SECTION 616 - IRRIGATION SYSTEM

616.01 Description. This section describes constructing permanent irrigation system, including pipes, sprinkler heads, drip emitters, valves, automatic controllers, remote control valves, power and control wiring, and related equipment and materials.

616.02 Materials.

(A) PVC Pipe and Fittings.

(1) Pressure Irrigation Mains.

(a) For mains 2-1/2 inches and larger, PVC pipe shall be Class 200, SDR 21, ASTM D 2241, with integral gasket bell end.

(b) For mains 2 inches and smaller, PVC pipe shall be Schedule 40, ASTM D 1785, with solvent-welded bell end.

(2) Laterals. Laterals shall be Class 200 PVC pipe, SDR 21, ASTM D 2241, with solvent-welded bell end.

(3) Threaded Risers and Nipples. Risers and nipples shall be Schedule 80 PVC.

(4) Other Risers and Fittings. Solvent-welded risers and fittings shall be Schedule 40 PVC, Type I.

(5) Cement. Cement shall conform to ASTM D 2564, or shall be product recommended by manufacturer.

(6) Sleeves. Sleeves shall be Schedule 80 PVC.

(7) Conduits. Conduits shall be Schedule 80 PVC, UL approved.

(B) Copper Pipe. Copper pipe for irrigation system shall conform to Subsection 707.11(A) – Copper Service Pipe.

(C) Drip Tubes and Fittings.

(1) Polyethylene Pipe. Polyethylene pipe shall be PE 2305 or PE 2306 pipe, Class C, SDR 15, ASTM D 2447.

(2) Drip Emitters. Pressure-compensating drip emitters shall include filtration system on inlet side, flexible black rubber diaphragm

to allow buildup of excess pressure within chamber for purging of sediment and other debris not captured by disc filter, and hard plastic diaphragm retainer with chamfered edges and recessed groove in center running full length of diaphragm.

Emitters shall independently regulate discharge rates for constant flow, with output pressure of 7 to 70 pounds per square inch and coefficient of variability of 0.03. Discharge rate shall be 0.61 or 0.92 gallon per hour. Emitters shall be continuously self-cleaning and utilize combination turbulent flow/reduced pressure compensation cell mechanism and diaphragm for uniform discharge.

(3) Barbed Insert Fittings. Barbed fittings for insertion of emitters into drip tubing shall be brown, molded plastic, and ultraviolet resisting.

(4) PVC Insert and Threaded Fittings. Inserts and threaded fittings shall be unplasticized PVC I or PVC II.

(5) Line Flushing Valve. Line flushing valve shall be black, non-serviceable, molded plastic. Valve shall run automatically during initial system pressure build up and shall discharge at rate of one gallon water for each 15 gallons per minute of demand. Working pressure shall be minimum of 4 pounds per square inch and maximum of 25 pounds per square inch.

(6) Pressure Regulating Valve. Pressure regulating valve shall be black, molded plastic, spring-operated, piston-type valve with regulation unit that can be serviced without having to remove valve.

(7) Disc Filter. Filter shall be black, molded plastic, disc-type filter. Filtration mesh shall be color-coded.

(8) Air and Vacuum Relief Valve. Air and vacuum relief valve shall be gray plastic, with internal sliding poppet.

(9) Stainless Steel Clamp. Stainless steel clamp shall be 304 AISI ear-type.

(D) Sprinkler Heads. Sprinkler heads shall conform to following:

(1) Lawn type sprinkler heads, shrubbery heads, and bubbler heads shall have plastic or brass bodies and adjustable spray.

(2) Lawn pop-up sprinkler heads shall have plastic or brass bodies, machined plastic or brass internal parts, and adjustable spray. Head shall include pop-up feature that returns head freely after operating on 30-degree incline.

(3) Jet sprinkler heads shall be plastic, brass, bronze, stainless steel, or combination of the metals. Nozzles shall be plastic or brass, precision-machined, removable, and interchangeable. Arms or levers shall be brass, bronze, or anodized aluminum. Part-circle heads shall have positive locking, adjustable arc stops. Impact or gear driven sprinklers shall work smoothly under specified operating pressure without stalling.

(4) Rotary pop-up sprinklers shall have same construction as jet sprinklers. Casing shall be plastic, brass, bronze, cast-iron, or aluminum, with non-corrosive coating. Cover shall be brass, bronze, or aluminum. Part-circle heads shall have positive locking, adjustable arc stops. Sprinklers shall have internal mechanisms that are removable from top. Sprinklers shall operate smoothly under specified operating pressure without stalling.

(5) If specified, part-circle jet and rotary pop-up sprinklers shall have anti-splash device.

(6) Nozzle sprinkler heads shall be plastic or brass.

(E) Springs for Sprinkler Risers. Springs for sprinkler risers shall be compression-type manufactured from 0.187-inch diameter OTMB spring wire or similar. Coil shall have inside diameter of 0.900 to 0.920 inch, and shall be wound at pitch of 0.475 inch. Spring shall be squared at ends only.

(F) Valves.

(1) Quick Coupling Valve. Quick coupling valve shall have two-piece body, self-closing cap, and service rating of 150 pounds per square inch. Quick coupling valve shall be brass or bronze, except for cap. Key or coupler for valve shall be brass, bronze, stainless steel, or combination of the metals.

(2) Garden Valve. Garden valve shall be straight-nose, brass, or bronze valve with replaceable compression discs. Handles shall be brass, bronze, or steel.

(3) Manual Control Valve. Manual control valve shall be brass or bronze bodied, straight or angle pattern globe valve with replaceable compression discs. Handles shall be brass, bronze, or steel. Manual control valve shall be same size as pipe served and shall withstand working pressure of 150 pounds per square inch.

(4) Gate Valve. Gate valve shall be bronze or iron bodied, bronze trimmed with internally threaded rising or non-rising stem, and of

flanged, threaded, or ring type. Gate valve shall have bronze, brass, or steel handles when valve is 3 inches or smaller. Larger valves shall have two square operating nuts. Gate valve shall withstand cold water working pressure of 150 pounds per square inch.

(5) Valve Assembly Unit.

(a) Control Valve. Control valve shall conform to Subsection 616.02(F)(3) – Manual Control Valve.

(b) Pressure Regulator. Pressure regulator shall conform to Subsection 616.02(G) – Pressure Regulator.

(c) Filter. Filter shall have reinforced polypropylene plastic body; disposable filter cartridge; cylindrical shape, approximately 5 inches in diameter and 12 inches long; and 3/4-inch NPT connections. Filter shall withstand working pressure of 150 pounds per square inch. Filter cartridge shall have 50-micron rating, withstand working pressure of 70 pounds per square inch, and operate at maximum temperature of 210 degrees F.

(d) Pressure Gage. Pressure gage shall have case and window of polycarbonate resin. Pressure gage shall be 1-1/2 inches in diameter, calibrated to read from 0 to 60 pounds per square inch in two-pound increments, and equipped with black aluminum pointer. Each valve assembly unit shall have two pressure gages.

(e) Valve Box. Valve box shall conform to Subsection 616.02(I) – Valve Box and Cover.

(6) Remote Control Valve. Electric control valve in specified size shall have brass or bronze body, straight or angle pattern, and solenoid that operates on 24 to 30 volts of alternating current. Minimum working pressure shall be 150 pounds per square inch. Remote control valve shall have integrated union in discharge side, shall be serviceable from top, and shall have automatic closing time greater than five seconds. Manufacturer of remote control valve shall be same as manufacturer of electric controller or master-satellite controller.

(7) Check Valve. Check valve shall be diaphragm type, globe patterned, hydraulically operated, with body and cover of cast iron, and with internal parts of brass or bronze. Pipe connection shall be screw or flange type. Minimum working pressure shall be 150 pounds per square inch.

(8) Pressure Relief or Sustaining Valve. Pressure relief or sustaining valve shall be hydraulically operated, pilot controlled, diaphragm type, globe or angle patterned, with screw or flange pipe connection. Minimum working pressure shall be 150 pounds per square inch. Valves one inch or smaller shall be spring-loaded. Pressure relief or sustaining valve shall maintain constant upstream pressure by relieving or bypassing excess pressure, and operate at pressure 10 percent higher than relief pressure specified in the contract documents.

(9) Pressure Reducing Valve. Pressure reducing valve shall be hydraulically operated, pilot controlled, diaphragm type, globe or angle patterned, with body and cover of brass, bronze, or cast iron, and internal parts of brass or bronze. Pressure reducing valve shall maintain constant outlet pressure despite fluctuating inlet pressure, and shall operate at discharge pressure specified in the contract documents.

(10) Air Relief Valve. Air relief valve shall be cast iron, brass, or bronze, with bronze body and cover, bronze trim, stainless steel floats, and shockproof synthetic seats. Air relief valve shall be rated for 150 pounds per square inch service pressure and 300 pounds per square inch maximum pressure. Air relief valve shall be painted with two coats of asphalt varnish in accordance with Federal Specification TT-V-51F.

(11) Anti-Drain Check Valve. Anti-drain check valve shall be spring-loaded, adjustable, Schedule 80 PVC virgin material, and shall be rated at 150 pounds minimum per square inch. Anti-drain check valve shall be preset at factory at five pounds per square inch.

(G) Pressure Regulator. Pressure regulator shall be bronze or brass, equipped with union and integrated strainer, and shall be able to withstand working pressure of 150 pounds per square inch. Regulator pressure shall be set between 30 and 40 pounds per square inch.

(H) Backflow Preventer. Backflow preventer shall be same size as pipe, and shall have service rating of 150 pounds per square inch for non-shock cold water up to 140 degrees F.

(I) Valve Box and Cover.

(1) Plastic Valve Box and Cover. Plastic valve box shall be similar in size to concrete valve box, and no larger than Type X plastic valve box in Table 616.02-3. Plastic valve box and cover shall be green and manufactured from polyolefin and fiber, HDPE (High

Density Polyethylene), or ABS (Acrylonitrile-Butadiene-Styrene). Valve box cover shall be marked with "IRRIGATION BOX," "IRRIGATION CONTROL VALVE," or "CONTROL VALVE."

Plastic valve box material shall conform to requirements shown in Table 616.02-1 - Material Requirements for Plastic Valve Box.

TABLE 616.02-1 - MATERIAL REQUIREMENTS FOR PLASTIC VALVE BOX

Physical Property	ASTM Test	Minimum Value		
		Polyolefin and Fiber	HDPE	ABS
Tensile Strength (psi)	D 638	3,400	2,250	6,000
Flexural Modulus (psi)	D 790	191,000	123,800	320,000
Impact Strength (foot-pound/inch)	D 256	0.6	Notch 1.98Un-notch 6.15	6.7
Deflection Temp. (Degrees F at 66 psi)	D 648	2.30	153	222

Plastic valve box and cover, when placed in compacted backfill, shall support uniform loads shown in Table 616.02-2 - Load Requirements for Plastic Valve Box.

TABLE 616.02-2 - LOAD REQUIREMENTS FOR PLASTIC VALVE BOX

Valve Box Type	Vertical Load on Cover (Pounds)
A	1,100
B	2,400
X	4,800

Plastic valve box shall conform to dimensions shown in Table 616.02-3 - Dimensions of Plastic Valve Box.

TABLE 616.02-3 - DIMENSIONS OF PLASTIC VALVE BOX

Valve Box Type	Minimum Wall Thickness, Excluding Web (Inches)	Depth (Inches)
A	5/16	10±
B	5/16	12
X	5/16	12

Plastic valve box cover shall conform to dimensions shown in Table 616.02-4 - Dimensions of Plastic Valve Box Cover.

TABLE 616.02-4 - DIMENSIONS OF PLASTIC VALVE BOX COVER

Valve Box Type	Length (Inches)	Width (Inches)	Minimum Edge Thickness (Inches)	Diameter (Inches)
A	---	---	2	9-1/8 ± 1/4
B	15-3/8 ± 1/8	10-1/8 ± 1/8	1-3/4	---
X	20 to 23	13-3/4 to 14	2	---

(2) Concrete Valve Box and Cover. Concrete valve box shall be manufactured from portland cement concrete with compressive strength of at least 2,500 pounds per square inch in accordance with Section 601 – Structural Concrete. Maximum density of concrete in finished product shall be 115 pounds per cubic foot and maximum absorption 15 pounds per cubic foot. Combined aggregates shall be proportioned such that surface of finished concrete is smooth and uniform in texture.

Cover of Type A concrete valve box shall be concrete, cast

iron, or zinc-coated steel. Cover of Type B or Type X valve box shall be cast iron or zinc-coated steel.

Concrete valve box shall conform to dimensions shown in Table 616.02-5 - Dimensions of Concrete Valve Box.

TABLE 616.02-5 - DIMENSIONS OF CONCRETE VALVE BOX

Valve Box Type	Min. Wall Thickness (Inches)	Depth (Inches)	Minimum Inside Dimension		
			Length (Inches)	Width (Inches)	Diameter (Inches)
A	1	12	---	---	6-7/8
B	1	11 to 12	17-1/4	9-3/8	---
X	1	12	21-1/2	12-1/2	---

Concrete valve box cover shall conform to dimensions shown in Table 616.02-6 - Dimensions of Concrete Valve Box Cover.

TABLE 616.02-6 - DIMENSIONS OF CONCRETE VALVE BOX COVER

Valve Box Type	Length (Inches)	Width (Inches)	Minimum Edge Thickness (Inches)	Diameter (Inches)
A	---	---	2	7-3/4
B	14-1/2	8-3/4	1-1/8	---
X	22-1/8	13-1/8	1-1/8	---

(J) Pump, Motor, and Motor Controller. Booster pump unit shall consist of pump and motor conforming to the requirements of this subsection.

Pump shall be centrifugal, close-coupled, single stage, single-end suction, with enclosed impeller, bronze fittings and mechanical seals. Pump discharge and total dynamic head shall meet the contract documents requirements. Pump shall be driven by NEMA listed, drip proof electric motor rated at 240 volts, three phases, 60 Hertz, and 1,750 or 3,500 revolutions per minute.

Each motor shall have appropriately sized, full-voltage magnetic starter with thermal overload and short circuit protection for each phase, in combination with fused safety switch, in accordance with Subsection 616.02(P)(4) – Safety Switches, in NEMA 1 enclosure with hinged cover. Overload reset and control operator shall be covered. Motor shall conform to NEMA Standard MG 1, and controls and starters to NEMA Standard ICS. Each starter shall include spare set of fuses.

(K) Switching Tensiometer.

(1) Bourdon-Tube Type. Switching tensiometer shall include vacuum gage and airtight, water-filled, rigid, clear plastic tube with porous ceramic tip at bottom to afford high flow rate for sensitive response. Vacuum gage shall have positive ON/OFF switch adjustable from 0 to 100 centibars. Electrical capacity of unit shall be 24 volts, alternating or direct current, 1/2 ampere, 10 watts. Wire leads shall connect switch to controller or solenoid valve.

(2) Solid-State Type. Unit shall operate by heat diffusion with one solid-state tensiometer for each remote control valve. Tensiometer shall be equipped with preset stress value of 24 centibars and override switch at top. Electrical capacity shall be 15 watts, alternating current. Tensiometers shall be connected in series with each remote control valve cable.

(L) Rain Sensor Switch. Sensor switch to prevent watering during periods of rain shall be compatible with irrigation control system and shall not interfere with watering program.

(M) Automatic Controller. Automatic controller shall have multiple program capabilities, 24-hour clock, 12-hour watering duration, and station timing programmable from 0 to 2 hours in 1-minute increments, and 2 to 12 hours in 10-minute increments.

(1) Controller equipment shall include heavy-duty surge protection, UL listed and CSA and CE approved, for input and output. Controller shall operate on minimum of 115 volts, single-phase, alternating current; or minimum of 24 volts, single-phase, alternating current, with external 115 to 24 volt step-down transformer. Backup fuse shall be included for supply overload. Backup battery shall be provided for programming under battery power or maintaining irrigation schedule during power outage.

(2) Controllers shall be wall-mounted or pedestal-mounted, and shall be equipped with moisture sensor and automatic rain shut-off switch.

(3) Controller shall be enclosed in accordance with manufacturer's instructions and Subsection 616.02(N) – Controller Enclosure.

(N) Controller Enclosure. Enclosure for controller shall be vandal and weather resistant, lockable, and constructed entirely of stainless steel.

(1) Main housing shall be equipped with stainless steel backboard for mounting of controller. Backboard shall include four removable stainless steel bolts. Side panels shall include louvers on top and bottom for ventilation.

(2) Adequate storage space shall be provided along inside of door for plans, operating instructions, and program schedules. Door shall be equipped with continuous stainless steel piano hinge at one edge and three-point locking mechanism at other edge. Handle for locking mechanism shall be located at base of door and shall be concealed within door. Padlock and two keys shall be provided for enclosure.

(O) Master-Satellite Control System. Master controller shall include at least two completely independent stations, operate on 120 volts of single-phase alternating current, and supply 30 volts of continuous current to satellite controllers.

Master controller shall be fully automatic and capable of providing complete 14-day minimum irrigation program. Controller shall be equipped with 24-hour clock with minimum incremental starts of one hour, circuit breaker protection, 30-volt transformer, and MANUAL/OFF/AUTOMATIC control switches. Time and clock set adjustments shall not require insertion or removal of pins. Captive pins are acceptable.

(P) Electrical Requirements. Electrical equipment and materials shall conform to NEMA Standards. Electrical work shall be done in accordance with the National Electrical Code, General Order No. 6 of the Hawaii Public Utilities Agreement, local power company rules, and local ordinances as applicable to the Project.

(1) Cables, Conductors, and Wire for Irrigation System.

(a) General. Wire and cable shall be single-conductor copper. Conductor shall be annealed, uncoated wire conforming to ASTM B 3. Conductors No. 6 and larger shall be stranded wire, Class B, conforming to ASTM B 8. Bare conductors shall be soft-drawn wire.

(b) Conductors in Conduit. Control and grounding conductors to be installed in conduits shall be insulated. Conductors shall be color-coded in accordance with Table 616.02-7 - Color Coding of Irrigation Conductors.

TABLE 616.02-7 - COLOR-CODING OF IRRIGATION CONDUCTORS

Description	Color
Phase A	Black
Phase B	Red
Phase C	Blue
Neutral Conductor	White
Grounding Conductor	Green
Control Conductor	No identical color within same circuit

Primary service conductors shall have 15,000-Volt class insulation. Insulating material shall be rubber with polychloroprene jacket, or cross-linked polyethylene with polyvinyl or polyethylene jacket. Conductors shall be stranded wire. Cables shall be installed without splicing between terminals.

Secondary voltage conductors shall have 600-Volt class insulation. Insulating material for conductors No. 6 and larger shall be cross-linked polyethylene with polyvinyl or polyethylene jacket. Smaller conductors shall be NEC Type RHW or THW.

(c) Direct Burial Conductors. Circuit conductors directly buried in earth shall have 600-Volt class insulation. Conductors shall be NEC Type UF, seven-strand or solid. Grounding conductors shall be bare. Circuit conductors shall be color-coded. Common conductors shall be white with tracer.

(2) Circuit Breakers. Individually enclosed circuit breakers shall be provided to protect pump motor feeders. Circuit breakers shall be molded-case type in accordance with UL 489 and shall include NEMA Type 1 hinged door enclosure. Each pole of circuit breaker shall

provide inverse time delay overload and instantaneous short circuit protection. Terminals shall be pressure type, sized for easy connection of wire. Breakers shall be lockable from either position, three-pole, 480 volts, with interrupting rating of 14,000 symmetrical amperes at rated voltage. Specifications for continuous current shall meet the requirements of the contract documents.

Individually enclosed circuit breakers shall be provided in accordance with Subsection 602.02(P)(3) – Panel Boards, when use is other than at pump motor feeders.

(3) Panel Boards. Panel boards shall conform to UL 67 and shall include NEMA Type 1 enclosure. Panel board circuit breakers shall conform to UL 489. Voltage, interrupting symmetrical ampere rating at rated voltage, and continuous current rating of circuit breaker shall be as specified in the contract documents. Panel board shall be equipped with insulated, groundable neutral bus.

(4) Safety Switches. Safety switches used in combination with motor starters shall conform to UL 98 and shall be heavy duty, three-pole, 240 volts, sized and equipped with fuses appropriate to motor served.

(5) Snap Switches. Snap switches used for on/off power control to circuits 120 volts and below shall be single-pole, 20 amperes, and shall conform to UL 20. Switches shall be mounted in enclosure.

(6) Meter and Service Equipment Cabinets. Cabinets shall be welded steel, sized for equipment housed, and shall be rain-tight equal to NEMA 3R. Door shall be tamper-proof, hinged and lockable. Backboard shall be exterior grade plywood, finished on one side, treated with fungus and insect repellant, and affixed to cabinet in shop with two-part epoxy cement and bolts. Entire cabinet shall be painted in shop in accordance with Subsection 708.03 – Dark Green Enamel Paint.

(7) Transformers. Transformer shall be dry, of rating in the contract documents, and totally enclosed in weatherproof case with integral wiring compartment. Transformer shall provide voltage step-down from 120 volts to 24 volts, shall conform to NEMA Standard ST 1, and shall be equipped with standard primary voltage taps in conformance with NEMA. Insulation shall be rated for 239 degrees F rise, Class F.

(8) Meter Sockets. Meter sockets for self-contained meters shall be seven-jawed and shall be acceptable to serving electric utility company.

(9) Ground Rods. Ground rods shall be rolled to round shape from copper-encased steel made by molten welding process or electro-formed molecular bonding. Copper surface of ground rod shall be hard, clean, smooth, continuous, and at least 0.013 inch thick. Ground rods shall be diameter and length specified in the contract documents.

(10) Receptacles. Receptacles shall be duplex, 15 amperes, and 125 volts in conformance with NEMA Configuration 5-15R. Receptacles shall be mounted in sheet metal box with cover in conformance with UL Standard 514.

(Q) Concrete. Concrete for jackets and reaction blocks shall be Class B and shall conform to Section 601 – Structural Concrete.

(R) Miscellaneous Materials.

Trench Backfill Material	703.21
Zinc-coated Pipe and Fittings	707.10
Copper Service Pipe and Appurtenances	707.11
Dark Green Enamel Paint	708.03
Concrete Pull Box	712.06(B)
Frame and Cover	712.07(A)
Cullet Materials for Drainage Systems	717.04

(S) Asbestos. Materials containing asbestos shall not be used. Asbestos that has already been installed shall be removed and replaced at no cost to the State.

616.03 Construction.

(A) General. Furnish materials and equipment for permanent irrigation system that are new and obtained from named and accepted manufacturers. Materials and equipment for temporary irrigation system do not have to be new, but shall be from named and accepted manufacturers. The Engineer will inspect and test materials.

(B) Responsibility of the Contractor.

(1) Obtain and pay costs of necessary permits and certificates.

(2) Repair damage, caused by the Contractors operation, to known underground utilities or other improvements.

(3) Exercise caution when working near existing improvements. Install barriers to protect against injury or defacement of improvements.

(4) Repair damage from leaks caused by faulty materials or workmanship during installation of irrigation system and during plant establishment period. Restore area to original condition.

(5) Provide one-year material warranty for repairs and modifications to permanent irrigation systems, commencing with date of final acceptance of permanent system.

(6) Provide repair and maintenance of temporary irrigation system from installation to removal.

(C) Pre-Construction Submittals.

(1) Within 10 days after award of the Contract, submit following:

(a) Construction Schedules. Provide six copies of separate schedules for construction of permanent and temporary irrigation systems. Include estimated completion dates, number of working days, and special coordination requirements.

(b) Equipment Lists. Provide six copies of separate equipment lists for permanent and temporary irrigation systems. Name manufacturer and provide catalog number. Include pipes, sprinkler heads, emitters, valves, irrigation control equipment, and other materials that will be installed.

(2) Shop Drawings. Within 30 days after award of the Contract, submit for the Engineer's acceptance six copies of detailed scale drawings and wiring diagrams for permanent and temporary irrigation systems. Note proposed deviations from the Contract. Include samples of materials, if required by the Contract.

(D) Post-Construction Submittals. Before final acceptance of landscape plantings and end of plant establishment period, submit following for the Engineer's acceptance:

(1) Service Manual. Provide six individually bound copies of service manual for permanent irrigation system in three-ring, hard cover binders. Include following:

(a) Index sheet with the Contractor's name, address, and telephone number.

(b) Equipment and material warranties and certificates.

(c) Equipment and material list with names, addresses, and telephone numbers of local or nearest manufacturers' representatives.

(d) Complete as-built irrigation drawings and diagrams.

(e) Controller charts.

(f) Complete, easy-to-understand instructions for operating and maintaining irrigation system, in sufficient detail for use by the State's maintenance forces.

(2) As-Built Drawings. Before backfilling, record as-built changes to irrigation system in red on working set of prints of the plans. Include accurate data showing locations of irrigation mains, connection points, valves, control wiring, electrical boxes, controllers, sprinkler heads, emitters, and capped ends for future extension. Reference changes to permanent improvements such as sidewalks, curbs, and monuments.

(a) Keep working set of marked-up prints at the Project site and update data daily.

(b) When construction of irrigation system is completed, furnish reproducible full-size tracings with transcribed as-built data. Submit working set and complete set of tracings indicating as-built condition of irrigation system to the Engineer.

(3) Keys. Furnish the following:

(a) Two long-shank keys or wrenches for adjusting flow rate of manual control valves.

(b) Two valve keys for 4-inch and larger gate valves.

(c) Six keys for irrigation controller.

(d) Six keys for controller enclosure.

(E) Workmanship. Conform to laws, codes, and regulations applicable to the work. Provide inspections and permits required by governmental authorities.

(F) Layout.

(1) Check grades to affirm that work can proceed safely. Keep within specified depths of construction. Take special note that dimensions in irrigation layout are horizontal and will differ from measurements taken along slopes.

(2) If site conditions do not allow pipes, valves, or sprinkler heads to be located as drawn, consult with the Engineer immediately for joint determination of revised location. Changes made without the Engineer's knowledge may not be accepted for payment.

(3) Do not construct in accordance with the contract documents if there are obvious discrepancies or differences. Bring these matters to the Engineer's attention and wait for direction before proceeding. The Engineer will hold the Contractor responsible for unauthorized work.

(4) If there is conflict between contract documents and the conflict has not been resolved before start of construction, obtain direction from the Engineer before proceeding.

(G) Utility Connections.

(1) Water. Provide water service connection in accordance with requirements of governing agency. Pay all related costs.

(2) Electric. Arrange with local power company for electric service connection to irrigation controllers. Pay all related costs.

(H) Excavation and Backfill.

(1) Provide trench excavation to install pipes. .

(2) Excavate trench to width necessary to install pipe; provide additional width for joints. Excavate to depth shown in the contract documents. If contract documents do not specify depth of excavation, provide minimum cover to finished grade as follows:

(a) 4 inches for drip irrigation tubing.

(b) 18 inches for irrigation main.

(c) 10 inches for irrigation lateral.

(d) 24 inches for sleeve or conduit under landscape pavement.

(e) 36 inches for sleeve or conduit under roadway pavement.

Rototill before installing drip irrigation system.

(3) Remove rocks larger than 2 inches, roots, and other obstructions completely, or cut obstruction to width of trench and six inches below pipe. Dispose of debris in accordance with Section 202 – Removal of Structures and Obstructions. Backfill over-excavation and tamp carefully to provide firm and smooth foundation for pipe.

(4) Wherever possible, place irrigation mains and other irrigation lines in same trench. Provide specified minimum clearance between pipes.

(5) Install barricades or temporary lighting at excavations if necessary for public safety.

(l) Assembling Pipe.

(1) Assemble pipe at point of connection in accordance with manufacturer's instructions. Adjust for site conditions and weather.

(2) Install irrigation pipe under existing pavement in accordance with requirements of the contract documents.

(3) Plastic Threaded Joints. Provide factory-molded joints only. Field threading of plastic pipe or fittings will not be allowed. Make plastic to metal connections using female plastic threads.

(4) Make metal-threaded joints using proper tools and joint compounds. Do not caulk. No more than three full threads shall be visible when joint is finished. Make field cuts only with permission of the Engineer.

(5) Make flanged connections using accepted gaskets and bolt sets. Tighten assembly bolts to proper torque.

(6) For bell-jointed pipe, provide concrete thrust blocks at irrigation main for pressure resistance. Follow standard plumbing practice in constructing thrust block.

(7) Install removable, non-decaying plugs at ends of pipe sleeves and control wire conduits.

(J) Laying Pipe and Emitters.

(1) Refer to landscape plans for routing of irrigation lines relative to plantings.

(2) Install parallel pipes in same trench and to same depth, with minimum horizontal separation of two inches. Do not permit parallel pipes to cross.

(3) Lay pipe flat on bottom of trench, and accurate as to specified alignment and grade. Do not place pipe on soft or unstable soil, or when water is present. Remove undesirable soil and replace with trench backfill material. De-water trench and allow backfill to dry.

(4) Except at connections, install bell-jointed pipe with bell end facing direction of laying.

(5) Provide minimum vertical separation of two inches at pipe crossings. Direct contact of pipe with other pipes or structures will not be allowed.

(6) Install drip tubes and fittings in accordance with manufacturer's instructions.

(7) Flush pipes thoroughly to remove debris and other foreign matter.

(8) Complete tests and repairs before paving over pipe.

(9) Inspect completed pipe sections for leaks at joints and fittings. Repair or replace pipe, if necessary, before backfilling.

(K) Flushing. Thoroughly flush pipe before installing valves, filters, sprinkler heads, and emitters. After flushing, partial backfill of pipe is allowed. Keep butt joints, fittings, and connections visible and free of obstructions.

(L) Installing Equipment.

(1) Valves.

(a) Thoroughly flush irrigation main before installing valves.

(b) Install valves plumb when connected directly to irrigation main, with sufficient clearance for operation and service. Locate valve no farther than 12 inches from irrigation main.

(c) Install gate valves before installing manual or remote control valve manifolds or quick coupler valves.

(d) Install manual control valves and gate valves as specified. Maintain accessibility to valves.

(e) Locate valve boxes so that outer edges are no closer than five feet to roadway pavement.

(f) Install control valves in valve boxes. Provide extension if necessary to keep soil clear of valve and solenoid. Provide individual box for each valve. Set valve box parallel with edge of sidewalk or roadway, and top of box flush with finished grade.

(g) Install remote control valve in location central to sprinkler or drip system. Adjust flow control for optimal efficiency.

(2) Valve Boxes.

(a) Install valve box on three-inch thick gravel bed for drainage. Keep dirt and debris out of box.

(b) Label valve box permanently with valve number and controller letter in manner shown in the contract documents or accepted by the Engineer.

(3) Automatic Control Wiring.

(a) Provide conduits for control wires at pavement crossings and wherever wires require protection from damage. Place invert of conduit minimum of 24 inches beneath surface of landscape pavements and 36 inches beneath surface of roadway pavements.

(b) Run wires in irrigation pipe trenches wherever possible. Bundle wires with wrapping tape at 10-foot intervals. Provide slack in wraps to allow wires to expand and contract. Place wiring for permanent irrigation system minimum of 18 inches beneath surface of planted areas.

(c) For control and ground wires, loop at least two feet of extra wire at each valve box, splice, change of direction, 500 feet of straight run, and at controller. Coil extra wire neatly within valve box.

(d) Use connectors as shown in the contract documents or acceptable to the Engineer.

(e) Splice wires only if run is greater than 2,500 feet. Make

splices and connections watertight. Locate splice at valve or within separate electrical pull box. Label pull box clearly and accurately.

(4) Rain Sensor and Automatic Controller.

(a) Install rain sensor in accordance with the contract documents.

(b) Enclose automatic controller and mount unit on wall or concrete pad in accordance with the contract documents.

(c) Use Class B concrete conforming to Section 601 – Structural Concrete for concrete pad and conduit encasements. Reinforcement shall conform to Section 602 – Reinforcing Steel and Subsection 709.01 (C) – Welded Wire Fabric Reinforcement.

(d) Make forms for pad and conduit encasements rigid and true to line and grade. Brace forms securely. Install conduits and anchor bolts in proper position, to required height, and hold in place with template until concrete sets. Construct pad level, slope edges to drain, and finish with steel trowel. Cure concrete seven days for pads and 72 hours for conduit encasements.

(e) Connect control lines to controller sequentially by assigned valve identification number. Label control lines at controller using permanent, non-fading markers to indicate valve identification number.

(M) Testing.

(1) Hydrostatic Test.

(a) Provide equipment and labor for hydrostatic testing of irrigation mains and laterals. Notify the Engineer at least three days in advance of test.

(b) Before proceeding, allow welded plastic pipe joints to cure for at least 24 hours. Cap sprinkler risers. Backfill center of pipe to prevent arching or slippage.

(c) Apply continuous static pressure of 60 pounds per square inch to pipe for one hour.

(d) Repair leaks that develop and repeat test. Do not backfill until there is no further sign of leakage.

(2) Testing for Operability.

(a) Before backfilling, open remote control valves and test circuits for leaks around barbed and threaded PVC fittings.

(b) Repair leaks and repeat test.

(c) If there are no further leaks, complete backfilling, contouring, and finish grading. Test operation of entire irrigation system by electrically actuating remote control valves.

(d) Run system until there are puddles or there is sheet flow to determine initial irrigation time and number of cycles per week needed to meet water requirements of plants.

(3) Testing for Coverage. Before start of planting period, run automatic controller through all of its cycles. Check watering for coverage and uniformity in company of the Engineer.

(N) Backfilling and Compacting.

(1) Do not backfill until all circuits have been tested, reports submitted, and circuits accepted by the Engineer.

(2) Fill remainder of trench. If there is over-excavation, shovel enough dirt to hold pipe in place. Maintain required space between pipes.

(3) Bring soil up to finished grade. Remove rocks that are larger than one inch while performing contouring and final grading.

(4) Hand-tamp backfill to at least 90 percent relative compaction.

(5) Reseed or replant if necessary. If ground settles during plant establishment period, restore trench to finished grade with compacted backfill.

(O) Controller Chart.

(1) Furnish controller chart with as-built drawings to show area controlled by each remote valve. Chart shall be black on white, hermetically sealed between two 20-mil clear plastic sheets, and reduced in size to fit inside door of controller enclosure.

(2) Attach non-fading copy of irrigation diagram inside door of controller enclosure. Show valve locations, numbering, and wire routings in diagram.

(P) Maintenance. Include water conservation as essential part of maintenance program.

(1) System Operation.

(a) Irrigate automatically as much as possible. Use manual watering if necessary to sustain plant growth.

(b) Provide completely operable and well-maintained irrigation system for entire duration of plant establishment period.

(c) Adjust time and duration of irrigation for optimal plant growth.

(2) System Maintenance and Repair.

(a) Keep controller and valve boxes clear of dirt and debris. Replace, repair, adjust, and perform work necessary for continued good performance of irrigation system. Maintain installed irrigation equipment, including mains, laterals, filters, screens, drip emitters, control valves, control wiring, automatic controllers, back-up batteries, quick coupler valves, sprinkler heads, risers, sleeves, valve boxes, pull boxes, lids, and covers.

(b) Replacement parts shall be new and original equipment.

(c) Perform repairs as necessary to restore system to its original condition.

(d) Observe operation of irrigation system and ensure that water is delivered to plants without wastage. Clean and adjust sprinkler heads as needed for optimal performance. Flush drip emitters to remove sediment.

(e) Look for broken or clogged sprinkler heads and emitters, malfunctioning or leaky valves, and other performance-hampering situations. Be especially watchful for plants that show signs of wilting. The Contractor shall be responsible for plants that die from lack of water.

(Q) Acceptance. The Engineer will not accept permanent irrigation system before acceptance of landscape plantings and conclusion of plant establishment period. Remove temporary irrigation systems and clean area within two weeks after conclusion of plant establishment period.

616.04 Measurement.

(A) Irrigation system will be paid on a lump sum basis. Measurement for payment will not apply.

(B) Engineer will measure components of system per each in accordance with contract documents.

616.05 Payment. The Engineer will pay for accepted pay items listed below at contract price per pay unit, as shown in the proposal schedule. Payment will be full compensation for work prescribed in this section and contract documents.

Engineer will pay for each of the following pay items when included in the proposal schedule:

Pay Item	**Pay Unit**
Permanent Irrigation System	Lump Sum
Temporary Irrigation System	Lump Sum
Components of the System	Each

Engineer will pay for copper service laterals and copper service connections under Section 624 - Water System.

Contractor shall pay for water used before acceptance of project or until termination of maintenance period for plantings, whichever is later.

END OF SECTION 616