http://extension.missouri.edu/p/G1801](http://extension.missouri.edu/p/G1801)
## Pump Cycling Rate, Max.

<table>
<thead>
<tr>
<th>Horsepower Rating</th>
<th>Cycles/Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 to 2.0</td>
<td>20</td>
</tr>
<tr>
<td>3 to 5</td>
<td>15</td>
</tr>
<tr>
<td>7.5, 10, 15</td>
<td>10</td>
</tr>
</tbody>
</table>
## Pressure Tank Selection

<table>
<thead>
<tr>
<th>Tank Size, gallons</th>
<th>Average Pressure, psi*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Pumping Capacity, GPM</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>5</td>
</tr>
<tr>
<td>82</td>
<td>11</td>
</tr>
<tr>
<td>144</td>
<td>19</td>
</tr>
<tr>
<td>220</td>
<td>29</td>
</tr>
<tr>
<td>315</td>
<td>42</td>
</tr>
</tbody>
</table>

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

Larger tank

OR

Variable-speed pump controller

Multiple tanks
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
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 (not engineered)
- 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

- 1.5-8.5 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
- Equipment & labor tradeoff
- Cost = $500-$700/acre (?)
Sprinkler Irrigation

Oscillating sprinkler covers 3,500 sq.ft. rectangle

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

- Whirling-head sprinkler covers 5 to 50 ft. diameter
- Rotary or impulse sprinkler covers partial to full circles
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
Drip Irrigation

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

- 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

- 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 = $900 - $1200 for 1st acre;
  $600 - $800/acre for rest
Wetting Patterns (Drip)

Cross Section of Soil Showing Wetted Areas

Wetted Area Appearing on Soil Surface
Sandy
Loam
Clay

Cross Section of Wetted Area in Soil
Sandy
Loam
Clay

Surface Installation (dripline near soil surface)

2' to 3'
3' to 5'
5' to 7'
Example Layout of Drip Irrigation System
Drip Irrigation Components

- **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
Drip Irrigation Components

✓ Check valve(s)
  - Stop backflow into water source
  - Critical if fertigating

✓ Filter system
  - 150-200 mesh screen
  - Manual or automatic backflushing
  - If you can see particles, the system can plug
Filter Selection

✅ 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
Filter Selection

✔ 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
  - Cannot handle sand well
Filter Selection

✅ Sand media

- 14” to 48” diameter
- Use swimming pool filter for smaller systems
- Use pairs of canisters for larger systems
- #16 silica sand = 150-200 mesh screen
- Work best at < 20 GPM flow per square foot of media
- Follow with screen filters
- Backflush to clean
Drip Irrigation Components

✓ 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
Solenoid Valves

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

- **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
Controller

✔️ Protect controllers from weather & pests
✔️ Use proper wiring (Type UF or USE)
Drip Irrigation Components

✓ 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
Laterals & Emitters

- 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)
Laterals & Emitters

- 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

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

Push barbed valve into hole

Layout & Connect

Push tape on & tighten collar nut
Low-Budget Options?

✔ What is your time worth?
✔ What is your mechanical expertise?

$129 for 15’ dia. x 3’ = 3,300 gallons

An Automatic Back Scratcher

Photo credit: www.walmart.com
Photo credit: http://hacknmod.com
Design Considerations

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

- 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
Planning Your System

✔ 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 grapes
    a. 290’ x 300’ field, 4.0% slope across rows, 2.3% along row
    b. 37 plants per row 8’ o.c., 28 rows 10’ o.c.,
    c. Irrigate up to 20 hrs./day
Sample Field Plan

<table>
<thead>
<tr>
<th>0 psi</th>
<th>300 ft. @ 2.3% slope</th>
<th>3 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

290 ft. @ 4.0% slope
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
Slope Measurement by Direct Reading

Two types of instruments
- Clinometer (Abney level)
- “Smart” level (electronic)
# Plant Water Requirements

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

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

✓ Calculate minimum pumping capacity needed & compare to water source

- GPD = Gallon/plant/day x # of plants

Example: Two acres 8’ x 10’ grapes

10 GPD x 1,080 plants = 10,800 gal.

per 20 hr. day = 540 GPH

= 9.0 GPM
Planning Your System

✓ 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 1/2 bath home & 19 GPM well
    a. Home needs 10 GPM, so field gets 9 GPM
    b. (9 GPM well cap. x 60 min/hr) ÷ 1 GPH/plant = 540 plants
    c. 540 plants / 37 plants/row ≈ 14 rows at once
    d. 28 total rows / 14 rows/block = 2 blocks
    e. 2 blocks x 10 GPD/plant ÷ 1 GPH/em. = 20 hrs.
Pumping Head

Total head in feet is the sum of:

- Elevation from water source to high point
- Pipe friction loss
- Miscellaneous friction loss of elbows, risers, valves, etc.
- Discharge pressure
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

<table>
<thead>
<tr>
<th>GPM</th>
<th>0.75&quot;</th>
<th>1&quot;</th>
<th>1.5&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2.8</td>
<td>0.8</td>
<td>0.1</td>
<td>--</td>
</tr>
<tr>
<td>10</td>
<td>11.3</td>
<td>3.0</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>15</td>
<td>21.6</td>
<td>6.4</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>20</td>
<td>37.8</td>
<td>10.9</td>
<td>1.3</td>
<td>0.4</td>
</tr>
<tr>
<td>25</td>
<td>--</td>
<td>16.7</td>
<td>1.9</td>
<td>0.6</td>
</tr>
<tr>
<td>30</td>
<td>--</td>
<td>--</td>
<td>2.7</td>
<td>0.8</td>
</tr>
</tbody>
</table>
### Example of Pumping Head Calculations

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation from water source to high point, feet</td>
<td>200.00</td>
</tr>
<tr>
<td>Pipe friction loss (400 ft. pipe x 1 psi/100’ x 2.31 ft./psi)</td>
<td>9.24</td>
</tr>
<tr>
<td>Misc. friction loss of elbows, risers, valves, etc. (convert to equiv. length of straight pipe)</td>
<td>6.25</td>
</tr>
<tr>
<td>Discharge pressure (15 psi x 2.31 ft./psi)</td>
<td>34.65</td>
</tr>
<tr>
<td><strong>Total head in feet</strong></td>
<td>250.14</td>
</tr>
</tbody>
</table>

Pump Curve Example

Photo credit: http://www.docstoc.com/docs/30713150/4-Submersible-Pump-Legend-High-Capacity-45-GPM
Sample Field Plan

0 psi  3 psi
300 ft. @ 2.3% slope

290 ft. @ 4.0% slope

5 psi  8 psi
Block #1

Block #2
# Troubleshooting Guide

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reddish-brown slime or particles near emitters</td>
<td>Bacteria feeding on iron</td>
</tr>
<tr>
<td>White stringy masses of slime near emitters</td>
<td>Bacteria feeding on sulfur</td>
</tr>
<tr>
<td>Green or slimy matter in surface water</td>
<td>Algae or fungi</td>
</tr>
<tr>
<td>White film on tape or around emitters</td>
<td>Calcium salts or carbonates</td>
</tr>
<tr>
<td>Presence of silt or clay</td>
<td>Inadequate filtration</td>
</tr>
</tbody>
</table>
Chemical Injection

✔ Kill bacteria & slime
  – Chlorine needs “contact time”
  – Powdered HTH can plug emitters
Chemical Injection

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

Rust & silt

Algaecide
Chemical Injection

- Apply fertilizer
  - Be sure it’s 100% water-soluble
  - Always inject it two elbows before the filter for good mixing
  - Use backflow preventer
Irrigation Resources on the Web

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

✓ Missouri Digital Soil Survey
  soils.missouri.edu/
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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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