DATE: November 3, 2022

SPECIFICATIONS FOR KENOSHA COUNTY BID #2220
AUTOMATIC IRRIGATION IMPROVEMENT PROJECT

AT

BRIGHTON DALE LINKS – RED PINE GOLF COURSE
KANSASVILLE, WI

IRRIGATION CONSULTANT

ERIK CHRISTIANSEN DESIGN GROUP, LTD.

ERIK CHRISTIANSEN ASIC–PIC
PROFESSIONAL IRRIGATION CONSULTANT

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I. General Conditions

The installation of the Irrigation System will have an Owner's Representative.

Owner's Representatives:
Jim Wallace – Superintendent
Brighton Dale Links - Red Pine Nine
830 248th Avenue
Kansasville, WI 53139
Phone: 262-925-8010
Email: James.Wallace@kenoshacounty.org

Irrigation Consultant:
Erik Christiansen – ASIC, TCEQ
President - EC Design Group, Ltd.
400 5th Street
West Des Moines, IA 50265
Phone: 515-225-6365
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The objective of these specifications is for removal of existing irrigation equipment and provide an assembled and installed Toro Lynx central control system, G4 OSMAC satellites, (2) Apple iPads w/Lifeproof case, RF/solar weather station, sprinklers, PVC piping and all associated equipment for the proper operation of an automatic sprinkler system. This system, when finished, will efficiently and effectively operate. Existing irrigation equipment including valves, heads, and controllers shall be returned to the Owner. Said system shall prove to be satisfactory in all aspects to the Owner and Owner's Representative and Irrigation Consultant. These specifications are to be followed with due perseverance in all respects.

The diagrammatic Plans and Specifications are intended to include everything obviously requested and necessary to do the proper installation of the work, whether each necessary item is mentioned herein or not, unless otherwise specified the contractor is expected to provide for the same.

Irrigation Plans with Specifications are intended to work together and any item or feature called for in one and not the other shall be as binding as if called for in both. If a discrepancy exists between an item called for in the Plan and the Specifications, the Plan takes precedence or the contractor can assume the more stringent as it applies to the best method of operation and installation.

All work specified herein or called for on the drawings shall comply in accordance with all governing ordinances, laws and regulations that apply to the project. If the contractor performs any work contrary to such codes, laws or regulations, they shall assume full responsibility and bear all costs necessary to correct the work, at no additional cost to the Owner or the Owner's Representative.

Bidders must study and compare the Drawings and Project Documents and shall be responsible for discovering and reporting to the Irrigation Consultant any error, omission, inconsistency or other defect that should be apparent to a reasonable prudent Contractor. The Irrigation Consultant will interpret, correct or otherwise clarify the Project Documents as necessary, and will make any interpretation, correction or clarification in writing and issue it an addendum to all Bidders.

Any work undertaken by the Contractor containing possible errors or conflict without or before a written interpretation or instruction by the Owner's Representative and Irrigation Consultant is done so at the Bidders own risk.

The successful Contractor will be required to install the irrigation system under the following requirements:

1. All open trenches and excavations must be marked and protected on a daily basis. Protection will include barriers and plywood covers over excavations and other necessary procedures to protect the public and other Contractors from the danger of construction activities.
2. The entire site must be left in a clean and safe condition at the end of each workday. "Clean and safe" will be at the discretion of the Owner's Representative and the Irrigation Consultant. The Contractor shall appoint a supervisor who shall be responsible for all safety measures, as well as for compliance with all applicable governmental laws, ordinances, rules and regulations such as, for example, "OSHA" and "Right to Know" legislation and all city, county and state codes.
3. The order of work will be as agreed upon with the Irrigation Consultant and Owner's Representative. The resulting agreement shall become the basis for the irrigation part of the master project schedule.
4. Contractor shall keep the existing system up and operating each night to water the entire golf course (as required by Owner) and Contractor shall coordinate with Owner each day as to the status of the existing irrigation system. Furthermore, Contractor shall water all new and replaced turf until time of irrigation system acceptance by Owner and Irrigation Consultant.

The omission of any material from this Specification is not to be interpreted to the effect that omitted material will not be furnished by the Contractor. All material and labor, unless specifically indicated as being furnished by others, must be furnished and installed by the Contractor under the signed agreement.

The Irrigation Consultant/Owner shall stake or mark out the location of power wire, any mainline and wire paths in the immediate area to be worked on prior to starting installation. In the event there are any discrepancies from the work shown in the plan, the Contractor shall verify the dimensions with the Irrigation Consultant before work may begin in that area. **The Contractor shall have available a minimum of four persons, staking flags, four 100 ft. tapes and shall produce "as staked" drawings, all for use during all staking visits by the Irrigation Consultant. Minimum (14) day advance notice to Irrigation Consultant for ALL staking visits.**

Routing of the pipe and wire are diagrammatic and the Contractor/Owner will be expected to make field adjustments. The Owner reserves the right to make pipe and/or cable routing changes from those shown in the plans in cases, but not limited to; where ledge, boulders or other obstacles impede the path. Minor changes of this nature shall not affect the cost or time limits of the work.

Valve boxes should be as indicated on the drawings. Communication cable shall not be run through bunkers or tees. No valve boxes shall be located within the fairway cut and shall not be installed in the walking path to or from the green.

Rock, shale, stones, organic matter or trash not suitable for use as backfill shall be dug and hauled to an accessible dumpsite on the property. The Contractor shall be responsible calling in all locates and will be responsible for all damage to underground utilities of which they are aware, including, but not limited to; gas, water, electricity, cable, telephone,

under-drains and drain tiles. Coordinate with the Owner's Representative and responsible utility marking firms the locations of existing underground utilities and drains.

The Contractor shall not assign or subcontract any part of the work without the expressed written approval of the Owner prior to the start of said work to be subcontracted. Acceptance of a subcontractor does not relieve the Contractor of his responsibilities under the agreement.

The Contractor shall maintain a minimum of one 40-foot storage trailer on site for storage of materials other than piping. Location of trailer(s) shall be at the staging area. The Contractor shall be solely responsible for meeting deliveries and they're off-loading. The Owner shall not be responsible for inventorying or off-loading any materials to be used in the irrigation system.

II. Instructions

Part 1 - General

1.1 QUALIFICATIONS AND INTERPRETATIONS

A. **Construction schedules *must be approved by Owner and Owner's Representative(s):***

Owner's Representatives:
Jim Wallace – Superintendent
Brighton Dale Links - Red Pine Nine
830 248th Avenue
Kansasville, WI 53139
Phone: 262-925-8010
Email: James.Wallace@kenoshacounty.org

Irrigation Consultant:
Erik Christiansen – ASIC, TCEQ
President - EC Design Group, Ltd.
400 5th Street
West Des Moines, IA 50265
Phone: 515-225-6365
Email: erik@ecdesigngroup.com

1. All bids must meet the requirements in the Quality Assurance Section IV item 1.3-A.
2. Irrigation said improvements must be completed in the time frame designated by the Owner and Owners Representative.
3. List all, if any, sub-contractors to be employed by the contractor on irrigation project.
4. Acknowledgment of receipt of addenda.
5. Completion of unit pricing.
6. Contract will be awarded, unless all bids are rejected, under normal circumstances, to the responsible Bidder whose bid and accepted alternative bids resulted in the lowest sum.
7. Owner reserves the right to reject any and all bids when such rejection is in the interest of Owner; to reject a bid or a Bidder who has previously failed to perform properly or complete on time contracts of similar nature; to reject bid or a Bidder who is not, in the opinion of the Irrigation Consultant or Owner, in a position to satisfactorily perform the contract. Owner also reserves the right to waive any informalities and technicalities in bidding. Owner may also accept or reject any alternatives.
8. All contractors must visit job site before submitting a bid.

1.2 CONTRACT SPECIFICATIONS

A. The detailed specifications, which follow, shall govern the materials furnished and work performed in the construction of the work covered by this contract.

B. No attempt has been made in the specifications to segregate work to be performed by and trade, subcontract or proposal item, under any one section of the specifications. Any segregation between trade or craft jurisdiction limits, and the establishment of subcontract limits, will be solely a matter of agreement between the Contractor and his employees and his Sub-contractors. The specifications will govern the construction of the entire work and the provisions thereof all govern each item and unit of work to which such provisions apply.

1.3 APPLICATIONS FOR PAYMENT

A. Each Application for Payment shall be consistent with previous applications and payments as certified by the Irrigation Consultant and Owner and paid for by the Owner.

B. Application Preparation:
   1. Payment will be based on the proportion of the total work completed during the period for which application for payment is being made. Contractor shall submit application for payment on the 9th of each month, for work completed from the 10th of the previous month.
   2. Include any contract revisions authorized by approved Change Orders issued prior to the last day of the construction period covered by the application. Payment for such authorized contract revisions will be computed based on the Unit Prices included on the Bid Form taken times the actual quantity of such materials instilled as result of such change as measured by the Contractor and reviewed by Owner.

C. Transmittal:
   1. Submit three executed copies of each Application for Payment to the Owner including waivers of lien and similar attachments, when required.
   2. Transmit each copy with a transmittal form listing attachments, and recording appropriate information related to the application in a manner acceptable to the Owner.

D. Final Payment Application:
   1. Submittals, which must coincide, with submittal of the final payment Application for Payment include the following on forms, and executed in a manner acceptable to the Owner
      a. Final waivers of liens from every entity involved with performance of Work.
      b. Consent of Surety of Final Payment. (If applicable)
      c. Itemized statements listing taxes, fees and similar obligations paid.

III. Project Close-out

1.1 SUBSTANTIAL COMPLETION

A. Preliminary Procedures: Before requesting inspection for certification of Substantial Completion, complete the following:
   1. Remove temporary facilities from the site.
   2. Complete final cleaning requirements as described below in this Section.
   3. If 100 percent (100%) completion cannot be shown, prepare a list of incomplete items, the value of incomplete construction, and reasons the Work is not complete.

B. Inspection Procedures: On receipt of a request for inspection, the Irrigation Consultant will either proceed with inspection or advise the Contractor of unfulfilled requirements. The Irrigation Consultant will either prepare the Certificate of Substantial Completion following inspection or advise the Contractor of work that must be completed or corrected before the certificate will be issued.
   1. If Irrigation Consultant indicates items to be completed before the Certificate of Substantial Completion can be issued, then the Irrigation Consultant will repeat inspection when requested and assured that the Work has been substantially completed. Total cost of re-inspections will be borne by the Contractor.
   2. Results of the completed inspection will form the basis of requirements for final acceptance.

C. In accordance with any pertinent section under separate cover.

1.2 FINAL ACCEPTANCE

A. Re-inspection Procedure: The Irrigation Consultant will re-inspect the Work upon receipt of notice that the Work, including inspection list items from earlier inspections, has been completed.

B. Upon completion of re-inspection, the Irrigation Consultant will prepare a certificate of final acceptance, or advice the Contractor of Work that is incomplete or of obligations that have not been fulfilled but are required for final acceptance. If necessary, re-inspection will be repeated. Total cost of re-inspection will be borne by the Contractor.

C. In accordance with any pertinent section under separate cover.

1.3 FINAL PAYMENT REQUEST

A. Submit the final payment request with supporting documentation for final payment.

B. Submit an updated final statement accounting for final additional changes to the Contract Sum.

C. Final payment will be made after Owner approval.

D. In accordance with any pertinent section under separate cover.

E. Upon approval of substantial walk-through and completion of punch sheet. Site must be 100% complete before contractor initiates substantial walk-through. If site is not ready for punch sheet/site visit, next visit will be at contractors' expense.

IV. Irrigation System

Part 1 - General

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including Bidding Requirements apply to work specified in this Section.

1.2 DESCRIPTION

A. Provide all labor, materials, equipment and supervision required to construct an underground irrigation system as shown and specified. The following work includes; but not limited to:
   1. Removal of existing equipment.
   2. Central, satellite controllers, sprinklers.
   3. Testing.
   4. Excavation and backfilling irrigation system work.
   5. Associated HDPE plumbing/fusion by certified HDPE fusion contractor as per specifications and accessories to complete the system.
   6. Wire sleeves (as required).

1.3 QUALITY ASSURANCE

A. Installer's qualifications: Minimum of 10 years experience installing golf course irrigation systems of comparable size. A minimum of 8 similar golf courses completed within the last 3 years.

B. Materials, equipment, and methods of installation shall comply with, but not limited to, the following codes and standards:
   1. All local and state laws and ordinances, and with all the established codes applicable thereto.
   2. American Society of Irrigation Consultants (ASIC)
   3. National Fire Protection Association (NFPA);
   4. National Electrical Code (NEC).
   5. American Society for Testing and Materials (ASTM).
   6. National Sanitation Foundation (NSF).
   7. The Irrigation Association (IA).

C. The Contractor shall take out all required permits, arrange for all necessary inspections and shall pay any fees and expenses in conjunction with the same as a part of the work under this Section.

D. Excavating, backfilling, and compacting operations: Comply with execution requirements and as specified.

E. **Supply Irrigation Consultant with min. of (4) people for all staking visits, flags and (4) 100' tapes. Visits must be scheduled a minimum of 14 days prior to proposed visit and have (5) or more holes prepared for staking.**

F. Obtain Irrigation Consultant's acceptance of installed and tested irrigation system prior to installing backfill materials.

1.4 SUBMITTALS

A. **Irrigation Contractor to provide completed station worksheet obtained from Irrigation Consultant prior to final approval. Must be up to date before pay applications approved and final retention released.**

B. Submit manufacturer's product data and installation instructions for each of the system components.

C. Submit the following material samples:
   1. Wire, wire connectors and sealer.

D. Submit the following equipment samples to Owner:
   1. Valves and valve access boxes.
   2. Controller.

E. Approved equipment samples will be returned to Contractor and may be used in the work.

F. Upon irrigation system acceptance, submit written operating and maintenance instructions. Provide format and contents as directed by the Irrigation Consultant **as well as completed station worksheet obtained from Irrigation Consultant.**

G. Provide irrigation system record drawings:
   1. The record as-built drawings shall be the original plan of the irrigation system as constructed. The final as-built drawings shall be prepared electronically at a scale of 1" = 100'. The drawings shall consist of a piping plan, a schedule plan, and a wiring plan, indicating the location, type and size of all wires, valves and other fittings. The drawing shall show all electronic controls, connections and wire splices. Measurements shall be indicated on the plan between sprinklers and valves. All pertinent materials shall be dimensioned from three fixed objects (i.e., drain valves, lateral isolation valves, mainline isolation valves, and wire splice connections). Station numbers shall be indicated on the drawings.
   2. The as-built drawings shall be made by an agent of the Contractor who shall utilize engineering skills and procedures in a manner satisfactory to the Owner's Representative in accomplishing his work. The record drawings shall be kept clean, dry and safe from damage at all times. The drawings shall be brought up-to-date at the close of each working day, and shall accurately indicate the location of all equipment placed to that time. In addition, a copy of the as-built drawing shall be mailed or delivered to the Owner's Representative every two weeks during the construction period. **No monthly pay requests will be approved without a current copy of the as-built drawings. No final approval will be given until the Owner approves the as-built drawings. Final "as-builts" shall be delivered electronically on 2019 AutoCAD .dwg or newer.**
   3. Identify field changes of dimension and detail and changes made by Change Order.
   4. **GPS irrigation collection by the Irrigation Consultant does not remove the obligation of the Contractor to produce all "as-built" scaled drawings as stated above. All locations must be located and flagged by Contractor prior to collection of those points by EC Design Group Ltd.**

1.5 DELIVERY, LANDS FOR STORAGE AND HANDLING

A. Deliver irrigation system components in manufacturer's original undamaged and unopened containers with labels intact and legible.
B. Deliver plastic piping in bundles, packaged to provide adequate protection of pipe ends.
C. Store and handle materials to prevent damage and deterioration. Store materials in locations designated and approved by the Owner.
D. Provide secure, locked storage for wire, pump station and similar components that cannot be immediately replaced, to prevent theft and therefore avoid installation delays.
E. Contractor has the right to a temporary construction facility for storage and protection of materials.

1.6 PROJECT CONDITIONS

A. Prior to any excavation at the site, contractor shall examine any applicable drawings, if any available from the Owner and/or Irrigation Consultant and consult with Owner's personnel and utility company's representatives to determine possible utility locations and depths. No compensation will be allowed for damage to existing utilities and systems.
B. Take precautions to ensure that equipment and vehicles do not disturb or damage existing site grading, walks, curbs, pavements, utilities, plants, and other existing items and elements on public and private property.
C. Promptly repair damages to adjacent facilities caused by irrigation system work operations. Cost of repairs at Contractor's expense.
D. Promptly notify the Irrigation Consultant of unexpected sub-surface conditions.
E. **Irrigation system layout is diagrammatic**. Exact locations of piping, valves, wire and other components shall be established by Irrigation Consultant in the field at time of installation and approved by the Owner or the Owners Representative before installation.
    1. Minor adjustments in system layout will be permitted to clear existing fixed obstructions.
F. Cutting and patching (cart paths, walks, drives, walls etc):
    1. Cut through concrete and masonry with core drills. Jackhammers are not permitted.
    2. Materials and finishes for patching shall match existing cut surface materials and finish. Exercise special care to provide patching at openings in exterior wall watertight.
    3. Methods and materials used for cutting and patching shall be acceptable to the Owner and Irrigation Consultant.
G. Protection of Persons and Property:
    1. Barricade open excavations occurring as part of this work and post warning lights.
    2. Operate warning lights as recommended by authorities having jurisdiction.
    3. Protect structures, utilities, sidewalks, pavements, curbs and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by this work.

1.7 GUARANTEE

A. For a period of one (1) year from date of **final acceptance** of work performed under this Section, the Contractor shall promptly furnish and install any and all parts and equipment which prove defective in material, workmanship or install at no additional cost to the Owner except trench settling and any pipe/fittings failures will be guaranteed for (2) years.

Part 2 - Products

2.1 ACCEPTABLE MANUFACTURERS

A. THE TORO COMPANY, IRRIGATION DIVISION, RIVERSIDE, CA

2.2 MATERIALS

A. General:
1. Provide only new materials, without flaws or defects and of the highest quality of their specified class and kind.
2. Comply with pipe sizes indicated. No substitution of smaller pipes will be permitted. Larger sizes may be used subject to acceptance of the Irrigation Consultant. Remove damaged and defective pipe.
3. Provide pipe continuously and permanently marked with manufacturer's name or trademark, size, schedule and type of pipe, working pressure at 73 º F. and National Sanitation Foundation (NSF) approval.
4. **All pipe and fittings (HDPE) shall be supplied from the same manufacturer throughout the entire job.**
5. **All sprinkler equipment must be purchased by the local authorized servicing regional distributor.**

B. Irrigation Mains/Laterals - PVC pipe, fittings and connections:
1. Polyvinyl chloride pipe: ASTM D2241 NSF-PW, rigid, un-plasticized PVC, extruded from virgin parent material. Provide pipe homogeneous throughout and free from visible cracks, holes, foreign materials, blisters, wrinkles and dents.
2. Gasketed pipe shall be used for 3" and larger diameter pipe. Gasketed pipe or bell end pipe to be used for 2" through 2-½" diameter pipe – **depending on actual method of installation**.
3. All pipe 2" diameter and over, shall be SDR 21, Class 200 unless noted on plan.
4. Glued PVC pipe fittings: ASTM D2241 schedule 80 PVC molded fitting suitable for solvent weld, slip joint ring tight seal. Screwed connections shall be Sch 80 PVC with no male adapters. Fittings made of other materials are not permitted.
   a. Size slip fitting socket taper to permit a dry un-softened pipe-end to be inserted no more than halfway into the socket. Saddle and cross fittings are not permitted.

b. All threaded PVC connections shall be made using Sch. 80 toe nipples and Sch. 80 couplers or socket fittings (where applicable). No threaded Sch. 80 fittings or male adapters.
c. PVC solvent shall conform to ASTM D2564 and is NSF approved for potable applications. Proper solvent shall be used for diameter of piping being glued. All solvent weld joints must set for 24 hours before being installed and be done in accordance with all manufacturer recommendations.

5. Ductile Iron fittings:
   a. Golf Grade Ductile Iron Deep Bell ductile iron fittings.
   b. Fittings shall be manufactured of ductile iron, Grade 65-45-12 in accordance with ASTM A-536. Fittings shall have deep bell push-on joints with gaskets meeting ASTM F-477.
   c. Golf Grade Deep Bell fittings shall be used on all PVC mainlines and lateral piping 2 ½" in diameter and larger.
6. Swing Joints:
   a. Toro/Lasco (or equal) 360º swing joint assembly. Contractor is responsible for proper installation of swing joints due to actual lateral depths lay lengths (as per manufacturer recommendations).
7. Service Tees:
   a. HARCO PVC Class 200 service tee as manufactured by The Harrington Corporation of Lynchburg, VA or Sch. 80 SxSxACME. **Note – all fittings must be approved in the submittal process as well as style of lateral installation.**
   b. Shall be located under all sprinkler heads and quick coupler valves **with appropriate thrust blocks at all change of directions and dead ends, laterals and mains.** (see detail)
8. Gasket Lubricant:
   a. Lubricant for assembling pipe and fittings shall be water soluble, non-toxic, non-objectionable to taste and odor imparted to the fluid, non-supporting of bacteria growth, and have no deteriorating effect on the PVC or rubber gasket. All pipe, couplings, rubber rings and lubricant shall be furnished by the same pipe manufacturer or as expressly recommended by them for use with their product.
9. "Air Release Valves":
   a. Air release valves shall be installed at high points on golf course and/or where diagrammatically noted on irrigation plan. Irrigation plan locations are diagrammatic; Contractor will be responsible for proper location as approved by Irrigation Consultant. Air release valves shall be installed in a Jumbo valve box and plumbed with a ball valve and wye strainer to isolate for maintenance (see detail).

C. V-I-H sprinklers, valves and associated equipment:
1. Products and associated equipment are to be provided by only one manufacturer for the complete project. Refer to the drawings for the quantity and diagrammatic locations of the following:
2. Sprinkler heads with swing joint assemblies – see detail:
   a. TORO INF54/55 V-I-H Series (see drawings)
   b. Spacing of heads shall not exceed manufacturer's maximum recommendations. Conform to manufacturer's specifications concerning diameter of throw and gallonage at given pressures.

3. Electric & Manual Isolation Valves:
   a. Rt/RW "resilient wedge" (or equal)-see plan
   b. 2" Harco/Leemco 90° PE lateral isolation valve – see plan.
   c. Size isolation valves to match line size-Manual Valves only.
   d. Installed in specified valve access box.
   e. Each style of isolation valve shall have (2) 4'-0" tee handle keys supplied by Irrigation Contractor.
4. Quick Coupler Valves:
   a. Toro 1" QCV with stabilizer and swing joint assembly.
   b. Provide matching quick coupler keys – (10) included in base bid – see spare parts section.
   c. Installed as specified on detail plan.
   d. All Q.C.V. shall be plumbed with a **1" brass insert swing joint with stabilizer.**

D. Control Equipment:
1. Refer to the drawings for the quantity and locations of the following:
2. Central Control
   a. TORO Lynx Central #LX-04-5-21 tuned to proper frequency with mapping software, specified premium computer, (2) Apple iPads w/Lifeproof case and 5 year technical support w/NSN connect.
   b. Paige Electric 36" ground rod and 96" plate assembly on each communication wire path for central control – see plan and details.
   c. Base antenna, antenna structure coaxial cable, lighting protection, ground plates, central UPS, and other items shall all be supplied and installed **as per manufacturer's recommendations; as per survey** for proper operation of said systems. **Contractor shall be responsible for any items, mentioned or not, for the operation of either specified radio system**.
   d. **FCC licensing and frequency shall be supplied by Contractor and performed by qualified agent, at no additional cost to the Owner**
3. Satellite Controllers: G4-XXP6R4 OSMAC satellite, plastic green cabinet with radio communication – see plan for station counts.
4. Weather Station: **Location by Owner**
   a. Toro T107-SP-XXX wireless/solar weather station.
   b. Station will come with all R.F. equipment from weather station to maintenance facility and be loaded with software to be able to communicate directly to central software programs. Contractor shall be responsible for any items and software, mentioned or not, for the operation of either specified weather station.

E. Primary Electrical Wire:
1. Type "UF", 600 volt, solid copper, single conductor wire with PVC insulation and bear "UL" approval for direct underground burial feeder cable with ground in conduit.
2. Size #00 Gauge - #12 Gauge. – (See Plan and Section V, 2.1)

F. Secondary Control Wire:
1. Electrical control and ground wire: Type "PE" 600 volt, solid copper, single conductor wire with polyethylene insulation "UL" approved for direct underground burial feeder cable. 12 gauge white common neutral and 14 gauge red control wire.

2. Wire color code: Provide color or "hot" wires red in color. Provide "common" wires white in color (one hot wire per head wire back to satellite). See plan and Section V, 2.2
3. No aluminum wire allowed.

G. Controller Communication Wire: **None – R.F.**

2.3 ADDITIONAL MATERIALS

A. Primary Electric wire connectors: **(as per manufacturer's recommendations)**
1. 3M COMPANY DBR-6 splice kits Socket seal type wire connectors or scotchcast and waterproof sealer, or Large 3M #4 Resin Bag UL listed for 600 volts and underground splice. All electrical connections shall apply to NEC standards and all local, state and federal codes whether listed or not or as per manufacturers latest standards.

B. Secondary Control Wire connectors:
1. 3M COMPANY #3570G-N direct burial splice kits. All electrical connections shall apply to NEC standards and all local, state and federal codes whether listed or not.

C. Valve Access Boxes:
1. Standard or Jumbo Box with extension kit-or equal; for air relief valves and isolation valves-See Plan

D. Thrust Blocking:
1. Thrust blocks are anchors placed between pipe or fittings and the solid/virgin trench wall. Specified blocking of concrete which is calculated to have a compression strength of 2,000 pounds per square inch. The mixture is one part cement, two parts washed sand and five parts gravel. Thrust blocks must be constructed so the bearing surface is in direct line with the major force created by the pipe or fitting. See diagram. The earth bearing surface should be undisturbed (virgin wall).
2. Thrust blocking is to prevent the line from moving when the pressure load is applied, transferring the load from the pipe to a wide load bearing surface. Thrust blocks are required where fittings are used to change direction (i.e. the following but not limited to; all tees, elbows, wyes, caps, valves and reducers etc.) of the pipe line. The thrust blocking must be formed against a solid trench wall (virgin wall) and these fitting areas must be excavated by hand, mechanical equipment will damage the bearing surface of the trench wall.
3. The size and type of thrust depends on pipe size, line pressure, type of fitting, degree of bend and type of soil. Thrust block size may be calculated by the example procedures shown below.
4. It will be the responsibility of the Contractor for all change of direction thrust blocks on all size piping. Furthermore, the warranty period for pipe and/or fitting failures is for (2) years from the date of acceptance.

Step 1 – Multiply the pressure level desired for testing by the appropriate value shown in the following table:

Pipe Size	Dead End or Tee	90 deg Elbow	45 deg Elbow	22 ½ deg Elbow
1 ½"	2.94	4.16	2.25	1.15
2"	4.56	6.45	3.50	1.78
2 ½"	6.65	9.40	5.10	2.60
3"	9.80	13.90	7.51	3.82
3 ½"	12.80	18.10	9.81	4.99
4"	16.20	23.00	12.40	6.31
5"	24.70	35.00	18.90	9.63
6"	34.80	49.20	26.70	13.60
8"	59.00	83.50	45.20	23.00
10"	91.50	130.00	70.00	35.80

Step 2 – Determine the bearing strength of the soil from the table below:

Bearing Strength of Soils

Soils and Safe Bearing Loads Lbs. Sq. Ft.	
Sound Shale	10,000
Cemented Gravel and Sand-difficult to pick	4,000
Coarse & Fine Compact Sand	3,000
Medium Clay - Can be spaded	2,000
Soft Clay	1,000
Muck	0

Step 3 – Divide the total thrust obtained in Step 1 by the bearing strength of the soil; this gives the square feet of area needed.

Side Thrust on Curves – An outward pressure exists on all deflections from a straight line. Good soil, properly tamped, can be sufficient to hold side thrust – unless soil conditions are unstable. In that case, to anchor against this side thrust, the blocking should be placed against the pipe on each side of the coupling. Do not thrust block the coupling itself.

Side Thrust

Pipe Size Inches	*Side Thrust Pounds per Degree*
1 ½"	5.1
2"	7.9
2 ½"	11.6
3"	17.1
3 ½"	22.4
4"	28.3

5″	43.1
6″	60.8
8″	103.0
10″	160.0
12″	225.0

Based on side thrust per 100 lb./in² pressure per degree of deflection.

Note: Multiply side thrust pounds by degrees of deflection times pounds of pressure divided by 100 to obtain total side thrust in pounds.

5. 2,000-psi test minimum on thrust block meeting all ASTM specifications C-33 and C-150 or C-175 standards. **Note: Thrust blocks can differ depending on the type of fittings and soils. Contractor must review all conditions for adequate thrust. Furthermore, a joint restraint may be required to obtain and secure a fitting from movement.**

E. Golf Grade Ductile Iron Fittings & Joint Restraints

1. Fittings for bell and gasket pipelines shall be ductile iron, slant-bell design, and deep bell type. Fittings shall be manufactured of ductile iron, grade 65-45-12 in accordance with ASTM A-536. Fitting gaskets shall be in accordance with ASTM F-477. All ductile iron fittings shall be equipped with four 90-degree apart, outwardly extending radial lugs to accommodate for appropriate method of mechanical restraints.
2. Fittings made from more than one piece shall utilize securely fastened bolt-on style spigot-bell links. Slip-on rings or loose rings as the method of attachment are not permissible.
3. All tee fittings used to connect remote control valve and quick coupling assemblies to the mainline shall be ductile iron, deep bell service tees.
4. All ductile iron bends; reducers, tees and gate valves shall be mechanically restrained. All bell and gasket joints adjacent to restrained joints shall be restrained in accordance to the manufacturers recommended design criteria and guides. **Note: Sites where ductile iron fittings without joint restraints and thrust blocks are acceptable in lieu of joint restraints and/or joint restraints that are used in cases of non-bearing soils or where joint restraints are used exclusively. See plans and details for actual site by site applications.**
5. The mechanical joint restraint shall be capable of securing the PVC pipe directly to the ductile iron fitting without the use of bolts, links and adapters. The joint restraint shall be capable of securing PVC gasket pipe joints and gate valves without use of threaded rods. Joint restraints made for iron or steel pipe are not permissible.
6. The joint restraint shall be manufactured from ductile iron, grade 65-45-12 in accordance with ASTM A-536. Bolts and nuts used on joint restraints shall be provided as part of the restraint assembly. Joint restraints shall be as manufactured by Leemco, Inc.
7. All joint restraints shall be installed using methods recommended by the manufacturer. All bolts and must be tightened as per manufacturer's recommended torque ratings.
8. All tees, bends, reducers and end caps should be restrained using LH Series clamp sets. Additionally, a certain number of bell-spigot joints before and

after a restrained fitting require LB Series joint restraints. There are also LG series clamp kits for restraining slip-on gate valves.

9. The following table lists values for the minimum restrained length of pipe ("L"). Every joint within the distance "L" should be restrained. Bends require that all joints be restrained on both sides of the bend for the specified length. The most critical are capped pipe and gate valves installed at terminating points for future connections; these should be treated as Dead End applications.

Table values are based on 125 psi test pressure, 2 feet cover, sand-clay type soil and safety factor of 2. For pressures other than 125 psi, multiply the "L" values by the actual pressure and divide by 100.

MATERIAL SPECIFICATIONS:
Clamps and Tie Rods: Ductile Iron ASTM A-536
Bolts and Nuts: Low Alloy Steel standard 304 Stainless Steel (Optional)

Pipe Size (in)	Minimum Restrained Length (L), feet Bends (degrees)				Reductions (sizes down)		
	11	22	45	90	1D	2D	DE
2	1	1	2	6	NA	NA	19
2.5	1	2	4	9	4	NA	23
3	2	3	5	11	8	10	30
4	2	4	9	20	14	20	45
6	3	6	13	29	30	40	63
8	4	8	15	38	33	55	83
10	5	9	19	45	31	56	100
12	5	10	21	53	54	58	118

Notes: 1D reduction denotes one size down (such as 4x3, 12x10)
2D reduction denotes two sized down (i.e. 4x2.5, 12x8)
DE is a dead end (for a cap, plug or a gate valve.)
More detailed tables are available upon request.

10. Ductile iron joint restraints shall be installed on all fittings and gate valves for all IPS-Size, ring joint PVC pipe. The joint restraint shall be capable of securing the PVC pipe directly to the lugs on the Leemco deep bell ductile iron fittings without the use of bolts, links and adapters. The joint restraint shall be capable of securing PVC pipe to PVC pipe and PVC pipe to ring joint gate valves without the use of threaded linkages.
All ductile iron fittings shall be secured to full-length pipes and on all bends and tee branches, the next joint of the pipe shall be secured. At least two full lengths of pipe must be secured when attached to bends and tee branched 8" and larger, and at least three full lengths of pipe must be secured to dead end pipe. Pipe joints that occur in less than full-length when attached to a fitting shall also be secured.
11. All fittings shall be deep bell, manufactured specifically for IPS-Size pipe and made of Grade 65-45-12 ductile iron. Fittings 4" and larger shall have slanted bells to allow deflection of pipe in all planes. Fittings shall have four

lugs at each push-on joint with ribbed and cupped gasket design, made from EDPM elastomer.

12. All quick coupling valves shall be fitted with Leemco Stabilizers. Quick coupling Stabilizers shall be manufactured in Grade 65-45-12 ductile iron; shall attach to the hex portion of the valve and be secured with a single bolt. Stabilizer shall have 12" span and be capable of resisting rotational and vertical motions. Stabilizers shall be LS-120 (3/4" and 1") and LS-150 (1 ½") as manufactured by Leemco, Inc., Colton, CA. Stabilizers made of plastic or fabricated from angle iron and U-bolts are not acceptable.

Part 3 - Execution

3.1 INSPECTION

A. Examine final grades and installation conditions. Do not start irrigation system work until unsatisfactory conditions are corrected and approved by Owner or Irrigation Consultant.

3.2 PREPARATION

A. Layout and stake the location of each pipe run and all sprinkler heads and sprinkler valves. Obtain Irrigation Consultant's acceptance of layout prior to excavating.
B. Strip sod for pipe trenches with a mechanical sod stripper uniformly 1" to 1-½" thick with clean-cut edges (for existing turf only).
C. Remove existing paving for sleeve installation. Saw cut existing paving to provide uniform straight transition at new to existing paving.
D. Place sleeves as indicated for installation of piping and control wire.

3.3 INSTALLATION

A. Excavating and backfilling:
   1. Excavation shall include all materials encountered, except materials that cannot be excavated by normal mechanical means.
   2. Excavate trenches of sufficient depth and width to permit proper handling and installation of pipe and fittings.
   3. If the pulling method is used, the pipe "plow" shall be vibratory type. Starting and finishing holes for pipe pulling shall not exceed a 1'-0" by 3'-0" opening.
   4. Excavate to depths required to provide 4" minimum depth of amended earth fill or sand bedding, free of all rock, and debris, for piping **on all sides and bottom of pipe** when rock or other unsuitable bearing material is encountered.
   5. Fill to match adjacent grade elevations with approved earth fill material. Place and compact fill in layers not greater that 8" depth.
      a. Provide approved earth fill or sand to a point 4" above the top of pipe - free of rock and debris
      b. Fill to within 6" of final grade with approved excavated or borrows fill materials free of lumps or rocks larger than 2" in any dimension.
      c. Provide clean topsoil fill free of rocks and debris for top 6" of fill.

6. Except as indicated, install irrigation main lines with a minimum cover of 24" based on finished grades with a minimum depth of 30". Install irrigation lateral lines with a minimum cover of 18" based on finished grades with a minimum depth of 24". No sweeping of lateral lines.
7. Excavate trenches and install piping and fill during the same working day. Do not leave open trenches or partially filled trenches open overnight.
8. Replace stripped sod in sufficient time to allow for satisfactory sod recovery and growth. Water stripped and reinstalled sod until irrigation system is placed in operation (irrigation contractor to return turf to original condition or better). Existing turf conditions only.
9. Replace paving of same materials, using joints and patterns to match existing adjoining paving surfaces.
10. Backfill shall be compacted to 95% standard proctor density. Contractor will be responsible for the restoration of all settlement for period of (2) years from acceptance as well as all pipe and/or fitting failures.
11. **Vibratory pulling method to be employed on all greens, tees and fairways where 2" piping is shown on plans. Note: Contractor must shoot or lay wire – pulling shall not be permitted. Furthermore, no pulling when encountering rocky soils.**

B. Plastic pipe:
1. Install plastic pipe in accordance with manufacturer's installation instructions. Provide for thermal expansion and contraction.
2. Saw cut plastic pipe. Use a square-in-sawing vice, to ensure a square cut. Remove burrs and shavings at cut ends prior to installation.
3. Make plastic to plastic joints with solvent weld joints or slip seal joints. Use only solvent and purple cleaner recommended by the pipe manufacturer's instructions. Contractor shall make arrangements with pipe manufacturer for all necessary field assistance.
4. Make plastic to metal joints with Sch. 80 piping.
5. Make solvent weld joints in accordance with manufacturer's recommendations.
6. Allow joints to set at least 24 hours before pressure is applied to the system.
7. Maintain pipe interiors free of dirt and debris. Close open ends of pipe by acceptable methods when pipe installation is not in progress.
8. All gasketed PVC pipe shall be installed per manufacturer's recommendation using appropriate gasket lube.
9. Pulled pipe shall be solvent welded 36 hours in advance of pulling.
10. Contractor shall not drag PVC pipe before installation.
11. No substitution of smaller pipe, only larger sized pipe will be permitted.
12. All piping must be installed as per manufacturer recommendations including piping velocity rates.

C. Sprinklers, fittings, valves and accessories:
1. Install fittings, valves, sprinkler heads, swing joints and accessories in accordance with manufacturer's instructions.
   a. Provide concrete thrust blocks, at all change of directions, bends, reducers, plugs and opposite side of tees and any other unstable point of piping network (see details). 2,000 psi test on thrust block meeting all ASTM specifications C-33 and C-150 or C-175 standards – see section on fittings and tables.

2. Set sprinkler heads perpendicular to finished grades, except as otherwise indicated.
3. Obtain Irrigation Consultant's review and acceptance of height for proposed sprinkler heads and valves prior to installation.
4. Locate sprinkler heads to assure proper coverage of indicated areas. Do not exceed sprinkler head spacing distances indicated (as per manufacturer recommendations).
5. Install pop-up gear driven sprinklers on specified swing joint assemblies. (See Detail)
6. Install quick coupling valves on specified swing joint assemblies. (See Detail)
7. Install controllers as detailed.
   a. Pedestal mounted in locations shown on drawings.
   b. Waterproof wire conduit to provide a complete, waterproof, permanent and neat job. All 120 VAC wiring, including inside of control box – as per local codes.
   c. Ground controller in accordance with manufacturer's recommendations (10 OHMS or less) with Paige Electric plate configuration to get to 10 OHMS or less; measure by a meager device. It will be the responsibility of the contractor to prove such measurement before getting released from the said system installation. (See Plan & details).

D. Paige Electric Control wiring:
1. Install electric control cable in the piping trenches wherever possible. Place wire in trench adjacent to pipe. Install wire with slack to allow for thermal expansion and contraction. Expansion joints in wire may be provided at 200-foot intervals by making 5-6 turns of the wire around a piece of ½" pipe instead of slack. Where necessary to run wire in a separate trench, provide a minimum cover of 18" or as per local codes.
2. Provide sufficient slack at site connections at remote control valves in control boxes, and at all wire splices to allow raising the valve bonnet or splice to the surface without disconnecting the wires when repair is required.
3. Connect each remote control valve or sprinkler head to one address of a central controller except as otherwise indicated.
4. Connect remote control valves or sprinkler heads to a common ground wire system independent of all others.
5. Make secondary wire connections to sprinkler heads, remote control electric valves and splices of wire in the field; using PE listed burial splice connectors (i.e.: 3M DBY or 3M DBR), in accordance with manufacturer's recommendations.
6. Provide tight joints to prevent leakage of water and corrosion build-up on the joint.
7. Provide new sleeves for all locations where existing sleeves are not indicated. Install new sleeves prior to paving installation wherever possible.
8. Install pipe sleeves under existing concrete or asphalt surface by jacking, boring, or hydraulic driving of the sleeve. Remove and replace existing concrete and asphalt surfaces where cutting is necessary. Obtain Owner's permission before setting existing concrete and asphalt surfaces. Where

piping is shown under paved areas that are adjacent to turf areas, install the piping in the turf areas.

9. One approved manufacturer shall be used for the entire project, no multiple manufacturers will be allowed **for all wire, pipe, cement and primer etc**.

E. Flushing, testing and adjustment:
1. After sprinkler piping and swing joints are installed and before sprinkler heads are installed, open control valves and flush out the system with full head of water. Swing joints should be extended above grade by 2-3 feet above grade by a section of pipe. This will help prevent contaminate piping during flushing.
2. Perform system testing upon completion of each section. Make necessary repairs and re-test repaired sections as required.
3. Adjust sprinklers after installation for proper and adequate distribution of the water over the coverage pattern. Adjust for the proper arc of coverage.
4. Test and demonstrate the controller by operating appropriate day, hour, and station selection features as required to automatically start and shut down irrigation cycles to accommodate plant requirements and weather conditions. Station to hold pressure for a minimum of 45 minutes at ± 3% of static set point.

F. Roadway Pipe Crossings HDPE DR11 4710 (see plan):
1. Contractor shall contact and obtain permission from all governing bodies and agencies.
2. Contractor shall install piping, sleeving and wire sleeves in accordance with said agencies.

G. Stream Pipe Crossings (See detail):
1. HDPE DR11 4710.
2. Piping shall be stable and restrained to stop movement of piping.
3. 2” minimal wire sleeve of PVC Sch. 80 conduit (gray in color) or as per local codes, shall be supported separately.

H. Bridge Crossings (See detail)
1. HDPE DR11 4710 can be used for all bridge crossings as needed.
2. Contractor is responsible for proper support system-See Plan
3. All piping to be hidden inside bridge trusses and exited by prefabricated "Z” piping.
4. “Z” piping restrained and/or connected with flanges.

I. Service:
1. When requested, return to the site during the subsequent fall season and winterize the system. Drain all water from the system and blow out the system with compressed air.
2. When requested, return to the site during the subsequent spring season and demonstrate to the Owner the proper procedures for the system start-up, operations, and maintenance (blow out climates only).

3.4 SPARE PARTS

A. Provide the following:
1. Two extra sprinkler head (s) of each size and type.
2. Two extra valve access box(s) of each size and type.
3. Four quick coupler valve keys and swivel elbows.

4. Two repair couplings for each size and type of pipe.
5. One set of service tools – as applicable.

3.5 DISPOSAL OF WASTE MATERIAL

A. Transport unsuitable excavated material, including rock or lava to designated disposal areas on Owner's property. Stockpile or spread as directed. Remove from site and legally dispose of trash and debris.
B. Maintain disposal routes clear, clean, and free of debris.

3.6 ACCEPTANCE

A. Test and demonstrate to the Irrigation Consultant and Owner the satisfactory operation of the system free of leaks.
B. Instruct the Owner's designated personnel in the operation of the system, including adjustment of sprinklers, controller (s) and central, valves and pump station(s).
C. Upon acceptance the Owner will assume operation of the system-See application for payment

3.7 CLEANING

A. Perform cleaning during installation of the work and upon completion of the work. Remove from site all excess materials, soil, debris, and equipment. Repair damage resulting from irrigation system installation.

V. Electrical

Part 1 - General

1.1 APPLICABLE STANDARDS

A. All apparatus, materials and work, shall be in accordance with standards, practices and codes of the electrical industry. Particular attention is directed to requirements of ANSI/NFPA 70 and Underwriters Laboratories, Inc. as suitable for purposes specified and shown.
B. The completed irrigation installation shall conform to all local and special laws, codes or ordinances of all Federal, State and municipal authorities with due jurisdiction.

1.2 PROJECT CONDITIONS

A. Locations of all controllers, heads and other elements of the system are to be approved by Owner or Owner's Representative before wiring is installed.
B. Conductor sizes are based on copper.
C. Wire and cable routing shown on the drawings are approximate. Route wire as required meeting project conditions-See plan

D. Take precautions to avoid damage to existing site elements and features, including wiring and piping for existing underground irrigation system. Promptly repair damage to such features, cost at Contractor's expense.

Part 2 - Products

2.1 PRIMARY CABLE - See plan

A. All power cables are single conductor or tray cable (or approved equal); UL listed for direct burial, and rated at 600 volts. The cable shall include three conductors, which are to be colored per wire industry standard or numbered as 1, 2, and 3. The size of the "hot" and "common" conductors are to be as shown on the irrigation plans, and the size of the "equipment ground" conductor as required by the National Electrical Code, or larger. The inner copper conductors are to be covered with high dielectric PVC and Nylon. The outer jacket will be black PVC and is to be sunlight resistant. (Paige Electric Co., (or approved equal) LP specification number P7266D for 10 AWG and smaller and specification number P7267D for 8 AWG and larger.)

B. Conduit: As required by code all branch circuit wires, for 120 volts and higher, shall be installed in electrical conduit. The wires shall be type THWN and sized according to the irrigation system plans. Paige Electric Co., LP specification number P7316. Installation shall meet all local codes and regulations as well as NEC requirements for burial conduit piping. The total cross-sectional area of the wires sleeved through the electrical conduit shall be no more than 40% of the internal cross-sectional area of the conduit.

2.2 SECONDARY CABLE

A. Wires connecting the remote control valves to the irrigation controller are single conductors, type PE. Its construction incorporates a solid copper conductor and polyethylene (PE) insulation with a minimum thickness of 0.045 inches. The wires shall be UL listed for direct burial in irrigation systems and be rated at a minimum of 30 VAC. Wire sizes and colors are defined in the irrigation plans and other specifications. (Paige Electric Co., (or approved equal) LP specification number P7079D.)

2.3 EARTH GROUNDING

A. It is the responsibility of the installer to connect all electronic equipment for which they are responsible to earth ground in accordance with Article 250 of the National Electrical Code (NEC). Grounding components will include the items described in the following paragraphs, at a minimum.

Use grounding electrodes that are UL listed or manufactured to meet the minimum requirements of Article 250 of the NEC. At the very minimum, the grounding circuit will include a copper clad steel ground rod, a solid copper ground plate and 100 pounds of PowerSet® earth contact material, as defined. See detail.

Ground rods are to have a minimum diameter of 5/8" and a minimum length of 10 feet. These are to be driven into the ground in a vertical position or an oblique angle not to exceed 45 degrees at a location 10 feet from the electronic equipment, the ground plate, or the wires and cables connected to said equipment. See detail. The rod is to be stamped with the UL logo (Paige Electric part number 182007.) A 6 AWG solid bare copper wire (about 12 feet long) shall be connected to the ground rod by the installer using a Cadweld GR1161G "One-Shot" welding kit (Paige Electric part number 1820037.) This wire shall be connected to the electronic equipment ground lug. See detail.

The copper grounding plate assemblies (Paige Electric part number 182199L) will have minimum dimensions of 4" x 96" x 0.0625" (satellites). A 25-foot continuous length (no splices allowed unless using exothermic welding process) of 6 AWG solid bare copper wire is to be attached to the plate by the manufacturer using an approved welding process. This wire is to be connected to the electronic equipment ground lug as shown in the detail of page 1. The ground plate is to be installed to a minimum depth of 30", or below the frost line if it is lower than 30", at a location 8 feet from the electronic equipment and underground wires and cables. Two 50-pound bags of PowerSet® with a neutral PH value (Paige Electric part number 1820058) earth contact material must be spread so that it surrounds the copper plate evenly along its length within a 6" wide trench. Salts, fertilizers, bentonite clay, cement, coke, carbon, and other chemicals are not to be used to improve soil conductivity because these materials are corrosive and will cause the copper electrodes to erode and become less effective with time.
Install all grounding circuit components in straight lines. When necessary to make bends, do not make sharp turns. To prevent the electrode-discharged energy from re-entering the underground wires and cables, all electrodes shall be installed away from said wires and cables. The spacing between any two electrodes shall be as shown in the detail of page 1, so that they don't compete for the same soil.
The earth-to-ground resistance of this circuit is to be measured using a Megger® or other similar instrument, and the reading is to be no more than 10 ohms. If the resistance is more than 10 ohms, additional ground plates and PowerSet® with a neutral PH value are to be installed in the direction of an irrigated area at a distance of 10', 12', 14', etc. It is required that the soil surrounding copper electrodes be kept at a minimum moisture level of 15% at all times by dedicating an irrigation station at each controller location. The irrigated area should include a circle with a 10-foot radius around the ground rod and a rectangle measuring 1-foot x 24-feet around the plate.

All underground circuit connections are to be made using an exothermic welding process by utilizing products such as the Cadweld "One-Shot" kits. Solder shall not be allowed to make connections. In order to ensure proper ignition of the "One-Shot", the Cadweld T-320 igniter must be utilized (Paige Electric part number 1820040.) The 6 AWG bare copper wires are to be installed in as straight a line as possible, and if it is necessary to make a turn or a bend it shall be done in a sweeping curve with a minimum radius of 8" and a minimum included angle of 90°. Mechanical clamps shall be permitted temporarily during the resistance test process but are to be replaced with Cadweld "One-Shot" kits immediately thereafter.

2.4 BONDING

A. Said grounding circuit is referred-to as "supplementary grounding" in the NEC. And for safety reasons, the NEC required that all supplementary grounds be "bonded" to each other and to the service entrance ground (power source) as shown. This is also "recommended practice" of IEEE Standard 1100-1999. Note that this is in addition to the equipment ground, which is commonly referred to as "the green wire." The power wires (black, white and green for 120 VAC and black, red and green for 240 VAC) must always be kept together in a trench/conduit/tray/etc. The bonding conductors are to be 6 AWG solid bare copper unless the system power conductors are larger than 1/0 AWG, in which case they are to be 4 AWG solid bare copper. All splices to the bonding conductors shall be made using a Cadweld "One-Shot" kit. See details. (Paige Electric part number 1820074)

2.5 SHIELDING – N/A

A. The bonding conductors are to be installed in such a way so that they act as shielding conductors. This becomes a network of solid bare copper wire over all the main bundles of other wires and cables. See details. The bare copper wire is to be installed as close to the surface as possible yet being sufficiently below the ground level as to prevent damage from maintenance equipment such as aerators. And it must be place above all other valve/power/communication wires and cables, per detail, and installed in all trenches as shown on the electrical plan drawings. It is not necessary to install this conductor over short wire runs (less than 150 feet) away from the main wire bundles. The conductor is laid in as straight a line as possible, and when necessary to make bends, do so in a sweeping motion using the detail as a guideline.

Part 3 - Execution

3.1 GENERAL

A. Installation of wiring shall be in accordance with Section IV Irrigation System and in accordance to irrigation system manufacturer's instructions.
B. Any wire or cable that is stressed or damaged in any way shall be replaced at the Contractor's expense.
C. Make splices with approved connector assembly as specified in Section IV Irrigation System.
D. Inspect wire and cable for physical damage and proper connection. Verify continuity of each control circuit.
E. Wire and Cable Installation: Wire and cable burial depth is dictated by the National Electrical Code®. Temperature changes cause wires and cables to expand and contract as much as 1% of the length. And high voltage power lines create large electro-magnetic fields that cause interference and corrupt signals in communication lines. It is therefore necessary to take certain precautions when installing these products.
The contractor shall install all wires and cables carrying up to 30 volts at a minimum burial depth of 6". If mechanical equipment, such as aerifiers and shovels, are expected to disturb the area, then the wires and cables shall be installed at a 12"

depth. For wires and cables carrying more than 30 volts and less than 600 volts, the minimum burial depth shall be 24". When installing wires and cables in a trench, they must be "snaked" so that some slack is created. At points along the trench where there are sharp bends, a loop of 12" to 24" shall be created to allow for shrinkage. When communication cables are in the same trench as power wires, there shall be a minimum separation between them of 12"

F. Wire and Cable Splices:

All electrical connections shall incorporate:

1. A solid mechanical connection of the copper conductors.
2. Electrical insulation of the mechanical connection.
3. A means to waterproof the insulated connection.
4. "Strain-relief" to prevent the connection from coming apart when wires/cables are pulled-upon.