A Client's Guide to Home Irrigation

perspective / fundamentals / laws / system construction

A Defensive Primer

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Introduction:

I came up through the commercial side of the landscape Industry starting in 1977. The first job to ever come across my desk was the Golden Gate National Cemetery[1] which, at $ 750,000.00, was a huge project for the time. I learned, on that one job, more about irrigation than many ever knew existed. The sizes and quantities of the materials used at GGNC were staggering. Bringing together the administrative and technical talent to run that project, and the skilled labor force vital to the planning and to the execution of a task of such enormity was truly both a challenging and inspiring responsibility. I fell in love with the elegant simplicity of irrigation on that project, a passion which persists to this day.

When I left commercial landscape for the residential side of the business it became immediately apparent that there were some very major differences, rough edges if you will, between commercial and residential landscape not the least of which was the standards by which projects were bid. On the commercial side of the industry the architect's intent was clearly defined in the project specifications. The buyer was assured of a specifically configured product premised on the use of products and practices which met the criteria defined by the specifications. Irrigation in the residential landscaping sector is a free for all characterized by a near complete lack of structure. Everyone just bids whatever it is that they feel will get the job done thereby eliminating any chance of getting comparable bids on the same work. Without a basis for comparison the owner looses any capacity to maintain quality control of the work, and will invariably default to price as a metric of value.

Because many homeowners have little, if any, understanding of how irrigation works ;they become targets for unscrupulous tradesmen. I find offensive the widespread indifference to true craftsmenship which characterizes much of our profession. Sadder still is the wide ranging lack of education which contributes to much of the mediocrity that is regretfully typical of the residential sector of the landscape industry. I greatly appreciate the efforts of organizations such as the California Landscape Contractors Association (C.L.C.A.)[2] to reverse this trend, but even the C.L.C.A. has it's limitations. Such behaviors, whether knowing or unwitting, on the part of so many has created an environment where the trust which should exist between an owner and his contractor has become a rare commodity. This primer is our attempt to provide to those for whom we would work the ability to guard themselves from predatory practices such as professional malfeasance, intentional deceit, and product misrepresentation.

The product which the landscape industry creates is an accomodation between the intricate interplay of human needs and the natural world. Such work may only be sucessfully acheived through the implementation of recognized standards of workmanship. Such standards need be recognized by both our industry and those whom we would serve as the rights to which every client is entitled. In this primer we are attempting to curb the chaos which wracks the residential side of the landscape industry by providing our clientele with a basic understanding of the components which make landscape irrigation work.

When homeowners understand that they have the right to insist on the adoption of certain minimum standards for the construction of their project's irrigation system; they will stand a much better chance of not having their project buried beneath the flow of a tide of overpriced junk which, within two years time, will have to be replaced . A well constructed irrigation system, one which recognizes the growing political significance of water, is vital to the continued health of every garden, and to the reponsible use of water resources in our communities.

Understanding the Work:

My focus in this primer is irrigation. Irrigation, while only a part of a project, is the silent butler of any landscaping project. It serves the greater project continuously while being both unseen and unheard. Irrigation, defined, is a means of conveying water from a service point of connection to any plant or plant grouping in a manner which shall provide the greatest benefit to said plantings. Prior to the solicitation of bids for any landscape project there are several questions which one should be able to answer about the

proposed project's irrigation system:
1. what is the available water pressure on your project
2. what is the nature and size of the irrigation service connection
3. is there an available 120 volt power source from which an irrigation controller may be run
4. does the property's soil grade fall or rise sharply
5. how permeable is the project's soil

The answers to these questions shall provide an owner with information about the type of systems which may be employed, the need for pressure reducing devices, whether subcontractors may be required to perform any part of the proposed work, and whether specialty sprinklers may be required as a part of the work.

Q1. Domestic water service line pressure may be taken from gauge readings in the immediate vicinity of the proposed point of connection or an owner may contact the community water utility to obtain a representative pressure reading typical for the area of the project in question. Should the pressures exceed 65 PSI; a homeowner would be well advised to consider the installation of a pressure reducing valve, Watts U5B[3] or equal, on the service main. If the irrigation point of connection proceeds the pressure reducing valve at the residence; the installation of a second pressure reducing valve, on the downstream side of the backflow prevention device, is strogly suggested. High pressures can have an extremely deleterious effect on unprotected remote control valves and sprinkler heads. Efficient sprinkler operation shall occur within a pressure range of15 - 55 PSI when measured at the sprinkler head. If, however, the domestic service line pressure readings are on the low end of the spectrum it shall be more difficult to effectively operate pop up type sprinklers. The homeowner shall still have several viable options available to him: a.) planting design should orient away from lawns and flat grown groundcovers, and more towards groupings of individual plantings, b.) an increased number of remote control valves (RCVs) each with a decreased number of sprinkler heads per RCV, this approach is of particular use when owners truly wish to have lawn or flat grown groundcovers on a lower pressure site, and c.) the use of water efficient, drip type irrigation.

Q2. Irrigation water, unless the garden is on a well or a pump supported system, originates from the domestic water service line which supplies water to the residence. In newer homes the domestic service has often been run in copper, and, in many cases, a copper tee with a capped stubout has been left in anticipation of the installation of an irrigation system. In homes built prior to 1990, however, the nature of the water service line is a matter of speculation. Knowing the size and composition of the service feed line will allow homeowners to not only anticipate the size of the irrigation main line [e.g. a ¾" domestic line is capable of supporting a 1" irrigation main line], but shall provide insight into the difficulty required to connect to the service main. Consider, a 30 year old ¾" galvanized steel main shall be much more difficult to tie into than a similarily sized copper main. Galvanized is rigid, and is highly susceptible to corrosion from prolonged exposure to moisture. Galvanized steel can be threaded with the proper dies; however, given the likelihood of the pipe having deteriorated from rust on the inner and outer surfaces, the homeowner may be well advised to replace the steel service line with a copper line. The timing would be auspicious. The landscape contractor could excavate and backfill the line, and a plumbing contractor may be retained to provide and install a new, copper service main.

Q3. Irrigation controllers should be located where accessibility is not restricted. While a garage may seem the most likely location; it would be a good idea to give some thought to mounting the controller on the exterior face of the residence. Unless the owners have a working familiarity with the selected controller ; it seems only reasonable to place the controller in a location where maintenance personnel are able to access it for purposes of testing and seasonal adjustment. This having been said, mention should be made of the new generation of Smart Line controllers, as manufactured by Weathermatic[4], Rainbird[5], Cyber - Rain[6], and others. Said timers have the capacity to be remotely adjusted, through a wireless connection to the owner's PC. A distinguishing feature of these controllers is their capacity to minutely and continuously re-program themselves as they receive weather related data from the internet or an onsite weather station. For the location of a Smart Line controller, with it's minimal requirement for

human interface, a garage installation makes perfect sense.

Controllers run on120 volt AC power. When mounted on the exterior of the residence, they should be located within +/- 10'0" of an existing weathertite power outlet. If an appropriate power outlet is simply not available on the exterior of the residence the homeowner has several choices: a.) to mount the controller in the garage, and to run the low voltage wiring overhead in NEMA TC-2[7] rated conduit to the exterior face of the garage, b.) have a licensed electrician pull power in a metal conduit from a newly designated 20AMP circut breaker at the electrical panel to the proposed location of the controller; power shall terminate at a ground fault circut interupter (GFCI) duplex outlet surface mounted in a weathertite box or, lastly, c.) pedestal mount a DIG Corporation's L.E.I.T.[8] series solar powered controller in an area of the site which has strong ambient light. Please note that option 'c' shall require that the remote control valves' solenoids shall be changed to DC Latching solenoids to accomodate the direct current generated by the solar controller.

Q4. If there are significant variations in the project grade it is probable that the type of irrigation given serious scrutiny shall be, rather than as a conventional spray type system, one which incorporates features such as a Seal-A-Matic (SAM)[9] closure designed to prevent low head drainage or the internal pressure regulator (PRS)[10] head which has the capacity to maintain a constant outlet pressure of 30PSI at each head, to put an end to the fogging caused by high pressures, and to restrict water loss by as much as 70% in the event that a head sustains damage. Rainbird's 1800 series SAM-PRS[11] sprinklers incorporates both of the attributes of the aforementioned heads. Alternately, if the soil gradient is greater than a 2:1 slope, that is to say 2'0" of horizontal run for every 1'0" of vertical rise, it shall become requisite to use a form of drip irrigation in the aforementioned areas.

Q5. Soil permeability is a reference to the ability of water to pass through soils. The capacity of water to drain through soil will necessarily be a part of the equation used to determine the type of irrigation which is most appropriate to a given site. As a for instance; soils with a high sand content shall be prone to drain rather quickly; therefore, the application of large volumes of water through a rotary type sprinkler system would wasteful. More appropriate to such conditions would be a low volume drip emitter system providing low water volumes of water to specific plantings over a protracted run time. While water would still pass through the soils it would do so at a rate consistent with providing maximum benefit to the plantings.

The process of addressing these five issues is intended to expand the homerowner's understanding of the type of system their project shall require, whom it may be necessary to involve in the safe completion of their work, and the variables which need be considered when planning a project. In the sections which follows I shall address the requisite legal requirements as well as the various sequential steps involved in the construction of an irrigation system. I have been doing this work for thirty five years, and I have developed in that time personal preferences. I do not mean to infer that my choices are the only valid alternatives; rather, they are the materials and methods which I have found to yield the best product for my clients.

Licenses and Insurance:

The State of California, through the Department of Consumer Affairs, administers the Contractors State License Board (CSLB) which oversees all persons acting as contractors on public,commercial, or residential projects within the State of California. All persons acting as contractors in California are required by law to possess all of the following:

1. a State issued contractor's license
2. a license bond in the amount of $ 12,500.00
3. general liability insurance
4. workers compensation insurance if employing one or more person(s)

A contractor's license is an assurance that the individual or company being considered for a given project

is qualified to perform the work described by the project plans and specifications. Homeowners are fully entitled to ask any contractor to show proof of licensing. This should not be an issue as the State provides pocket licenses to contractors that have passed the State examination for their trade(s). License number(s) must be displayed on all business cards, business correspondences, advertisements, and promotional materials. With the internet homeowners may now access the CSLB's website to verify a contractor's license, review his history, and, if necessary, to lodge a grievance against a contractor.

The license bond is a minimal gaurantee to homeowners and businesses that, in the event that a contractor should abandon a project prior to completion, the owners shall not be left without recourse. The bond will cover, at least in part, the cost to complete the work in question.

While the extent of general liability insurance coverage is not legally specified; contractors must retain liability insurance if for no other reason than it is a commonsense precaution. There are numerous hazards on a project site, and it would only seem prudent that a contractor retain some form of business insurance, beyond the mandatory license bond, that will protect his on going activities. Here again, the homeowner may request that a certificate of insurance be issued as proof of insurance.

Workers Compensation is perhaps the most important form of insurance that a contractor must carry. On a construction site there are no end of possible ways in which an individual may be hurt, or possibly killed, just by being in the wrong place at the wrong time. The cost of medical care is prohibitively expensive; therefore, the State has mandated that all licensed contractors who employ one or more individuals acting as employees must retain workers compensation insurance**. What many homeowners fail to appreciate is that should they retain an unlicensed contractor to do work on their property, and should an individual in the employ of said contractor be injured in the course of the work, that it shall be the responsibility of the homeowner to pay for the subject individual's medical care and long term treatment.**

Submittals:

When making any purchase; it is understandable that the buyer shall want to know what it is that they are spending their money on. Irrigation is not an inconsequential expenditure; yet, many individuals are seldom well informed about the nature of their commitment. The submittal process is an effort to provide clients with specific information about their purchase. Submittals obligate a contractor to meet an agreed upon criteria, and should cover each of the following:

1. main, lateral, sleeve, conduit, and polyethylene piping
2. primers, glues, joint sealant compounds, and/or tapes
3. backflow prevention device inclusive of the material used for the manifold assembly
4. irrigation controller inclusive, if applicable, of the controller enclosure
5. remote control valves inclusive of the materials used for the valve assembly
6. remote control valve boxes
7. in line shutoff valves (ball valves or gate valves)
8. valve boxes for control valves
9. garden faucets, if applicable, inclusive of the materials used to construct the riser assembly
10. valve wire
11. wire connectors
12. alpha numeric identification tags
13. lateral line sprinklers inclusive of the materials used to build the swing joint assemblies
14. drip emitter heads

It is not uncommon for commercial landscape contractors to have to present to the landscape architect, for review and consideration, as many as eight (8) copies of the irrigation submittals. Clearly this is somewhat excessive as the relationship between a homeowner and a contractor is much less public. It is my opinion that it would be adequate were the contractor to present three (3) copies of the irrigation

submittals to the owners.

Submittals should be presented in the form of a booklet, bound in a clear plastic folder which is in turn secured on left side by a continuous retention clamp. The cover page should list the project name and address as well as the name of the contractor, contractor's license number, and contact information. A second page is to serve as a table of contents listing the materials contained in the submittals, the name and address of the company which has supplied the respective materials, and a website for the manufacturer of the noted materials. The actual submittals shall be printed, pictorial representations of the specific products accompanied by sufficient techincal data to give the owners a sense of the quality of the proposed construction.

It shall be the responsibility of the owner to review these submittals, and to make any changes which he or she may feel are warranted. A caveat about changes. A change may entail additional costs. If, for instance, an owner wanted to use PVC SCH. 80 line fittings on the main line in place of PVC SCH. 40 fittings. This is not an unheard of practice; however, SCH. 80 fittings are double to triple the cost of SCH. 40 depending both upon the size and length of the main line. The contractor, in this case, would be entitled to adjust his bid price to defray the additional expense. Once any requested changes have been negotiated; the owner shall return one (1) copy of the approved submittals to the contractor with the explicit understanding that only the materials which have received the owner's approval shall be used to construct the work.

Construction:

A. The point of connection (P.O.C.) is the single point at which the irrigation main line ties into the domestic service line. Inasmuch as the form of the P.O.C may vary; I shall use a hypothetical connection to demonstrate how the work is to be accomplished.

1. excavate a 4'0" x 2'0" x 2'0" hole over the domestic service line at a distance of some 48" from the face of the residence.
2. exercise care when digging around the service main as they are often shallow, no more than 12" - 15" in depth, and are often trenched in with other utilities such as the sanitary sewer line.
3. fully expose the service line on all sides
4. after providing the owners with a minimum of 24 hours notice; shutdown the domestic service line at either the water meter or, should one exist, an in line gate valve
5. determine the approximate location for the reduced pressure vacuum breaker (ref. Subsection E)
6. using a hacksaw cut the domestic service line removing a 1" wide section of the pipe
7. allow the line to drain down
8. using emery cloth, sand the exposed ends of the cut domestic service line
9. with a wire brush burnish the insides of the run ends of the copper line fitting
10. cover both the sanded main and burnished fitting surfaces with a thin film of flux paste
11. wrap the upper portion of the in line fitting with a cold, wet cloth
12. using a propane torch heat the street side of the service line to a point where the flux paste begins to "boil"
13. apply 50/50 silver/tin solder to the heated joint until the solder is drawn into the joint
14. remove the wet cloth from the joint and apply it to the freshly made joint
15. repeat steps 12 and 13 on the residence side of the service line
16. cut an 8" length of Type K copper, repeating steps 8, 9, 10, 12, & 13 to solder a copper male adapter to the 8" length of copper pipe
17. repeating steps 8 -14 solder the 8" length of pipe to the outlet side of the in line fitting
18. using #5 Rectorseal[12] as a joint sealant thread a brass ball valve, Nibco[13], Red & White[14], or equal, to the iron pipe threads (IPT) of the copper male adapter, and close the valve
19. slowly open the water meter or gate valve to pressure test the soldered connections

20. after 20 minutes, when it is clear that the solder joints are not leaking, furnish and install a black Carson 910[15] series round valve box at the ball valve
21. open all faucets and showerheads in the residence, and hose bibbs in the garden or at the residence to allow trapped air to escape
22. once the air has been purged from the lines close all outlets, and backfill and compact the P.O.C.
23. repair or replace any damaged sod or landscape planting

B. Trenches for irrigation piping may be dug either manually or mechanically. It is extremely important to be aware of the locations of lines which have been previously installed by other trades so as to avoid accidental damage to these lines or possible injury to your personnel. If a contractor is unclear as to the exact location of another trade's lines test holes should be hand dug to make this determination. Should the project entail working in a public thoroughfare or City easement there are no cost locator services [e.g. Underground Service Alert or U.S.A.][16] which can pinpoint the location of existing utilities.

Some trenching shall occur prior to the actual commencement of irrigation work. These ditches are excavated for the installation of irrigation wire conduits and piping sleeves. Typically, such trenches shall be excavated in areas such as driveways, patios, or walkways where running either wire or piping after the fact would be virtually impossible. It is not essential that these trenches be dug seperately; rather, it is common practice to dig one trench to accomodate both the pipe sleeve(s) and wire conduit. This practice, not surprisingly, is referred to as "common" trenching.

Trenches for future mains, laterals, and wire are to be excavated in such a manner that the lines shall have the following depths of coverage over the lines: mains (18"), wires (18"), and laterals (12"). The location of all sleeves and conduits shall be documented on the irrigation 'as - built' drawings, and shall be dimensioned from two fixed reference points. When running sleeves or conduits it is best to remember that in construction the unexpected can happen. If the contractor finds himself to be working in an area in which the work of others may be changed; he shall be best advised to run his sleeves long, and to provide himself with either additional sleeves or an alternate route other than what is shown on the plans. When the contractor does move on to the project site to complete the balance of the irrigation work the same requirements shall govern the excavation of the main line, lateral line, and wire trenches.

C. Sleeves and wire conduits shall be installed prior to the balance of the irrigation to permit a contractor access through what would otherwise be impassable areas. Sleeves shall be, at minimum, twice the size of the line that is to be run through them; therefore, if the main line is a 1" pipe, the sleeve should be a pipe 2" in diameter. Water lines, either main or lateral piping, shall pass through a length of standard, white PVC SCH. 40 water line as maufactured by Pacific Western[17], or equal; the valve wires are to be run through a length of National Electrical Manufacturers Association (NEMA) TC-2 PVC SCH. 40 gray conduit as manufactured by Carlon[18], CANTEX[19], or equal. Once set the open ends of all sleeves and conduits shall be closed with either 10MM tape or PVC SCH 40 slip cap fittings.There is a trend towards the use of #18 American Wire Gauge (AWG)[20] multi conductor cables on many residential irrigation projects. Because #18 wire is much smaller, and despite the fact that the cable may have a widely varying number of conductors, the requisite size of the conduit may be as small as ¾". Were an owner to elect to use a #14AWG single strand, solid copper wire, a larger conduit would be necessary. A 1" NEMA TC-2 conduit shall accomodate six (6) #14AWG Underwriters Laboratory Underground Feeders (UL - UF)[21] wires; therefore, the size of the conduit would be contingent upon the number of wires run.

D. Main line pipe shall be PVC SCH. 40 with a burst strength of 330PSI, or better, as manufactured by Pacific Western, or equal. Lateral lines buried at a the specified depth shall be PVC Class 200 solvent weld pipe. If, for any reason, it is necessary to install lateral lines at a lesser depth the contractor is strongly urged to use PVC SCH. 40 solvent weld pipe. Main line and lateral line fittings shall be rated as PVC SCH. 40 as manufactured by Lasco[22], or equal. Assembly of the main and lateral lines is to be accomplished by means of five step process. Utilizing IPS Weld On low VOC[23] primer and cement each solvent welded pipe joint shall be made as follows:

1. de-burr cut ends of PVC pipe, clean with a clean cloth both the joint socket and the cut end of the pipe
2. holding both the pipe and fitting level apply IPS Weld On P70 primer to the proposed new joints, allow time (approximately 15 seconds) for the surface layer of pipe or fitting to soften
3.holding both the pipe and fitting level apply IPS Weld On705 series solvent weld cement to the primed surfaces of the pipe and fitting of the proposed new joint. Never apply excessive solvent weld cement.
4. insert pipe into the fitting and give either the pipe or fitting a quarter turn to expell air bubbles which may have entered into the newly made joint
5. firmly hold pipe to fitting for a period of 30 seconds*
* DO NOT backfill fittings until the lines have been tested under pressure, ref. Subsection M

D.1. Accessibility to the P.O.C, the relationship of the area(s) of work to either the P.O.C or to the R.C.V, or excedingly rocky soil conditions may necessitate the running of a portion of either the main line or lateral line piping above grade. Should piping above grade prove to be unavoidable such on grade or through structure lines shall be Type K copper. Lines shall be secured at 4'0" on center (o.c.) with either copper 'C' clamps or plumbers tape anchored to the sheetrock #8 drywall screws and expandable plastic wall anchors.

E. The intent of the backflow prevention device is to permanently seperate irrigation water from the domestic potable water service . Contamination may derive from glues and solvents used to assemble the irrigation system, or from common chemical agents used in the garden that have found their way into the irrigation system.

The backflow prevention device shall operate on a reduced pressure (RP) principle.The device shall consist of two independent check valves, plumbed in a series, with a pressure monitored chamber in between. The chamber is maintained at a pressure that is lower than the water supply pressure, but high enough to be useful downstream. The reduced pressure principle is guaranteed by a differential pressure relief valve which automatically relieves excess pressure in the chamber by dicharging to a drain. The RP unit shall be a Febco 825Y[24] or as manufactured by Wilkins[25], Watts[26], or equal.

Reduced pressure principle backflow prevention devices shall be installed at a minimum height of 12" above the highest head on the job. The assembly may be installed on a galvanized steel manifold; however, the long term interface of dissimilar metals (steel and brass) shall create an condition under which electrolysis shall weaken the structure, making this option a less viable choice . A preferred option would be the use of Type K copper pipe and fittings. Pipe and fittings should be of the same size as the backflow prevention device. Assembly of the manifold should follow the enumerated steps:

1. cut Type K copper pipe
    a. 2 each 30" lengths (minimum)
    b. 4 each 8" lengths
2. sand with a fine grit emery cloth all pipe ends, 12
3. burnish the inner surfaces of the copper fittings, 12 (**do not burnish any threaded fitting surfaces**)
    a. 2 each Copper (C) x Female Iron Pipe Thread (FIPT) adapters
    b. 2 each C x Male Iron Pipe Thread (MIPT) adapters
    c. 4 each C x C 90 degree bends
4. apply a thin film of copper flux to both the sanded pipe ends and the burnished fitting surfaces, 24
5. with a propane torch heat and solder, using a 50/50 silver and tin solder , the following joints
    a. 2 each 8" pipe to C x FIPT female adapters
    b. 2 each 8" pipe to C x MIPT male adapters
    c. 2 each solder 5a to C x C 90
    d. 2 each solder 5b to C x C 90
    e. 2 each solder assembly 5c to base of 30" pipe
    f. 2 each solder assembly 5d to top of 30" pipe

6. lightly apply Rectorseal #5 joint sealant to the exterior threads of the C x MIPT adapters, and gently thread the assembled copper manifolds into the inlet and outlet sides of the backflow unit
7. hand tighten each of the two assemblies to achieve a snug fit; wrapping a cloth around the C x MIPT adapters, in sequence, tighten each of the assembled copper manifolds with an 18" pipe wrench
8. provide and install, at the inlet and outlet sides of the manifold assemblies, a PVC SCH. 40 MIPT x SOC male adapters wrapping the threaded portion of each male adapter (total of 2) with a double wrap of ½" teflon tape
9. stake, from the inside of the copper manifold, with 1" x 1" x 1/8" x 36" angle iron to brace each of the two vertical risers of the manifold, secure the angle iron to the risers using stainless steel screw clamps (two clamps per vertical risers)
10. it is suggested that in areas where freezing weather is common that lockable, thermal cover be provided for the backflow prevention device; at the very least it is suggested that all vertical and horizontal copper piping be covered with an insulating pipe foam.

F. Remote control valves (RCVs) are, quite simply, electronically actuated ON/OFF switches. However, instead of illuminating a room, they provide a regulated flow of water to the various planting areas of a garden. RCVs range widely in size, manufacture, and quality. Weathermatic's 12024E[27] and 21024E[28] are built to last, simple to work with, extremely easy to maintain, and well priced. These valves, in my opinion, provide the best return for the money spent.

Valves are installed below grade in a valve box. Valve box footprints are 15"W x 20"L x 15"D with the boxes being set flush to the project finished grade on a 3" bed of pea gravel. Carson's series 1419-12B[29] is a 12" deep rectangular valve box. Unless specified otherwise the standard valve box is green in color; I prefer to use a black valve box because irrigation was never intended to be obtrusive, but, rather, to blend into the background. Valve boxes are installed with the pea gravel bedding after the valve manifold has been built and the RCV itself installed. RCVs are installed one valve to each valve box, and, while this may seem to be a waste of space, one should have the experience of trying to repair an individual RCV set in a box with three other valves. The difficulty factor, thus the cost, to repair a valve is increased exponentially for every valve in the box other than the one which requires repair.

In any discussion of valve boxes it is necessary to address problems which may occur. Yes, I know, how likely is it that one could experience a problem with a box ? A true enough statement on it's face, but, should an owner's family not be the only ones to make habitual use of a garden, the likelihood of there being problems related to the valve boxes has just shifted. Gophers can be a problem on any of a number of levels; however, for the purposes of this discussion, one will find that gophers are most incredibly obliging about storing excess soils, the result of their subterranean activities in the cavities of remote control valve boxes. One will have only to have opened a valve box, and to have found it completely full of soil to know that I am correct on this matter. Gophers can fill a valve box with a surprising dispatch, and, after you have spent a good hour digging out the box, they will happily fill it again.

The remedy to this situation is fairly simple. If the gopher are unable to access the valve box there is no problem. If gophers are known to frequent the project site, or if their presence is noted during an initial project walk through; the contractor is strongly urged to include in his proposal a cost to enclose the bottom of all valve box, as well as the two openings in either end of the box, with ¼" opening hot dipped galvanized hardware cloth. The hardware cloth shall be screwed into the body of the valve box with ¾" screws set in place with a light gauge ring washers to assure that the screw heads shall be capable of securing the wire fabric in place.

The layout of each RCV follows the irrigation main line with the valves themselves being set in the approximate center of the areas which are to be watered. The construction of the valve manifold begins at the irrigation main line with the setting of an in line tee or ninety degree fitting with a threaded outlet the same size as the RCV. All main line fittings shall be PVC SCH. 40, primed and glued in place as was described in subsection 'D.' The manifold itself shall be assembled in the following order:

1. on the outlet side of the in line threaded fitting furnish and install a 6" PVC SCH. 80 nipple
2. at the top of the PVC SCH. 80 nipple install a thread x thread (TT) PVC SCH. 40 ninety degree bend
3. connect a 3" PVC SCH. 80 nipple to the outlet side of the PVC SCH. 40 ninety degree bend
4. thread on to the 3" PVC SCH. 80 nipple a line size PVC SCH. 80 TT ball valve, Lasco or equal
5. thread to the outlet side of the ball valve a second 3" PVC SCH. 80 nipple
6. thread the RCV onto the last 3" nipple
7. on the outlet side of the RCV install a PVC SCH. 40 MIPT x SOC male adapter

All threaded ends on the SCH. 80 nipples are to be sealed, prior to making each connection, with Teflon paste. As each joint is made the contractor is only to firmly hand tighten the connections. No jawed wrenches are to be used on any PVC nipple or fitting. Field identification of an individual RCV shall be accomplished by means of alpha numeric tags [e.g. A-3][30] hung from the valve's solenoid lead wires.

G. While the installation of RCVs is as described in subsection F; drip irrigation valves shall vary with the addition of an emitter manifold to the basic valve assembly. An emitter manifold is a means by which particulant matter may be screened from water, and by which the line pressure may be brought to manageable range which then may be efficiently dealt with by the small orifices which are typical of drip irrigation systems. Rainbird's ¾" PRF-075-RBY[31] neatly combines both the filtration and pressure reducing functions into a single unit. The inlet and outlet sides of the unit are fitted with MIPT threads thereby making the connection to both the RCV, and to the emitter lateral line a matter of fittings. If the RCV is greater in diameter than the filter/reducer unit use a thread x thread (TT) reducer bushing to connect the unit to the valve. On the opposite end use a female adapter (FIPT x SOC) with a ¾"x½" slip reducer bushing and a CA700 ½" compression adapter to connect the unit to the polyethylene emitter lateral.

H. While not a mandatory element of an irrigation system; a homeowner would be wise to consider asking his contractor to install garden faucets, Champion B401[32] or equal, at each side of the residence serviced by the new main line. If there are areas which are not served by the new main line, areas where the homeonwer would like to have a ready source of water, the main line may be extended in order to provide water service to a new garden faucet.

The garden faucet shall be installed as a part of the main line in the following manner:

[all threaded PVC to PVC joints are to be made with teflon paste, and all metal to PVC joints with #5 Rectorseal]

1. fit the proposed main line with a PVC SCH. 40 tee with a ¾" threaded outlet
2. extend from the outlet side of the main line tee a ¾" x 3" PVC SCH. 80 nipple
3. fit the end of the SCH. 80 nipple with a ¾" PVC SCH. 40 thread by thread (TT) 90 degree fitting
4.extend from the threaded outlet of the 90 degree fitting a ¾" x 8" PVC SCH. 80 nipple
5. fit at the end of the ¾" x 8" PVC SCH. 80 nipple a ¾" TT PVC SCH. 40 90 degree bend
6. extend from the outlet side of the ¾" TT PVC SCH. 40 90 degree bend a ¾" x 3" PVC SCH. 80 nipple
7. fit at the end of the ¾" x 3" PVC SCH. 80 nipple ¾" TT PVC SCH. 40 90 degree bend
8. cut a length of ¾" Type K copper pipe 36" in length; sand with an emery cloth both ends of the copper
9. burnish interior, smooth surfaces of two ¾" MIPT x C male adapters
10 apply a thin film of copper flux to the ends of the pipe, and to both MIPT x C adapters
11. heat in sequence either end of the copper pipe until the flux begins to "boil"
12. solder, using 50/50 silver/tin solder, allowing the heat to draw the solder into the pipe fitting
13. fit copper riser assembly into the PVC triple swing assembly
14. stake the copper riser with a 1" x 1" x 1/8" x 36" angle iron; secure with two screw clamps
15. install Champion B401 bent nose, or equal, garden faucet

I. Irrigation controllers have become increasingly sophisticated with the passage of time. You may recall that at the outset of this primer there was a brief discussion of the first job that I ever worked on, the

Golden Gate National Cemetery. Out of purely personal interest I made a comparision between the Rainbird control system utilized at GGNC in 1977, and the Rainbird system which might be used today. It's like trying to compare the first computer built by Apple Inc.with it's iPad2. Night and day. There is no comparison....except that they were both designed to do the same thing, to move water efficiently.

For purposes of this discussion I have elected to use the Hunter series PC-300[33] outdoor mount controller as embodying the qualities of craftsmenship, innovation, and function. Flexibile, easy to use, with the ability to integrate today's more modern remote water monitoring devices which, if elected by a project's owner, would permit the controller to self adjust it's programming as climactic conditions changed. While it is not the Rainbird Maxicom2[34]; the Hunter system is far better than the mediocre controllers sold by most retail outlets, and is certainly more representative of the many sophisticated advancements which have been made in irrigation technology.

To begin, the Hunter controller runs off 120 volt alternating current (VAC). The contractor shall need to hardwire the controller to the closest GFCI duplex outlet. Hardwiring shall consist of the following:

1. shutoff the breaker switch at the electrical panel which controls the chosen power outlet
2. remove the existing face plate of the existing 120 VAC outlet
3. loosen the duplex outlet and expose the power connections
4. mount a box extension on the face of the existing box
5. wire #12THHN stranded wire to the common (white), power (red), and ground (green) poles, do not cut the wire
6. remove ½" knockout on the box extension
7. insert liquidtite flexible conduit end fitting through removed knockout, lock in place with lock ring
8. secure liquidtite conduit to the wall face using ¾" 'C' clamps anchored to exterior wall with #10 scews set in expandable wall anchors
9. insert barb x thread fitting into the end of the flex conduit
10. thread a locking ring onto the end of the threaded outlet
11. pull #12THHN stranded wires through the flex conduit, strip cable sheath back by ½", and temporarily cap with yellow #12 lock nuts

The Hunter PC-300 is a three station controller with capacity to increase to fifteen total stations by means of three or nine station expansion modules. Modules simply lock in place within the clock. The controller has three program settings each with four independent start times, and a maximum per station run time of 6 hours. The controller may be interfaced with the WSS[35] a wireless, local solar sensor which transmits real time weather information back to the controller to adjust the individual valve run times, and run frequencies. The controller case has three mounting screws which are to be set into residence facia. Use the mounting template provided with the unit to set screws.

12. drill the base of the controller case to a ¾" diameter and insert the liquidtite flex conduit
13. fit conduit into the controller case and lock it down with a second lock ring
14. pair power wires from the transformer with the corresponding incoming power wires
15. splice wires with #12 wire nuts, and, using electrical tape, seal all exposed wire and secure wire nuts to wiring
16. reset duplex outlet at the existing wall outlet
17. reinstall the face plate at the existing duplex outlet
18. reset the circut breaker
19. check the installation for sparking or other signs of faulty workmanship
20. program the irrigation controller

J. The running of 24 volt irrigation wires from the controller to the RCVs located through-out the project is not a complex process; nonetheless, there are several basic tenants which must be observed. Control wires which are run above grade, whether hung overhead or run vertically, shall be installed in a PVC conduit which conforms to NEMA TC-2 specifcations as manufactured by Carlon, CANTEX, or equal.

Conduit shall be sized as stipulated in subsection C. All NEMA rated conduit shall be gray in color. Directional changes in above grade conduit runs may be accomplished with either sweep 90 degree bends or line sized condulets. Condulets are fittings which permit the contractor to make hard turns in the wire runs. Condulets, because they incorporate a removeable face panel as a part of their construction, are also reasonable in line wire splice connection points. As irrigation wire is designed to be direct burial wire conduit runs may generally end with a sweep 90 degree bend which runs wire into the main line trench. Control wire shall be run with the main line piping whenever possible. Smaller gauge, solid copper wire, #18AWG, may be run as a part of a single multiple wire cable. The multiple wire cable is inclusive of both the white (common) wire and a varying number of differnet colored (power) lead wires. The use of the #18AWG cable is appropriate up to a distance of 3,000 lineal feet which is adequate for most residential installations. Calculations for the size of wire to be used as either the common wire or the power leads on projects where the distances involved are in excess of 3,000 lineal feet must be made prior to submitting a proposal for the work in question.

Wire, as noted in subsection B, shall be run at a depth of coverage not less than 18". At this depth wire, one of the more fragile components of the irrigation system, is well protected from damage, or so one would think. At a depth of coverage of 18" control wires are less at risk from a wantonly placed shovel blade; however, drawing upon my experience at the GGNC project to which I made earlier reference, gophers are attracted to low voltage current, and are known to chew through power cables thereby rendering the system useless. The Golden Gate National Cemetery, $ 750,000.00 worth of work, was made wholly inoperable by gophers within four years of having been brought on line.

It does not matter how heavy the wire used may be; gophers can, and will, damage or destroy the system by disrupting the low voltage power distribution network. This problem is magnified when multiple wires are run in a single wire sheath as is the case with #18AWG. One foray by curious gophers could severely damage a system. If the project has a gopher problem; the only effective counter measure of which I am aware is to run all of the system's below grade wiring in conduit. Should such measures become necessary conduit runs shall be run to the RCVs, and, using sweep 90 degree bends, the cable shall be swept into the aleady enclosed valve box, refer to the discussion of valve boxes in subsection F, connected to the common lead of the RCV solenoid in the following manner:

1. the incoming common line (white) shall be paired with the common lead of the RCV solenoid (black), and the outgoing common line (white).
2. using DryConn[36], or equal, waterproof connectors splice incoming and outgoing common wires to the RCV solenoid common wire
3. selecting one of the various #18AWG colored, power leads repeat step #2 joining the power lead to the RCV solenoid (black)

As the wire's name, "common", would imply the white wire is common to all of the valves on the system, and is to run continuously from the irrigation controller to the last valve on the system. The individual power wires are to run from the controller, but shall terminate at the the respective irrigation control valves.

J. PVC lateral lines shall be furnished and installed as described in subsection D. The location oflateral line sprinklers shall be a function of several considerations:

1. the length and width of the area to be watered
2. the available line pressure
3. the type of vegetation to be watered
4. the project gradient
5. the nozzling required for the specific application

Rainbird's 1800 series spray heads are, in my opinion, the best built spray heads available on today's market. The series 1804 (4" lawn pop up)[37], 1806 (6" shrub pop up)[38], and 1812 (12" shrub pop up)[39]

are durable and well suited to their respective applications.

Example: If watering an irregularily planted, tall shrub bed on a sloping grade which is 6'0" in width and 22'0" in overall length what heads would one use ? Tall shrubs....1812; sloping grade (3:1 to 2:1)...SAM; nozzling....2 15'RCS (right center strip nozzle)[40] set diagonally to each other, 2 15'LCS (left center strip

nozzle)[41] also located diagonally to one another, and 2 4' x 30' SST (sidestrip spray nozzle)[42] set opposite one another at the centerline of the planter bed.

Further, were the three heads situated on the one side of the bed abutting a wall of the residence; whereas, the heads on the outside of the bed were immediately adjacent to a lawn, only the heads on the lawn side of the bed would be pop ups. The heads against the house wall would be Rainbird series PA-8S[43] shrub adapters, with the referenced nozzles, mounted on top of fixed, vertically installed PVC SCH. 80 risers. It is consider poor technique to use fixed risers against headerboards, or any vehicular or pedestrian surface where they will become a trip hazard.

In more expansive residential settings Hunter's PGJ[44] series rotors are, in my opinion, the most versatile head for the job. Key adjustable from 40 to 360 degrees, a ½" female NPT threaded inlet, a range of heights which includes fixed position shrub rotors, 4", 6", and 12"pop ups, and a rack of eight various nozzles which are sold with each individual heads. These heads are designed to meet the most demanding criteria.
Irrigation heads, despite their stated spray radii, need to be placed in such a manner that the spray from one head shall overlap the adjoining heads thereby assuring complete coverage of the effected planting beds. This is absolutely critical in lawn areas where gaps in coverage show themselves all too readily. The location of sprinkler heads, whether pop up sprays or gear driven rotor heads, shall follow this same axiom. If sprays are not overlapping then coverage is lacking.

K. Swing joint assemblies, for the benefits they provide, are too often ignored by the trades. Swing joints form the connection between the lateral line and the sprinkler head; however, a swing joint is much more than a connection between two parts of the same system. The swing assembly is in large part what enables a sprinkler head to endure years of carelessness by maintenance personnel. The assembly provides the more rigid head with the flexibility to withstand repeatedly being runover by mowers, trampled in areas of heavy foot traffic, and the ability to reset a sprinkler to the existing grade without having to dig up the head and much of the surrounding plantings.

The swing joint is a simple, inexpensive assemly which contributes disproportionately to it's installed cost. The size of the assembly is determined by the diameter of the sprinkler head's female inlet. Comprised of three high density polypropylene (HDPE) male thread by female thread street 90s, Lasco or equal, and a single PVC SCH. 80 nipple , Lasco, or equal. The individual components of the assembly are installed seperately so as to permit optimal adjustment of the swing joint depending upon which head is being used. Assembly shall be as follows:

1. thread the first marlex street 90 into the lateral line fitting
2. thread the Schedule 80 nipple into the connecting street 90
3. thread the second marlex street 90 onto the exposed threaded end of the PVC SCH. 80 nipple
4. thread the third marlex street 90 onto the second marlex street 90
5. hand tighten all threaded components of the assembly
6. PVC and HDPE are self sealing and do not require the use of teflon tape or teflon paste
7. cap the swing assemblies, and pressure test the lateral line, ref. Subsection M
8. mount the sprinkler head using the swing assembly to adjust it's height in relation to the grade

L. Emitter laterals, unlike other sprinkler lines, are not run in an extruded PVC pipe; rather, emitter laterals are run in a plyable, polyethylene hose as manufactured by DIG Corporation[45] or equal. Most emitter lines are run as a generic ½" line which leads to some confusion. Irrigation supply houses will commonly sell

material with an outside diameter (O.D.) of .700, and an inside diameter (I.D.) of .600; whereas, many retail outlets will sell material which is widely at variance with the standardized commercial specs. The import of this discrepancy is twofold:

1. the larger, heavier walled commercial material will allow the distribution of greater volumes of water over a more extensive lateral run than the smaller product sold by many retail outlets
2. should the nature of the project be either a repair or an extension of an existing system the lack of uniformity of materials, while technically soluable, shall create delays in the work which may add to the project's cost

Emitter lines may be run either on grade or in a 3" slit trench, and, in either case, shall be staked 5'0" on center with 6" steel jute mesh staples. The choice of whether to run on grade or to trench should consider: a.) aesthetics, b.) functionality, and c.) vulnerability. Will running emitter lines on grade harm the overall aesthetics of a project ? Will the use of trenched irrigation drip lines become an impediment to future expansion of the system ? Are the lines susceptible to damage from either pedestrian traffic or from curious animal life ?

In a setting where neither children nor the range of common animal life forms typical to most gardens are not present; I would suggest that running drip irrigation laterals on grade would be an acceptable means by which to manage this issue. This having been said, such situations are not typical of what may be found on many project site. Trenching would, in my opinion, be a better approach. Lines run on grade are an eyesore even when buried beneath 2" of firbark mulch. From a practical standpoint, if an expansion of the system is anticipated at some future time, the relative difference between on grade and trenched emitter laterals is negligible. Finding an emitter line buried at a depth of 3" is marginally more difficult than making a connection to an on grade system, but it is hardly an insurmountable difficulty.

The greatest single problem posed to an on grade installation of emitter lines is from the various common garden fauna [e.g. squirrels, rodents et. al.]. Water acts like a magnet for most creatures, and an on grade emitter line is an easily accessible water resource. The thin wall of the polyethylene emitter lateral is not a deterent to an animal in need of water. The result can be a series of expensive line and line fitting repairs. With a simple trench all of the above noted problems may be avoided.
There have been any number of advances in drip irrigation technology whch one cannot help but appreciate; however, I believe in the industry adage that irrigation follows planting, when making a choice of materials and methods by which to drip irrigate planting beds. A solid polyethylene hose will allow one to follow the planting design with a greater degree of latitude than an emitter line which has had the emitter heads preset in the line at specified spacings. I have seen how these "improved" systems operate, and the result is often an unnatural rigidity in the planting scheme, and far too much water in the planting beds. Part of this may be due to the technology having not been well understood, poor selection of the specific product used, or simply too much time on the controller. Whatever the reason the same mistakes would be hard to replicate with a plain, unsophisticated length of polyethylene pipe.

Watering on a drip emitter lateral requires a connection to the ½" polyethylene hose. The following steps will provide one with the desired results:

1. using a Rainbird Xeriman Tool, series #XM TOOL[46], puncture the polyethylene tubing
2. install at the puncture site a ¼" Rainbird XBF1CONN[47] connector
3. extend a length of DIG Corporation ¼" PQBV[48] flex tubing from the in line connector to the plant requiring water
4. at the plant Rainbird provides a myriad of emitter choices
    a. ½ GPH to 2 GPH Xeri Bug Emitters[49] (4"pots, 1 gallon - 5 gallon containers)
    b. 5GPH to 24 GPH Pressure Compensating Modules[50] (15 gallon container - 36" Box Container)
    c. .50GPH/Lineal Foot to 1.0GPH/Lineal Foot ¼" Landscape Dripline[51] (planters, window boxes, or larger individual plants)
5. emitter heads shall be mounted above grade on a 6" plastic stake[52]

6. ¼" Landscape Dripline shall be laid on grade

M. Prior to the commencement of the backfilling of the PVC main and lateral lines the contractor would be well advised to pressure test the system to be assued that all fittings and connections are sound. "Centerload" all mains and laterals before pressurizing the respective segments of the system. This process involves backfilling the trench with excavated spoils. Placement of spoils shall be onto all sections of the main and lateral lines between pipe fittings. Do not backfill to a depth of more than 6", and leave all line fittings completely exposed. All RCVs and garden faucets shall be closed down. To ascertain that the line and all of it's associated fittings and valves are devoid of defect water from the City service main is introduced into the main line. At the terminus of the main line a pressure gauge shall have been mounted. Once the line has been "charged" this gauge shall hold at a constant pressure reading, plus or minus 3PSI, for a period of two (2) hours. During this time the contractor shall visually inspect all assemblies, faucets, remote control valves, and line fittings for any sign of leakage. Leaks which are dicovered during testing shall be corrected, and the line shall be re - pressurized.

Pressure testing of the PVC lateral lines shall take place after the line has been assembled and the sprinkler swing assemblies installed, but prior to the setting of the sprinkler heads. The swing assemlies, once installed, shall be capped with a PVC threaded cap. As the laterals are not constant pressure lines it is not essential that the respective lines be subjected to a prolonged period of testing; rather, once the lines have been put under pressure, the contractor shall make a visual inspection of the line to detect any substandard workmanship. Again, leaks which are dicovered during testing shall be corrected, and the line shall be re - pressurized.

Testing of the high density polypropylene (HDPE) emitter laterals is as important as the check of the higher pressure sprinkler laterals. Albeit that poorly made joints are less common on emitter lines than on sprinkler lines, owing largely to the lack of solvent welded fittings, it is still possible to misalign a compression fitting. It is important that the contractor be alert to this possibility; however, of greaterconcern, is the uniform function of each emitter head on the respective systems. It is critical that due recognition be given to the fact that when one is dealing with heads which have openings of 1/16" or less that it will be extremely easy to loose a good deal of plant material in a very short time span because of a minor obstruction.

N. Once the system pressure testing has been successfully completed the centerloaded material should be spread evenly over the main and lateral lines. Backfilling of either the main or laterals shall take place in 6" soil lifts. Each lift of soil, once placed and graded even, shall be tamped in place either mechanically or manually. If the soil is extremely dry; it is suggested that the contractor water settle the trench backfill. Light moisture during the backfilling of the trenches shall greatly assist in the proper settlement of fill soils.

At the irrigation main line it is strongly suggested that the second lift placed shall be coarse fill sand 3" to 6" in depth. Fill sand, because of it's different texture and appearance, is used to alert future contractors to the presence of wires and a constant pressure main line. Complete the trench backfill by placing and compacting the final soil lift. Compaction at this juncture is critical to the correct fill process in order to avoid the likelihood of trench settlement which, over time, would leave deep, visible ruts in the landscape grade.

O. 'As built' drawings are developed from the maintained field set of plans, and from dimensions taken after the installation has been completed. These drawings are intended to show the dimensioned location of the following work:

1. the irrigation point of connection
2. the backflow prevention device
3. pipe sleeves and wire conduits
4. the location of the irrigation main line

5. gate valves installed on the main line
6. the placement of the irrigation controller
7. the remote control valves inclusive of numerical identification and valve size
8. any garden faucets installed as a part of the work
9. wire trench which is not a part of the main line run
10. the identification of the areas served by the respective remote control valves

Included on the 'as built' drawings shall be a legend of the materials used to construct the irrigation system, and the supply sources from which the respective materials were obtained.

This primer is my idea of what landscape irrigation should be. I am not speaking here in absolutes as there is always more than one way in which to accomplish a specific end. My thought was to provide homeowners with a fleshed out model of what is meant by quality materials and workmanship. My hope would be that, were an owner to solicit five (5) bids on a landscape project, they would all come in within a couple of thousand dollars of one another because the wildcard - irrigation - had been thrown out. We'll have to see. To those folks that have actually taken the time to read this article; I thank you for your interst, and would gladly discuss anything contained herein that you may have questions about.

REFERENCES:

1. GGNC or the Golden Gate National Cemetery is a federally administered military cemetery in San Bruno, California
2. CLCA or the California Landscape Contractor's Association is a statewide association of landscape professionals. The CLCA functions as the political voice, the public face, the ongoing educational venue, and social arm of the landscape industry in California
3. Watts U5B pressure regulating valve as manufactured by Watts Water Technologies, Inc. 815 Chestnut Street North Andover, MA 01845-6098 (corporate)
4. Weathermatic SmartLine controllers as manufactured by Weathermatic 3301 W. Kingsley Road, Garland, TX 75041
5. Rainbird® ESP-MC series hybrid controllers as manufacutred by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
6. Cyber-Rain XCI Pro controllers as manufactured by Cyber-Rain, Inc., 6345 Balboa Boulevard, Ste. 230, Encino CA 91316 (corporate)
7. NEMA or the National Electrical Manufacturers Association is a trade organization responsible for the determination and application of standards for electrical product(s) fabrication
8. L.E.I.T. solar powered controllers as manufactured by DIG Corporation 1210 Activity Drive, Vista, CA, 92081 (corporate)
9. SAM or Rainbird® 1800 series Seal-A-Matic™ series sprinkler heads are designed with an in head check valve to prevent low head drainage as manufacutred by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
10. PRS or Rainbird® 1800 series Pressure Regulating Stem sprinklers feature the patented PRS pressure regulator built into the stem, saves water by maintaining optimum water pressure for the ideal spray nozzle performance. Manufacutred by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
11. SAM-PRS or Rainbird® 1800 series SAM-PRS sprinkler combines the features of notations #9 and #10 in a single head. Manufacutred by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
12. RectorSeal® #5® pipe thread sealant is a soft-set, slow drying compound which seals, lubricates, and protects threaded pipe and fittings. It can be pressurized immediately for piping up through 2" and 100PSI (for natural gas, air, and water only) and is ideal for application with a wide variety of fluids and gases, including potable water applications. Manufactured by RectorSeal, 2601 Spenwick Drive, Houston, TX 77055
13. NIBCO® series brass, threaded ball valves as manufactured by NIBCO INC. 1516 Middlebury Street Elkhart, IN 46516-4740

14. Red White series brass, threaded ball valves as manufactured by Red White Valve Corp. 20600 Regency Lane, Lake Forest, CA 92630
15. Carson series 910-12B round, non-hinged, bolt type valve box as manufactured by Carson Industries, Inc., 1925 Street, LaVerne, CA 91750
16. U.S.A. or Underground Service Alert (Northern California) may be reached by dialing 811, 800-227-2600, or www.usanorth.org
17. Pacific Western or Pacific Western Extruded Pipe is a division of JM Eagle located at 3500 Robin Lane, Shingle Springs, CA 95682. Pacific Western manufactures a wide range of Class and Schedule pipes for irrigation applications inclusive of Class 200 and SCH. 40 piping. The website may be reviewed at www.pwpipe.com
18. Carlon® Electrical Products is a division of Thomas and Betts Corporation. Carlon manufactures a wide range of electrical product for home, commercial, and industrial apprlications. Carlon's website address is www.carlon.com
19. CANTEX, Inc. is a subsidiary of Sumitomo Corporation of Japan, and of Sumitomo Corporation of America. CANTEX, Inc. is located at 301 Commerce Stree, Ste. 2700, Fort Worth, TX, 76102 (corporate), with pipe extrusion facilities located in Florida, Ohio, Texas, and Arizona
20. #18 American Wire Gauge (AWG) multi conductor cable equivalent to Barogation™ sprinkler cable as manufactured by Coleman Cable, Inc. 1530 Shields Drive, Waukegan, Illinois 60085
21. #14 American Wire Gauge (AWG) single strand, solid copper wire Underwriters Laboratory (U.L.) rated as a direct burial Underground Feeder (U.F.) equal to Paige Irrigation wire spec. P7001D-Rev. 9 as manufactured by Paige Electric LLP P.O. Box 368 Union, NJ, 07083-0368
22. Lasco or Lasco Fittings, Inc., an Aalberts Industries company, manufactures and distributes PVC SCH. 40 pipe fittings, PVC SCH. 80 nipples and fittings. LASCO Fittings, Inc. 414 Morgan Street, Brownsville, TN 38012
23. P70 and 705 primer and solvent weld cement as manufactured IPS® Corporation 455 W. Victoria Street, Compton, CA 90220 (Weld-On® Cements and Primers)
24. Febco 825Y reduced pressure principle backflow prevention device as manufactured by Watts Water Technologies, Inc. 815 Chestnut Street North Andover, MA 01845-6098 (corporate)
25. Wilkins Model 375 reduced pressure principle backflow device as manufactured by Wilkins a Zurn company 1747 Commerce Way, Paso Robles, CA 93446
26. Watts series 009 reduced pressure principle backflow devide as manufactured by Watts Water Technologies, Inc. 815 Chestnut Street North Andover, MA 01845-6098 (corporate)
27. Weathermatic 12024E remote control valve as manufactured by Weathermatic 3301 W. Kingsley Road, Garland, TX 75041
28. Weathermatic 21024E remote control valve as manufactured by Weathermatic 3301 W. Kingsley Road, Garland, TX 75041
29. Carson 1419-12B rectangular valve box as manufactured by Carson Industries, Inc., 1925 Street, LaVerne, CA 91750
30. Alpha numeric irrigation identification tags as manufactured by T. Christy Enterprises, Inc., 655 E. Ball Road, Anaheim, CA 92805
31. Rainbird® ¾" PRF 075 RBY Pressure Regulating Filter device as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
32. Champion B401 brass bent nose garden faucet as manufactured by Arrowhead Brass & Plumbing, 4900 Alhambra Avenue, Los Angeles, CA 90032
33. Hunter PC-300 Pro C 3 station expandable controller as manufactured by Hunter Industries, Inc., 1940 Diamond Street, San Marcos, CA 92078 (U.S.A. corporate)
34. Rainbird® Maxicom2® is a multi-site irrigation central control system which permits hundreds of sites and weather sources to be controlled and monitored from one location through telephone, cellular, radio (450-470 MHz), spread spectrum radio (900 MHz), direct cable connect, short haul modem, fiber-optic modem, Ethernet device server, Wi-Fi device server, or fiber-optic device server communication. The Maxicom2 is manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
35. Hunter WSS is a Wireless Solar Sync sensor which monitors local weather and adjusts irrigation runtimes, manufactured by Hunter Industries, Inc., 1940 Diamond Street, San Marcos, CA 92078 (U.S.A.

corporate)
36. DryConn Black/White silicone filled connectors as manufacured by King Innovation® Inc., 42 North Central Drive, O'Fallon, MO 63366 www.kinginnovation.com
37. 1804 Rainbird® series 1804 lawn pop up sprinkler as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
38. 1806 Rainbird® series 1806 6" shrub pop up sprinkler as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
39. 1812 Rainbird® sereis 1812 12" shrub pop up sprinkler as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
40. 15'RCS Rainbird® 15' radius throw 1800 series right center strip spray nozzles as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
41. 15'LCS Rainbird® 15' radius throw 1800 series left center strip spray nozzles as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
42. 4' x 30' SST Rainbird® 1800 series side strip spray nozzle as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
43. PA-8S Rainbird® high density polypropylene shrub spray adapter as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
44. Hunter PGJ series rotary sprinklers inclusive of PGJ-00 (shrub rotor), PGJ-04 (4" pop up rotor), PGJ-06 (6" pop up rotor), and PGJ-12 (12" pop up rotor) as manufactured by Hunter Industries, Inc., 1940 Diamond Street, San Marcos, CA 92078 (U.S.A. corporate)
45. DIG Corporation .700 outside diameter (O.D.) x .600 inside diameter (I.D.) solid polyethylene emitter hose as manufactured by DIG Corporation 1210 Activity Drive, Vista, CA, 92081 (corporate)
46. Rainbird® Xeriman Tool, series #XM TOOL, hole punch as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
47. Rainbird® a ¼" Rainbird XBF1CONN connector as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
48. DIG Corporation ¼" PQBV .156 I.D. x .245 O.D. distribution tubing as manufactured by DIG Corporation 1210 Activity Drive, Vista, CA, 92081 (corporate)
49. ½ GPH to 2 GPH Xeri Bug Emitters as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
50. 5GPH to 24 GPH Pressure Compensating Modules as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
51. .50GPH/Lineal Foot to 1.0GPH/Lineal Foot ¼" Landscape Dripline as manufactured by Rain Bird Corporation, 970 West Sierra Madre Avenue, Azusa, CA 91702 (corporate)
52. Agrifim S6 6" tubing stakes as manufactured by Agrifim, a division of NDS cprporation, 337 W. Bedford Avenue, Fresno, CA, 93711

Disclaimer: This article is a compilation of opinions and attitudes learned over a period of thirty five years. The guidance suggested in the body of this article is not an absolute; rather, it is provided to the consumer as an aid in forming a better understanding of irrigation.