Irrigation Strategies	2/16/24

The goal in writing this primer is to collect and centralize details that should be of interest to most gardeners. Hopefully this will provide some basic information as well as some advanced details pertaining to garden irrigation. Some gardeners may prefer to simply use their water hose to irrigate their garden, and others may want to use simple controller, while others may want a more sophisticated system. Similarly, determining the water budget can be done by trial and error, or by starting with a baseline and modifying the time / volume of water used, and others may elect to calculate using accepted formulas. To that end, I have plagiarized both QWEL and UCANR to provide an introduction to various topics.

Most of the enclosed information has come from:

Qualified Water Efficient Landscapers (**QWEL**): this course is offered in most counties, and is an excellent guide. Most of the cut&paste is this document comes from the QWEL Reference Guide. I believe the course is still offered free, is probably still taught by conference call, and that passing the exam provides a state wide recognized accreditation. The QWEL Reference Manual is available free online in pdf format. You can also google "QWEL Manual Pdf" to download a copy.

University of California Agriculture and Natural Resources (**UCANR**): this includes may programs, such as the UC Master Gardener Program. This primer contains a number of cut&paste section from UCANR.

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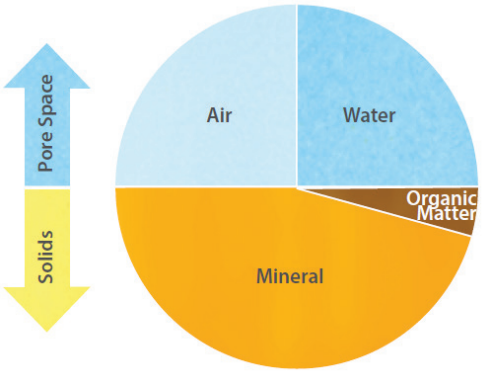
Section 1: Background Information
Section 2: First Strategy: Water by Hand
Section 3: Second Strategy: Simple Controller Attached to Spigot
Section 4: Third Strategy: Controller with External Irrigation Valves
Section 5: Irrigation Pipe / Hose / Tubing
Section 6: Irrigation Design
Section 7: Irrigation Valve
Section 8: UCANR Example of Vegetable Garden Irrigation
Section 9: UCANR Example of Fruit Tree Irrigation
Section 10: QWEL Controller Programming Solution
Section 11: Examples of Controller Programming
Section 12: Rebate Programs
Section 13: Checklist After Presentation

Section 1: Background Information

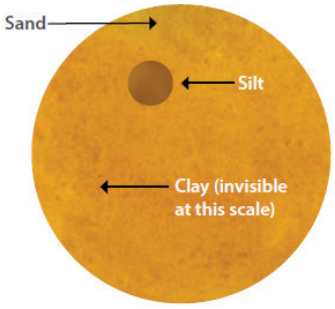
Soil has 4 major components: air, water, organic matter and mineral matter.

Figure 3-1: Major components of soil



The Mineral Matter is broken down into: sand, silt and clay. An understanding of the particle sizes helps to understand how water is retained.

Figure 3-4: Relative size of soil separates



Each garden and its soil is unique, and an important date point is knowing your soil type. There are 2 test methods available: ribbon test and jar test. There is no free soil testing facility in California, and you would need to go to a private lab for testing. But, this test is usually not very useful for heavily amended garden beds.

Ribbon Test: create a ½ inch ball and wet the soil to make it pliable. If the ball breaks, then you have sand. Otherwise ..

Figure 3-9: Texture by "feel" test

- If the soil can be shaped as a ribbon without breaking apart, it indicates various amounts of silt and clay.
- A ribbon less than 1 inch long indicates a type of loam soil.
- A ribbon from 1 to 2 inches indicates a type of clay loam soil.
- A ribbon greater than 2 inches long indicates a type of clay soil.

Jar Test: once the percentage of particles is determined using the Jar Test, use the Soil Triangle to determine your soil type.

Figure 3-8: Sedimentation test

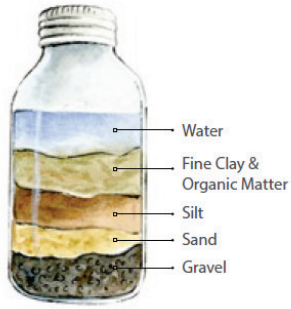
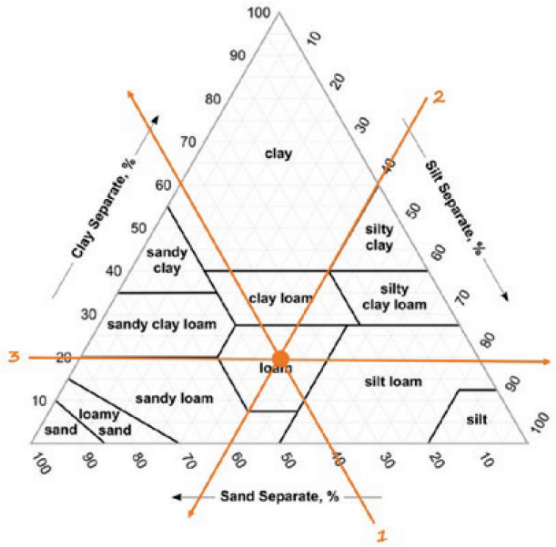


Table 3-1: Example soil textural classes

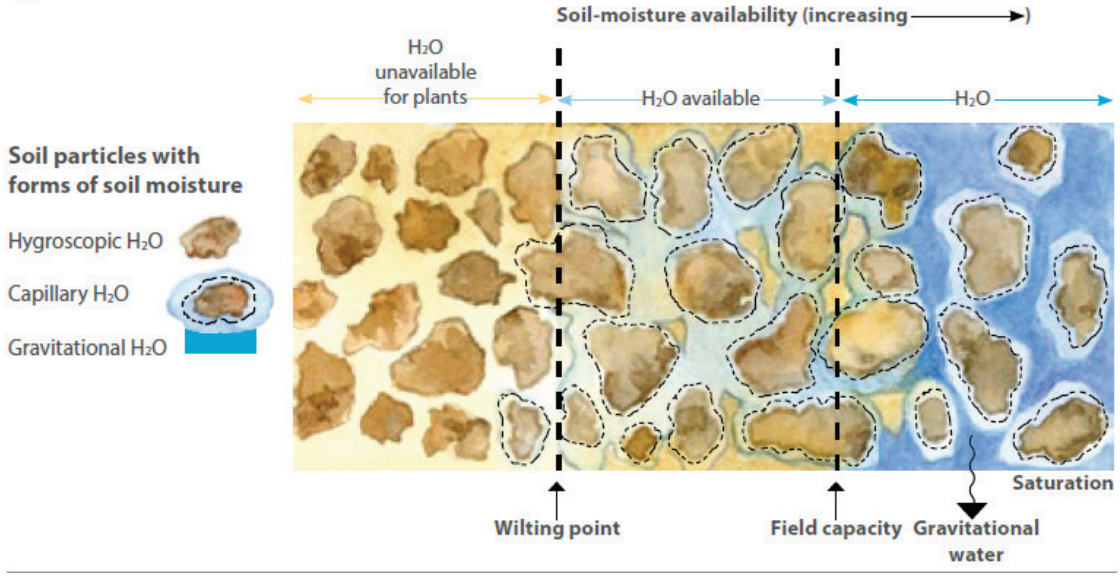
Percent Sand	Percent Silt	Percent Clay	Textural Class
40	40	20	Loam
30	35	35	Clay loam
60	30	10	Sandy loam

Figure 3-5: Soil textural triangle (image courtesy of United States Department of Agriculture)



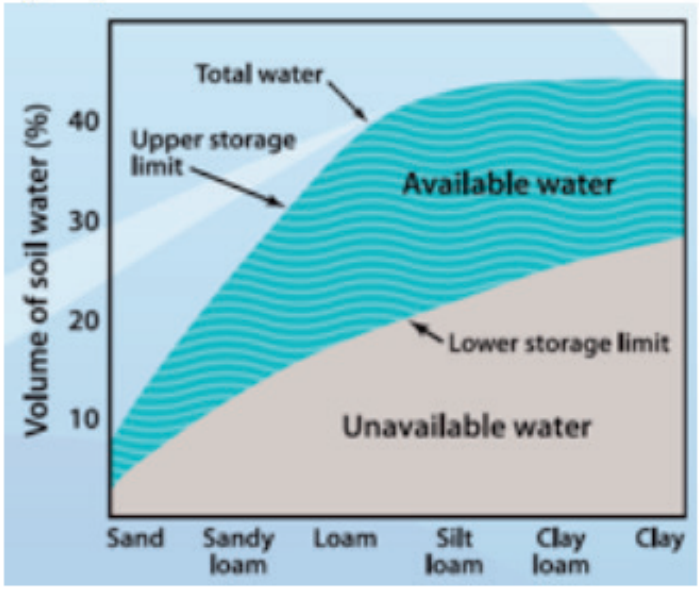
Soil Moisture: One of the strategies in using an automated irrigation system is to be able to maintain the soil moisture in a zone between the Field Capacity Point and the Wilting Point.

Figure 3-14: The soil moisture reservoir



In the following figure, the turquoise area shows the volume of available water as a function of the soil type. The Loam / Silt Loam provides the most available water. A characteristic of clay is that is does not readily give up its water easily (and clay contains a lot of minerals).

Figure 3-15: Soil water (image courtesy of Soil Quality Pty Ltd)



The following shows various soil irrigation profiles. Note variations in Distribution Uniformity (DU) and Irrigation Efficiencies (IE). The profile is affected by the soil type, but also by the characteristics of the irrigation. For example, a very wide spacing in drip emitters may result in poor DU. Uneven drip emitter values on the same line could cause

Figure 7-2: Excessive watering with poor DU

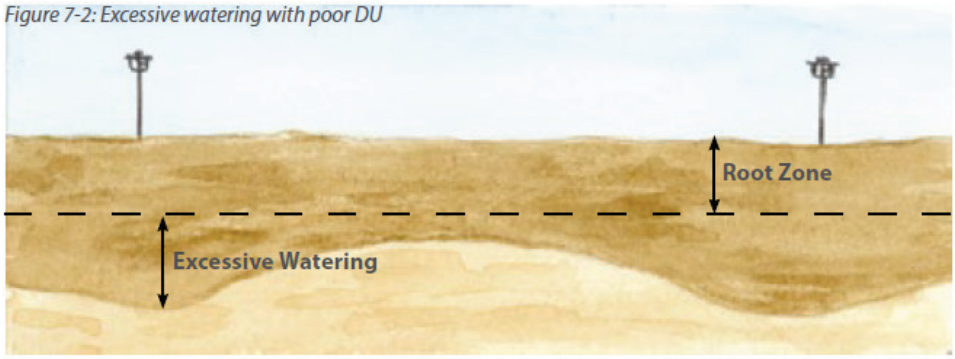


Figure 7-3: Insufficient watering with poor DU

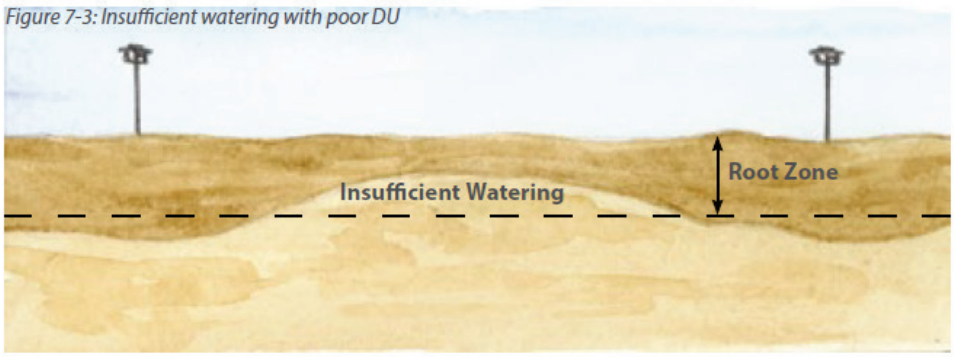


Figure 7-4: Good DU with poor IE

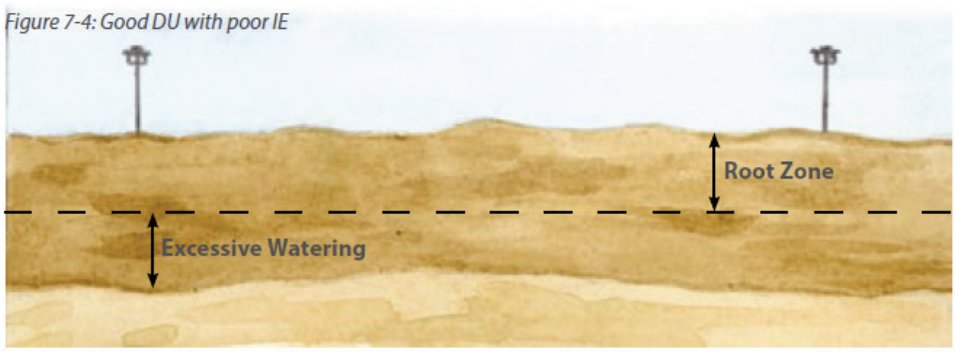
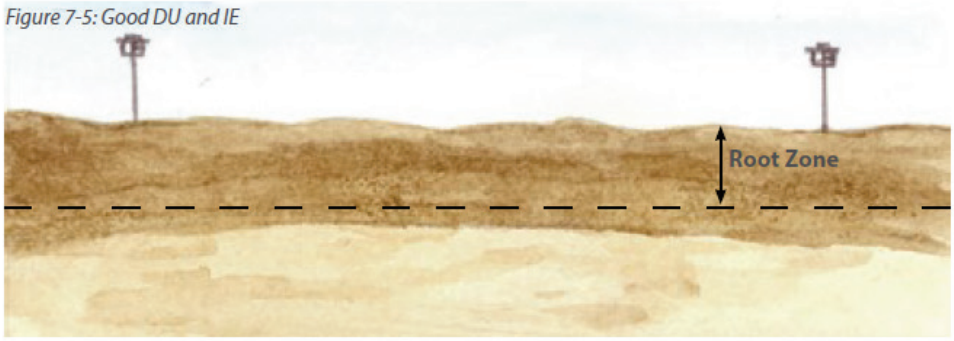


Figure 7-5: Good DU and IE



Section 2: First Strategy: Water by Hand

The simplest irrigation method is to use a water hose and water your garden by hand. You judge the frequency and the volume of water you deem appropriate, and spray the garden early in the morning to better assure that water is absorbed into the ground before the sun's heat increases the potential for evaporation.

Soil Moisture Measurement: To see the effectiveness of the watering, use your hand or a trowel to inspect the level at which water has infiltrated the soil. Another method is to use a Soil Moisture Meter. They are available on Amazon (<$10).

The insulator in the tip separates 2 dissimilar metals, which when inserted in a moist environment creates a battery. The soil completes the circuit around the insulator and causes the meter to deflect. More moisture means more conductivity, which means more meter deflection. The numerical reading provides a relative value, not an absolute measurement. The goal is to observe the meter movement at different soil depts to determine the degree of water infiltration. Using this procedure, the irrigation time can be confirmed or modified as required.

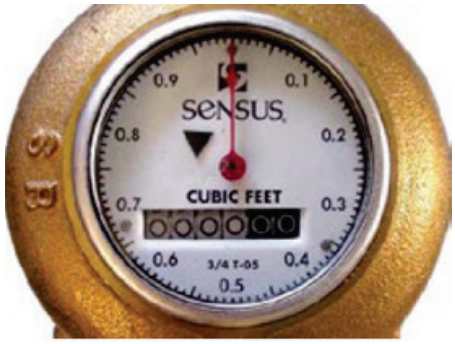
To understand your garden's requirement, measure the moisture content before you water, and then again after watering. Compare the results against Figure 7-2 to 7-5 above.

An inherent problem with this type of probe is that the battery action which occurs at the tip will cause the eventual erosion of the tip. The tip material will disappear. To delay this action, clean the probe tip with a dry rag before storing. Using sandpaper to clean the metal surface (1 inch of the probe tip) will renew the metal's ability to conduct, resulting in a longer life of the probe.

A fundamental check that the meter is working is to place the probe tip in water, or saturated soil, to ensure that the meter deflects.

Water Meter: the city water connection to the house / garden may be done 2 ways. You may have 1 line that goes to the house and is used for both house and garden, or you may have individual lines for the house and for the garden.

Low Flow Indicator: Note the small red star or black triangle which is built into the water meter. This wheel is activated by even the smallest water flow. This is a great indicator of a leak in the system.



Section 3: Second Strategy: Simple Controller Attached to Spigot

Attaching an Irrigation Controller directly to outdoor water spigot is very common. Lowes has low cost single line controllers (<$20), and 4 channel systems (<$70). Amazon has a lot of questionable controllers. There are also Bluetooth or Wi-Fi units available. More sophisticated units will have moisture sensors, and/or local weather connectivity.

Figure 9-1: Left to right (1) Hunter Pro-C, (2) Irritrol Rain Dial-R, (3) Rain Bird ESP-ME, (4) Toro Evolution (images courtesy of Hunter Industries Inc, Irritrol, Rain Bird Corporation, and The Toro Company)

Regardless of level of sophistication, these units all attach to the spigot, and the system must have the following associated components.

Controller: the simplest is a single line, battery operated unit, with a built-in timer / valve. Custom programming is required for start time, duration, number of cycles, number of days, seasonal adjustments, manual mode, and perhaps other parameters.

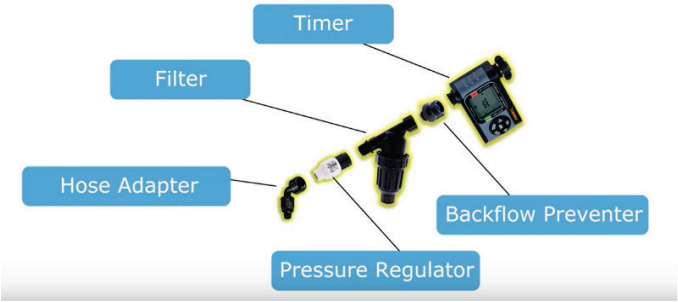
Backflow Protection: an anti-siphon device preventing irrigation water from the garden from entering the house potable water system (may be due to a change in water pressure). This device may reduce your water pressure ;by ~ 10 PSI.

Filter: a filter to prevent particulate matter from clogging emitters

Pressure Regulator: a pressure regulator to reduce the water pressure to a range acceptable to your emitter manufacturing recommendations.

- At my house, the city pressure is 70 Pounds Per Square Inch (PSI), and I use 30 to PSI reducers
- Pressure must stay within equipment supplier recommended pressure
- For example, some Netafim emitters are rated for 14 to 58 PSI

Drip Line Adaptor: to make the connection from the irrigation system to the drip fitting (hose thread vs. pipe thread).



Attached to the above irrigation control system is a network of water delivery components, such as hoses, emitters, etc. Lowes carries (for example) Rainbird ½" pressure compensated tubing or separate emitters to be used with ¼" tubing.

Even with this automated system, regular inspection is required to confirm that the moisture level is kept between the **Witling Point & Field Capacity**.

Section 4: Third Strategy: Controller with External Irrigation Valves

This strategy introduces more options for expansion, since separate irrigation valves can be added, and the controllers have more sophisticated programs or options.

Controller: more sophisticated than strategy #2, and could include:
- More lines, to greater than 20 zones
- May be Bluetooth or Wi-Fi controllable
- Can be co-located or remotely located
- May included daily / weekly / seasonal programing
- May have humidity sensing, wind sensing, or local weather sensors

Other Irrigation Components:

- Water Meter, Gate Valve, Backflow Preventer, Pressure Regulator Filter
- Master Valve / Mainline (normally open valve, opens on loss of power)
- Supply Header / Manifold: serves as distribution point for multiple zones.
- Irrigation Valve: valves with Solenoid, 1 valve per zone, can be connected via wires or Bluetooth or Wi-Fi
- Drip Line / Emitters, Exhaust Header / Manifold, Flush Valve

For simplicity, assume that all connection hardware is 1" PVC Schedule 40.

Figure 5-6: Irrigation system overview (image courtesy of Hunter Industries Inc)

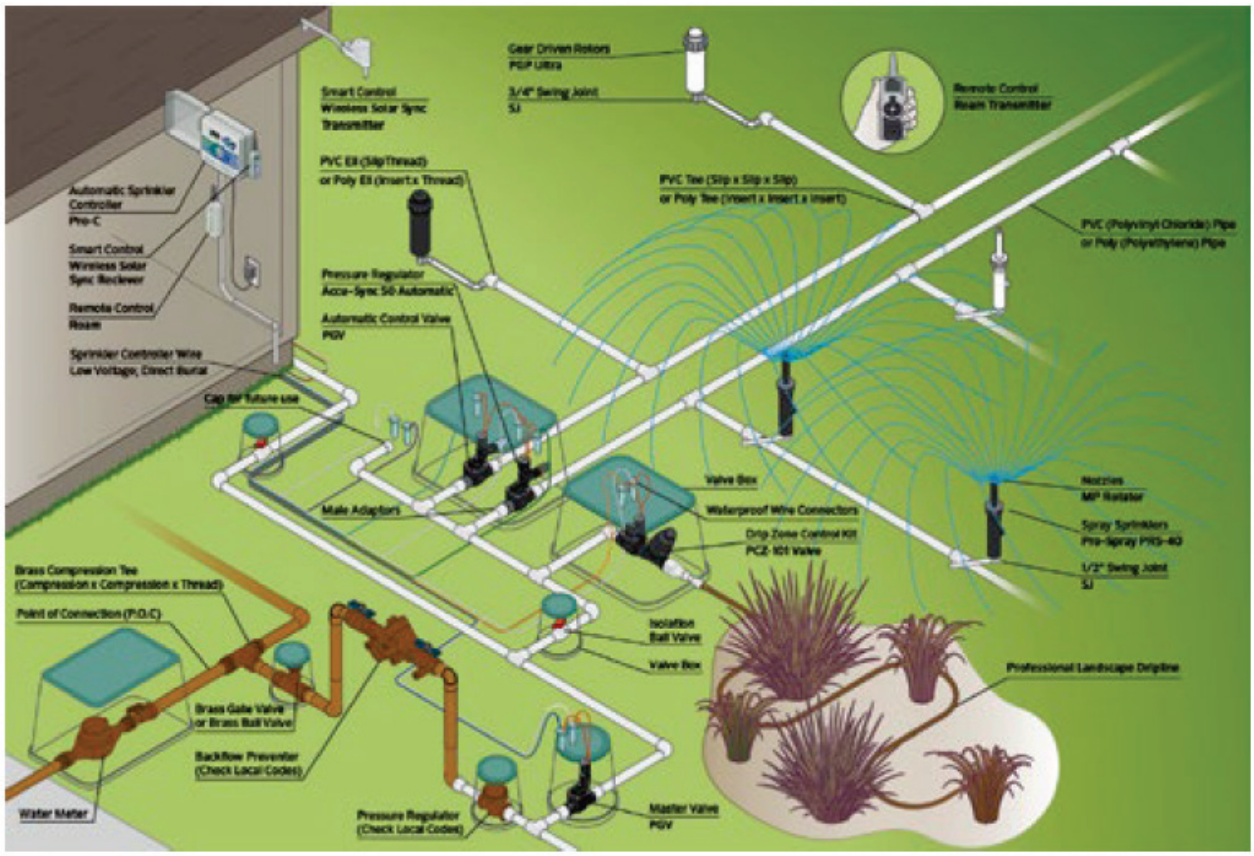
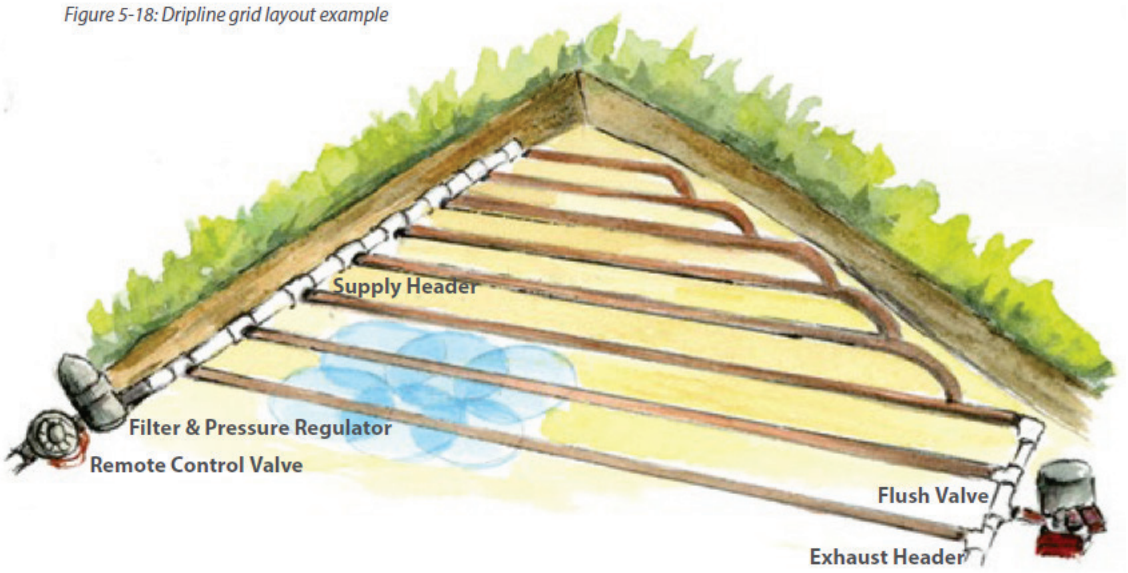
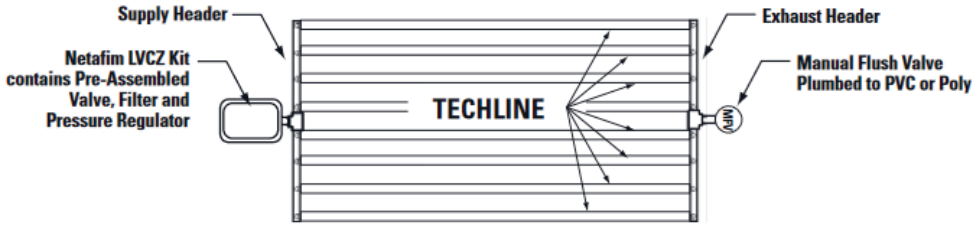


Figure 5-18: Dripline grid layout example



Basic GRID Layout



BASIC GRID LAYOUT:

- Headers should be indented 2" - 4" from hardscapes and planting areas.
- Headers may be PVC, polyethylene or in zones under 5 GPM, Techline HCVXR and CV or Techline Blank Tubing.
- Headers must be sized to accommodate the flow of the zone without exceeding 5 feet per second velocity. (Zone Water Requirement calculations are on pages 11 and 12.)
- Start rows of Techline 2" - 4" away from the edge of hardscapes, and move across the area with equal row spacing that does not exceed the recommendations of Table 1: General Guidelines (see page 6). (The 2" setback will help provide enough moisture to prevent heat damage to plant material generated by hardscapes such as asphalt). Start rows about 4" away from planting beds.

Section 5: Irrigation Pipe / Hose / Tubing

- PVC can be solid or flexible, connected by primer / glue
- PE is flexible, thinner that PVC, can be pulled when deploying, use insert fitting
- HDPE is mostly commercial, connected by butt fusion or electrical fusion
- ALWAYS maintain a safe flow velocity (<5 FPS)
- The larger the pipe diameter, the lower the pressure
- The smaller the pipe diameter, the greater the pressure loss

Mainline

- Install 12" deep (min), commercial is 18"

Lateral Line

- Usually use Class 200 (but may use Schedule 40 for consistency)
- Install 8" deep for residential, or 12" for commercial

PVC Schedule 40

- Schedule 40 refers to wall thickness
- Schedule 40 pipe has thicker wall than Class rated pipe in sizes up to 4 inches
- Schedule 40 is thinner wall that Schedule 80
- Schedule 40 wall thickness remains constant for all pipe sizes
- Schedule 40 is thinner than Schedule 80

PVC Class 200 or 315

- Class Pipe: indicates pressure rating, eg. 200 PSI at 73F
- Class Pipe has different wall thickness for different sizes
- Class 200 pipe has pressure rating of 200 PSI at any size of pipe
- Class 200 at nay size has a pressure rating of 200 PSI

Rainbird

- Polyethylene tubing

Purple Pipe

- Indicates water is non-potable

Generally accepted guideline

Tubing Size	Maximum Run Length	Maximum GPH Supplied
1/4"	30 feet	30 GPH
1/2"	200 feet	200 GPH
3/4"	480 feet	480 GPH
1"	960 feet	960 GPH

Drip Line Advantages (data from Netafim)

- Pressure compensated emitters
- Virtually clog resistant
- Uses 30-70% less water than overhead irrigation
- Operating pressure 25 to 50 PSI
- Emitters 6", 12", 18", 24" apart
- Require 5.3 to 23.8 GPH
- 12 or 17 mm diameter

Section 6: Irrigation Design

- Determine soil type using: Ribbon Test, Jar Test (clay / silt / sand) and Soil Triangle (Page 3-5)
- Watering Moisture Goal: below Field Capacity and above Wilting Point (Page 3-12)
- Pressure Compensated Internal Check Valve
- 10 to 12 PSI lost due to Backflow Device
- Dripline Recommendation
    - Do not mix driplines of different rates or different emitter spacing on the same valve
    - ½ inch diameter tubing is recommended for permanent installation (less pressure loss than ¼ inch tubing)
    - Match emitter spacing to soil type (eg. Clay soil more suited to lower application rate)
    - Pressure compensated emitters
    - Built-in check valve
    - Grid pattern with a supply header and exhaust header
    - Follow manufacturer recommendation for max line run length
    - Stay within emitter min and max pressure recommendation
    - Include a flush valve
    - Include an air/vacuum relief valve at highest point
- Vegetables need 1" of water per week
- 1" of mulch reduces water requirement by 25%
- Water speed must be < 5 FPS (feet per second)
- Drip must be within manufacturer recommendation
- Dripline
    - Spacing (inches): 6, 12, 18, 24
    - Flow (in/hr): 0.26 to 1
- Bubbler volume (GPH): ½, 1, 2, 4, 6
- ETo Zone
    - Pleasanton: 14
    - Livermore: 8
- Master Valve should be Normally Closed

Water application rate in Inches per Hour, dependent on soil type, emitter flow rate, emitter spacing, and row spacing.

Figure 5-19: Netafim Techline CV precipitation rate chart (image courtesy of Netafim USA)

GENERAL GUIDELINES	TURF												SHRUB & GROUNDCOVER											
	CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL			CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL		
EMITTER FLOW	0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH			0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH		
EMITTER SPACING	18"			12"			12"			12"			18"			18"			12"			12"		
LATERAL (ROW) SPACING	18"	20"	22"	18"	20"	22"	12"	14"	16"	12"	14"	16"	18"	21"	24"	18"	21"	24"	16"	18"	20"	16"	18"	20"
BURIAL DEPTH	Bury evenly throughout the zone from 4"to 6"												On-surface or bury evenly throughout the zone to a maximum of 6"											
APPLICATION RATE (INCHES/HOUR)	0.19	0.17	0.15	0.30	0.27	0.25	0.98	0.84	0.73	1.48	1.27	1.11	0.19	0.16	0.14	0.30	0.26	0.23	0.73	0.65	0.59	1.11	0.99	0.89
TIME TO APPLY ¼" OF WATER (MINUTES)	80	89	97	50	55	61	15	18	20	10	12	13	80	93	106	50	58	66	20	23	26	13	15	17
Following these maximum spacing guidelines, emitter flow selection can be increased if desired by the designer. 0.9 GPH flow rate available for areas requiring higher infiltration rates, such as coarse sandy soils.																								

Friction Loss: For a flow rate of 10 GPH, determine pressure loss for a 1" Schedule 40 pipe. Velocity must be kept under 5 FPS.

Figure 5-2: Friction loss chart for schedule 40 PVC (image courtesy of Hunter Industries Inc)

FRICTION LOSS CHARACTERISTICS
PVC SCHEDULE 40 IPS PLASTIC PIPE
(1120, 1220) C = 150
PSI loss of 100 feet of tube (PSI/100 FT)

Sizes 1/2" thru 6"
Flow GPM 1 thru 600

SIZE	1/2"		3/4"		1"		1 1/4"		1 1/2"		2"	
OD	0.840		1.050		1.315		1.660		1.900		2.375	
ID	0.622		0.824		1.049		1.380		1.610		2.067	
WALL THK	0.109		0.113		0.133		0.140		0.145		0.154	
FLOW G.P.M.	VELOCITY F.P.S.	P.S.I. LOSS	VELOCITY F.P.S.	P.S.I. LOSS	VELOCITY F.P.S.	P.S.I. LOSS	VELOCITY F.P.S.	P.S.I. LOSS	VELOCITY F.P.S.	P.S.I. LOSS	VELOCITY F.P.S.	P.S.I. LOSS
1	1.05	0.43	0.60	0.11	0.37	0.03	0.21	0.01	0.15	0.00		
2	2.11	1.55	1.20	0.39	0.74	0.12	0.42	0.03	0.31	0.02	0.19	0.00
3	3.16	3.28	1.80	0.84	1.11	0.26	0.64	0.07	0.47	0.03	0.28	0.01
4	4.22	5.60	2.40	1.42	1.48	0.44	0.85	0.12	0.62	0.05	0.38	0.02
5	5.27	8.46	3.00	2.15	1.85	0.66	1.07	0.18	0.78	0.08	0.47	0.02
6	6.33	11.86	3.60	3.02	2.22	0.93	1.28	0.25	0.94	0.12	0.57	0.03
7	7.38	15.77	4.20	4.01	2.59	1.24	1.49	0.33	1.10	0.15	0.66	0.05
8	8.44	20.20	4.80	5.14	2.96	1.59	1.71	0.42	1.25	0.20	0.76	0.06
9	9.49	25.12	5.40	6.39	3.33	1.97	1.92	0.52	1.41	0.25	0.85	0.07
10	10.55	30.54	6.00	7.77	3.70	2.40	2.14	0.63	1.57	0.30	0.95	0.09
11	11.60	36.43	6.60	9.27	4.07	2.86	2.35	0.75	1.73	0.36	1.05	0.11
12	12.65	42.80	7.21	10.89	4.44	3.36	2.57	0.89	1.88	0.42	1.14	0.12
14	14.76	56.94	8.41	14.48	5.19	4.47	2.99	1.18	2.20	0.56	1.33	0.17
16	16.87	72.92	9.61	18.55	5.93	5.73	3.42	1.51	2.51	0.71	1.52	0.21
18	18.98	90.69	10.81	23.07	6.67	7.13	3.85	1.88	2.83	0.89	1.71	0.26
20	21.09	110.23	12.01	28.04	7.41	8.66	4.28	2.28	3.14	1.08	1.90	0.32
22			13.21	33.45	8.15	10.33	4.71	2.72	3.46	1.29	2.10	0.38
24			14.42	39.30	8.89	12.14	5.14	3.20	3.77	1.51	2.29	0.45
26			15.62	45.58	9.64	14.08	5.57	3.17	4.09	1.75	2.48	0.52
28			16.82	52.28	10.38	16.15	5.99	4.25	4.40	2.01	2.67	0.60
30			18.02	59.41	11.12	18.35	6.42	4.83	4.72	2.28	2.86	0.68
35					12.97	24.42	7.49	6.43	5.50	3.04	3.34	0.90
40					14.83	31.27	8.56	8.23	6.29	3.89	3.81	1.15
45					16.68	38.89	9.64	10.24	7.08	4.84	4.29	1.43
50					18.53	47.27	10.71	12.45	7.87	5.88	4.77	1.74

How to Read the Friction Loss Chart

- Select pipe size at the top of the chart.
- Each pipe size has two columns:
  - Velocity
  - PSI Loss
- Select flow rate on the left side of the table.
- Find the pressure loss value that corresponds to the two readings.
- For example, the pressure loss for 1-inch schedule 40 PVC with a flow rate of 10 GPM is 2.40 PSI per 100 foot of pipe.
- Ensure velocity is outside of shaded area (< 5 FPS).

Section 7: Irrigation Valve

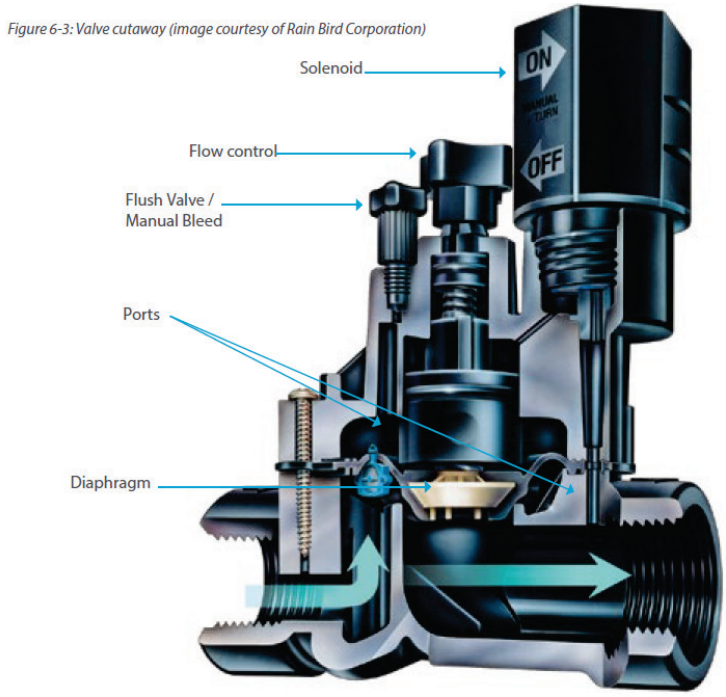


Figure 6-3: Valve cutaway (image courtesy of Rain Bird Corporation)

Valve

- Quarter turn CW for OFF, quarter turn CCW for ON
- Bleed screw
- Fill hole with landscape fabric, bricks, gravel
- Controller (programming)
    - Seasonal Adjustment
    - Weather Data from internet

Section 8: UCANR Example of Vegetable Garden Irrigation
https://mg.ucanr.edu/Gardening/Vegetable/Caring/Irrigation/

Gardens in most areas of California require regular irrigation to provide the soil with the moisture needed for maximum plant growth. Vegetable crops are not drought tolerant. In order to produce good quality and good yields of vegetables, the soil must be kept moist during the crop cycle.

During years of normal rainfall, winter rains in most areas usually wet the soil to about 1 foot or more deep by spring. If the soil is not wet to this depth, irrigate before seeding or transplanting so that the soil is wet to a depth of several feet. Irrigation, as it applies to home vegetable gardens, is presented here in a very brief format.

As a rule, it is necessary to irrigate your vegetable garden one to three times a week in summer and once or twice per week or less in other seasons. The frequency is determined by the depth of crop roots, soil texture, and weather conditions. Wet the soil to just beyond the bottom of the root system at each watering. If you only keep the surface of the soil moist, most of the water evaporates into the air.
Adjust the amount and frequency of irrigation according to the water use and root depth of each type of vegetable you grow, if possible. When this is not feasible, adjust irrigation to meet the needs of shallow-rooted crops. If their needs are met, the medium and deep-rooted crops will get enough water. This same rule applies anywhere topsoil is shallow—only 1 to 2 feet of soil is available for root growth, such as in raised beds and many urban properties.

Under ideal soil conditions, shallow-rooted crops have main root systems in the top 6 to 12 inches of soil. Examples are: cabbage, cauliflower, lettuce, celery, sweet corn, onion, white potato, and radish. Moderately deep-rooted crops are those with the main root system in the top 1 to 2 feet of soil. Examples are: snap bean, carrot, cucumber, eggplant, peas, pepper, and summer squash. For deep-rooted crops, the main root system is in the top 2 to 4 feet of soil. Examples are: asparagus, globe artichoke, cantaloupe, pumpkin, tomato, and watermelon.

Drip irrigation offers several advantages to home gardeners: Water is placed more accurately in the root zone; water is applied at a slow rate, so there is little or no waste; aisles or furrows are dry, so you can work in the garden while irrigation is in process; plant foliage is not wetted; less water is required; and little or no management is required while irrigating. The disadvantages are the added costs of the drip irrigation equipment and occasional problems of plugging of the tiny drip orifices. However, the advantages generally outweigh the disadvantages, and a drip irrigation system, when correctly installed and maintained, can be very helpful to the serious gardener. The emitters in a drip system have a flow rating, such as 1 gallon per hour, and summing the number of emitters will give you the gallons applied to the planted areas. This value can be used as in the sprinkler irrigation discussion above to estimate watering depth.

Most vegetable need about 1 to 2 inches of water each week, says Robert Westerfield, consumer horticulturist with the University of Georgia. This includes both water you provide as well as rainfall, so paying attention to how the week's forecasted storms come together is your first responsibility. Mar 3, 2023

Section 9: UCANR Example of Fruit Tree Irrigation
https://homeorchard.ucanr.edu/The_Big_Picture/Irrigation/#wateruse

Daily water use is called evapotranspiration (ET), which is the amount of water evaporating off the soil surface plus the water used (transpired) by the tree. ET is expressed in inches per day. A typical summer reference ET is 0.3 inches per day. Reference ET is measured or based on a grass crop, which is typically more than the actual ET for trees and other plants. Using a percentage of the reference ET, e.g. 70 or 80% (or 100% with mature trees with cover crop), will closely estimate the actual ET for your own trees or orchard. For most deciduous fruits (not nuts which are higher), mid-summer percentage of reference ET is 86% (110% with cover crop). (UCANR)

Adjustment must be made for young trees under drip irrigation. Two times more water should be applied to small trees less than 20% full size, gradually reducing the adjustment until trees reach 70% full cover.
Soil type will help you estimate water holding capacity (inches of water available to plants). Soil texture influences the water holding capacity of soils. The proportion and absolute amount of water available to the plant in coarse-textured, sandy soils is less than in fine-textured, clay soils, therefore clay holds the most water. (UCANR)

Each foot of soil depth holds:
Sands 1.0–1.5 inches of water
Loam 1.5–2.0 inches of water
Clays 2.0–2.5 inches of water

Rooting Dept: Soil depth down to an impermeable layer, usually. Rooting depth varies among plants and is often overlooked in discussing water needs. Roots extract water differently along the vertical profile of soil. The concentration or mass of roots is typically greater near the soil surface. Because of that, water extraction or absorption from soils is greater near the surface. In general, about 40% of the total water extracted occurs in the upper quarter of the root zone, 30% from the second, 20% from the third, and 10% from the lowest quarter.
Effective rooting depth (ERD) is a term used to note the depth where water absorption is most active. ERD for trees would be a minimum of two feet – more in deeper soils. A number of variables affect ERD including soil texture and depth, tree species, age, rootstock differences, and more. (UCANR)

Water Management Guide for Temperate Fruit Trees

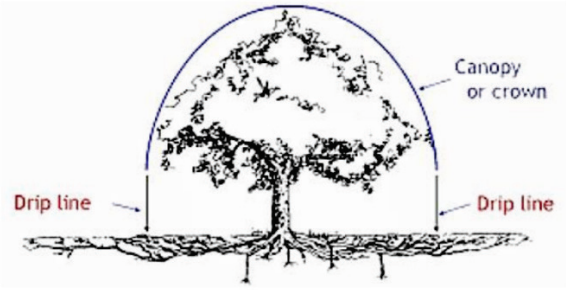
Tree Size, or area plant covers in square feet (ft^2) to the drip line (% canopy)	Daily Water Use in Gallons per Day			
	E.T. 0.10"/day Cool day, early spring Late fall, foggy	E.T. 0.20"/day Warm day in spring or fall; some fog	E.T. 0.25"/day Hot day, mid-summer No fog	E.T. 0.30"/day Very hot (100°F) Windy, mid-summer
1 $foot^2$	0.062	0.125	0.156	0.187
1 yr. old (4 ft^2)	0.25	0.50	0.62	0.75
2 yr. old (10 ft^2)	0.62	1.25	1.56	1.87
3 yr. old (36 ft^2)	2.25	4.5	5.61	6.73
4 yr. old or 100 ft^2 semi-dwarf mature	6.20	12.5	15.6	18.7
Large standard mature tree (300 ft^2)	18.6	37.5	46.8	56.1
One acre solid cover (43,560 ft^2)	2,715	5,431	6,788	8,146

From: Growing Temperate Tree Fruit and Nut Crops in the Home Garden
Paul M. Vossen
Tree Fruits and Nuts Farm Advisor, Sonoma and Marin Counties
University of California Cooperative Extension
2000

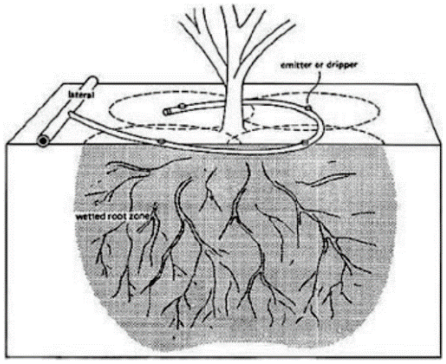
Efficiency adjustment: Adjustment must be made for young trees under drip irrigation. Two times more water should be applied to small trees less than 20% full size, gradually reducing the adjustment until trees reach 70% full cover.

Example
A 2 year-old semi-dwarf fruit tree occupies a space of 10 ft^2. It has 2, 1 gal/hr emitters, and on a warm spring day the water use rate (ET) is about 0.20 in/day.
How much: 1.25 gal/day × 2 (for an efficiency adjustment on young trees with 10–15% canopy) = 2.5 gal/day.
How often: 2.5 gal/day divided by two emitters per tree = 75 minutes per tree every day or 2.5 hours every other day.

Example
A mature standard sized (large) fruit tree occupies and area of 300 ft2 with four, one 1 gal/hr emitters per tree. On a hot summer day it uses 0.25 in/day (ET).
How much: 46.8 gallons per day (from Guide).
How often: 46.8 divided by 4 emitters = 11.7 hours everyday. Every other day = 23.4 hours.



For trees dripline should be placed at the edge of the canopy. UCANR California Center for Urban Horticulture.



Placement of dripline for newly planted shrubs. UCANR California Center for Urban Horticulture.

Non-UCANR: water deeply when the roots have dried out. This may mean once a week or month depending on the weather, soil condition, and the age of the tree.

For PSI, look at manufacturer spec to find required pressure, then measure max available volume of water to ensure that there is enough water to drive all your emitters that are downrange from the pressure reducing device

5 CONTROLLER PROGRAMMING SOLUTION

Suggest how the peak month weekly irrigation run times could be used to program a conventional irrigation controller.

5.1 The programs below are based on management decisions and are just one potential solution.

5.2 Weekly run time should be between IRT_{MIN} and IRT_{MAX}.

5.3 The schedule programmed should be continually evaluated and adjusted to maintain plant material to the desired level of appearance.

Table 10-11: Traditional landscape controller program

Hydrozone	Week Run Time (mins)	Number of Days to Irrigate	Daily Run Time (mins)	Number of Cycles Per Day
Turf – front yard	36	3	4	3
Turf – parkway	36	3	4	3
Shrubs	20	2	5	2

5.4 Turf irrigated 3 days per week for 4 minutes with three cycles, for a total run time of 12 minutes each day, or 36 minutes each week.

5.5 Shrubs irrigated 2 days per week for 5 minutes with two cycles, for a total run time of 10 minutes each day or 20 minutes each week.

Table 10-12: Sustainable landscape controller program

Hydrozone	Week Run Time (mins)	Number of Days to Irrigate	Daily Run Time (mins)	Number of Cycles Per Day
Natives - front yard	30	1	15	2
Natives - parkway	30	1	15	2

5.6 California natives irrigated 1 day per week for 15 minutes with two cycles for a total run time of 30 minutes a week.

5.7 The relatively long run time for the sustainable landscape hydrozones is due to the much lower precipitation rate compared to the traditional landscape.

PRO-C
CONTROLLER PROGRAMMING INSTRUCTIONS:

Hunter®

SETTING THE DATE AND TIME

1. Turn dial to the **Date/Time** position.
2. **YEAR:** Press + and − to change the year. Press → to advance to **MONTH**.
3. **MONTH:** Press + and − to change the month. Press → to advance to **DAY**.
4. **DAY**: Press + and − to change the date. Press → to advance to **TIME**.
5. **TIME**: Press + and − to select **AM**, **PM** or **24 HR.** Press → to select hours. Press + and − to change the hour shown on the display. Press → to select minutes. Press + and − to change the minutes.

The date, day and time have now been set.

SETTING PROGRAM START TIME

NOTE: A single watering start time will start the program (A,B,C) and all stations assigned to the program will run sequentially.

1. Turn dial to the **Start Times** position.
2. Select program A, B or C by pressing PRG.
3. Press + and − to change the start time.
4. Press → to select the next start time, or PRG for the next program.

To eliminate a programmed start time: Press + and − to set the start time to **OFF** (which is between 11:45 PM and midnight).

SETTING STATION RUN TIMES (WATERING DURATION)

1. Turn the dial to the **Run Times** position.
2. Select program A, B or C by pressing PRG.
3. The display will show the station number and the program letter selected (A, B or C). The run time will be flashing.
4. Press + and − to change the run time.
5. Press → to advance to the next station.
6. Repeat steps 4 and 5 for each station.

SETTING DAYS TO WATER

1. Turn the dial to the **Water Days** position.
2. The controller displays currently programmed active day schedule information. This dial position provides four different water day options: water on specific days of the week, interval watering, or water on odd days or even days. Each program can only operate using one type of water day option.

SELECTING SPECIFIC DAYS OF THE WEEK TO WATER

1. With the arrow cursor on a specific day (the cursor always starts with Monday), press + to activate a particular day of the week to water. Press − to cancel watering for that day. After pressing a button the cursor automatically advances to the next day. A ♦ indicates a water day. A 💧 icon indicates a no water day.
2. Repeat step 1 until desired days have been selected.

Please refer to Owner's Manual for interval and odd or even day scheduling.

RAIN SENSOR BYPASS SWITCH

If a sensor is preventing system operation (or no sensor is installed and the switch is in the **ACTIVE** position), **SENSOR OFF** will be displayed. Move the switch to **BYPASS** and the rain sensor will be bypassed.

SEASONAL ADJUSTMENT

1. Turn dial to the **Seasonal Adjust** position.
2. Press + and − to change the seasonal adjustment from 5% to 300% in 5% increments. The station run times displayed will automatically be recalculated.

CLEARING CONTROLLER'S MEMORY/RESETTING CONTROLLER

If you feel that you have mis-programmed the controller, there is a process that will reset the memory to factory defaults and clear all data that has been entered into the controller.

1. Hold down the PRG button.
2. While holding down the PRG button, press and release the reset button on the back of the front panel, wait until the display reads 12:00 AM, then release the PRG button.
3. All the memory has been cleared and the controller may be reprogrammed.

MANUALLY OPERATING A SINGLE STATION

1. Turn dial to the **Manual** position.
2. Station run time will flash in the display. Press → to move to the desired station. Press + and − to set the watering duration.
3. Turn the dial to the **RUN** position to run the station. (Station designated will water, then controller will return to automatic mode).

ONE TOUCH MANUAL START AND STATION ADVANCE

With the dial in the **RUN** position, press and hold → until **STATION 1** appears in the display. Release the arrow button to run all stations for their programmed run time (one touch).

To adjust run times prior to running all stations, press and hold the → until **STATION 1** appears and then press + and − to select the run time and → to advance and adjust all programmed stations.

WATERING SCHEDULE

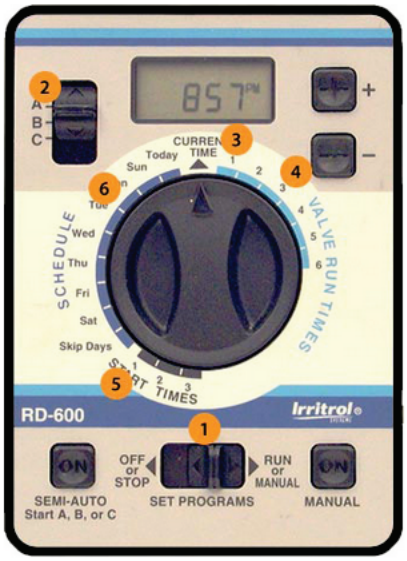
PROGRAMS		A							B							C						
WATER DAYS		M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Interval or Odd/Even Days																						
Event Day(s) Off																						
START TIME(S)	1																					
Set the time(s) to start the program's watering cycle(s).	2																					
⚠ *Only one program start time is needed to run the cycle.*	3																					
	4																					

STATION	Location	Station Run Time	Station Run Time	Station Run Time
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
TOTAL RUN TIME: To determine the duration of each watering cycle, add up all the run times for each station.		For Program A	For Program B	For Program C

Website hunterindustries.com
P/N: 700765 LIT-335 G 1/14

PRO-C | Hunter

Programming Your Controller



1. For easy programming, first slide the "Set Program" (1) toggle to the middle, and then start in the upper left corner of your controller and move clockwise through the settings. Start with program A (2).
2. Set the dial to current time and use the +/– buttons to locate the current time of day. Turn the dial one click to the left and use the +/- buttons to locate the day of the week. You only have to do this once (3).
3. Turn the dial to the "valve run times" to select a station and use the +/– buttons to enter the amount of watering time for that valve, which sends water to a particular zone in your yard or garden (4).
4. Turn the dial to start times and use the +/– buttons to select time you'd like your irrigation to begin. You can have three different start times per day, but typically you only need one (5).
5. Now turn the dial to "schedule" the days you want your irrigation to run or the numbers of days to skip in between watering. Use the +/- buttons to enter this information (6).
6. Now repeat steps 3, 4 & 5 for each station/valve you are controlling, and program A is complete. Use programs B & C for other zones that require difference frequencies of watering, such as turf, Xeriscape, vegetable gardens, etc.

Programming Tips

- Group stations or valves that require similar watering frequencies on the same program (such as A, B, or C)
- Enter only one start time for each program even when there are multiple stations or valves
- Enter different start times on different programs (A, B, C) to avoid overlap of water times.
- Use multiple start times if excessive runoff is a problem

Irrigation Timer Program Example – Summer Watering Schedule

Valve/Station	A Program	B Program	C Program	Valve/Station Description	Start Times	Watering Days
1	30 Minutes	-	-	Turf Sprinklers	4 a.m.	Mon. & Thur.
2	30 Minutes	-	-	Turf Sprinklers	-	-
3	-	3 Hours	-	Desert Shrubs, Drip	7 a.m.	Every 14 Days
4	-	25 Minutes	-	Citrus Trees, Bubblers	-	-
5	-	-	6 Hours	Desert Trees, Drip	11 a.m.	Every 21 Days

Setting Your Hunter Irrigation Controller

Setting your irrigation controller may seem daunting or confusing, but really, you just need 3 main things:

1. A time of day to turn on.
2. A day(s) of the week to turn on; and
3. How long (in minutes) each zone/station will run.

Let's learn how to set these 3 things!

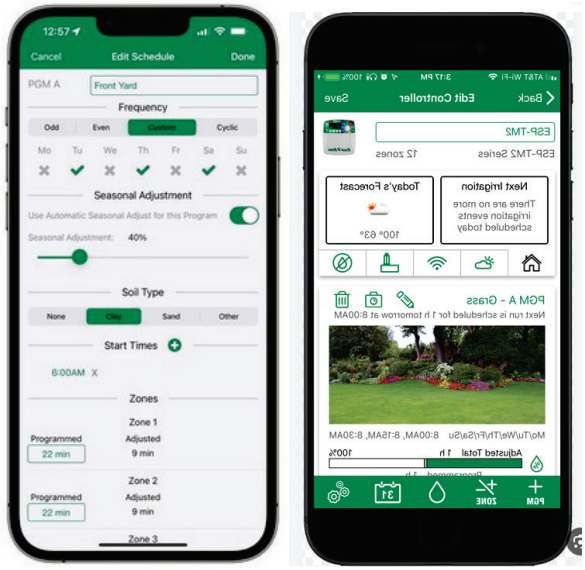
Hunter Pro-C, ICC, X-Core controllers

1. Set the time(s) of day for the program to turn on:
    - Turn dial to SET PROGRAM START TIMES
    - Display will show OFF. Push **+** or **–** button to turn the time on. Pushing **+** turns on a midnight (12:00 am); pushing **–** moves to 11:45pm. Use the **+** or **–** to adjust the time to when you want.
        - The time moves in 15-minute increments.
        - Pay attention to whether you are setting for AM or PM.
    - Add a 2nd start time by pushing right arrow **(→).**
        - Display will show OFF, add a time by pushing **+** or **–**
    - Pushing right arrow **(→)** again will bring up the 3rd and 4th start times. Generally, these aren't needed. Keep it off unless your yard has a steep slope.

2. Set the day(s) of week for program to turn on:
    - Turn dial to SET DAYS TO WATER
    - Screen will show all the days of week abbreviated at the bottom of the screen, starting with MON (Monday), which will have a blinking water drop on top of the words. This is showing you where the cursor is.
    - Pushing **+** will turn a day on to water (there will be a water drop)
    - Pushing **–** will turn a day off (the water drop will have a circle with a line thru it or be blank depending on your controller age).
    - Use → ← to move the cursor back and forth between the days.

3. Set how long each zone/station will run:
    - Turn dial to SET STATION RUN TIMES
    - Display will show "Station 1" and 0:00. This is station 1 and how many hours or minutes it will run.
        - Push **+** button to add time. The numbers shown are minutes being added. Continue to push **+** until you get to the length of time you want the station to run.
    - Move to Station 2 by pushing the right arrow (→).
        - Push **+** button to add time. The numbers shown are minutes being added.
    - Continue repeating these steps until all stations have minutes added on.

- When finished with these 3 steps, turn dial back to RUN. This will allow the controller to start running the schedule you've set automatically.
    - You can also turn the dial to SYSTEM OFF to keep the irrigation turned off until you want it to run. Having it on OFF does not erase what you've just programmed.



Section 12: Rebate Programs

Zone 7 Rebate

- Lawn Conversion to Low Water Use Plants
- Smart Irrigation
- High Efficienct Clothes Dryer

Cal Water Rebate

- Lawn to Garden
- Smart Irrigation Controller
- High Efficiency Sprinkler Nozzle
- Large Rotary Nozzle Rebate
- Spray Body with PR and Check Valve
- Spray to Drip
- Hi Efficiency Clothes Dryer
- Hi Efficienct Toilet
- Landscape Tune Up

Pleasanton

- Eco Friendly Lawn Conversion

Section 13: Rebate Programs

Backflow	wifi vs Bluetooth	oops plug for hose
Emitter insertion	emitter values	different ½" hose sizes
Vegetable vs. tree dripline	wetness probe	pressure compensated
PSI vs. GPH	pressure reducer	city water pressure
Dripline emitter spacing	water uniformity	water efficiency
Water budget	plant factor	ETo and ET
¼" = 30 / 30	½" = 200 / 200	solenoid
Manifold	flush valve	timer / backflow / filter / regulator
Friction	soil triangle	jar test vs. ribbon test
Wilting point vs field capacity	clay is tiny tiny tiny	maximum water speed
Schedule 40	Hydrozone	Purple pipe
¼ inch tubing, hose size, couplers	Pressure reducer	Backflow protector
Soil texture triangle	Wilting Point	Field Capacity
Saturation	Test: Soil Ribbon and Jar	Hydrozone