PART 1 – CENTRAL SOFTWARE & COMPUTER for TORO DXi

General Overview

A. The Water Management System shall be a cloud-connected Toro DXi Water Management System (WMS)
B. The System shall include the following general components:
   1. Toro DXi WMS Software (Version 4.0.x.x)
   2. Toro DXi Field Controllers with conventional wiring terminals, wireless output board terminals or two-wire (each controller capable of up to 204-stations)
   3. Toro DXi Communications Hardware
   4. Central Computer utilizing Windows 10 Operating System
C. The system central computer may be furnished by the owner or purchased as part of the Water Management System package from Toro. The owner supplied computer must meet the minimum specifications as required by central software

Central Software

A. The central software shall have the following programming features:
   1. Access to the programming features of field controllers through PC-based cloud-connected central software
   2. Controls up to 999 field controllers
   3. Group field controllers into "Systems" for system-wide adjustment of:
      a. Rain Shutdowns
      b. Percent Scale (Percent Adjust)
      c. ET adjustment from shared weather source
      d. Alarm reporting
      e. Flow usage
   4. Separate each field controller into 16 unique programs
      a. Each program shall have the following setup options:
         i   Specified start times (1-8)
         ii   6-week Active Water Days scheduling
         iii Hour/minute or Minutes/seconds runtime format
         iv   Percent Adjust from 0–255% by field controller, program or station, across the system
         v   Cycle Delay
         vi   Program Repeats
         vii Continuous Run (Continuous Program Repeat from start to end time)
         viii Water Window
         ix   Activate Auxiliary Pump
         x   ET-based Run Time
         xi   Soil Moisture based operation
         xii Percent Scale from 0–255% by field controller, program or station, across the system
         xiii Two Sensor alarms: Stop, Start, Pause based on dry contact sensor status
         xiv Omit Dates
         xv   Irrigation or Non-Irrigation programs
         xvi Volumetric Shutdown: by day, week, biweekly, monthly

5. Separate each field controller into 16 watering day schedules
    a. Each schedule shall have the following:
        i   Rolling 6-week format
        ii   Multiple standard Odd/Even or Interval options
6. Adjustment of station runtimes by:
    a. Manual runtime adjustment
    b. Manual percentage adjustments
    c. Maximum cycle time with station delay
    d. Automatic acquisition of evapotranspiration data
    e. Historical evapotranspiration
    f. Soil moisture sensor readings
B. The central software shall have the ability to import maps and have interactive symbols representing field locations of valves.
C. Map shall include the following:
    1. Jpg or bmp formatted image
    2. Valve icons indicating
        a. Manually activated valves
        b. Automatically activated valves
        c. Master valve or pump operation
D. The central software shall have the ability to monitor up to (2) flow inputs directly connected to each field controller and an additional (14) via Toro DXi Wireless Output Boards or (3) via flow decoder or any combination of both
E. Central software shall have the ability to:
    1. Learn and record flow of individual stations
    2. Record flow on a daily, weekly, yearly basis
    3. Record station flow violations including:
        a. High flow
        b. Low flow
        c. Zero flow
        d. Mainline high flow
        e. Volumetric shutdowns
F. The central software shall be able to automatically schedule program start times based on flow of individual stations.
G. Flow optimization shall include the following features:
    1. Create water sources with maximum flow
    2. Create flow zones associated to water sources with maximum flow
    3. Individually assign stations to water sources or flow zones
    4. Automatically run the Scheduler at a predetermined time
    5. Automatically run the Scheduler after retrieval and recalculation of ET runtimes
    6. Automatically send rescheduled start times to field controllers
H. The central software shall be able to have (4) levels of security access
    1. Administrator
    2. Program changes, manual starts, rain days, controller configuration changes
    3. Program changes, manual start, rain days
    4. Manual start, rain days
I. The central software shall be able to pre-program Omit Days via calendar selection and shall allow for a one-time or annual omit of selectable programs per controller

J. The central software shall be able to monitor (2) alarm switch inputs per controller, either normally open or normally closed. A pre-programmed action shall take place that includes:
1. Start programs based on switch change of state
2. Stop and block programs based on switch change of state
3. Pause programs based on switch change of state
K. The central software shall have the ability to monitor (16) wireless or wired soil moisture sensors per field controller (one per program) Each sensor shall be able to learn low and high moisture levels and control program starts and cycles based on moisture thresholds Sensor readings will be in volumetric values and can be scaled from 0% to 100% The central software shall be able to graph 14 days of soil moisture, temperature and salinity from two sensor levels from the wireless sensor and soil moisture and temperature from the wired sensor and display current moisture readings to set thresholds
L. Threshold settings shall allow for the following methods of control:
1. Threshold settings shall allow for start on low moisture, stop on high
2. Start on low threshold and run pre-set time
3. Start when below high moisture and run to high threshold
4. Start on low threshold and run based on evapotranspiration calculated time
5. Sensor control shall include "plant stress protection" enabling starts based on depletion trends
M. The central software shall have the ability to connect to an unlimited quantity of weather stations:
1. The weather stations can be either virtual via the internet or from an onsite installed weather station
2. The weather stations will measure and store temperature, relative humidity, dew point, wind speed and direction, and solar radiation for use in the calculation of evapotranspiration
3. The central shall automatically communicate ET data to field controllers for recalculation of watering times
N. The central software shall be capable of monitoring rainfall at a weather station or rain collector and implement a rain delay based on user-defined inputs including:
1. Rain threshold amount
2. Sampling period
3. Saved rain off to activate when threshold reached
4. System to affect
5. Reset condition
O. The central software shall be capable of monitoring temperature from a weather station and implement a delay based on user-defined inputs including:
1. Temperature threshold amount
2. Sampling period
3. Saved shutdowns activate when threshold reached
4. System to affect
5. Reset condition
P. The central software shall provide a Controller Activity/Alarm Report This report will display and print controller alarm and warning events that show various field anomalies Such events include:
1. Failed communications
2. Station high flow (Informational or Shutdown)
3. Station low flow (Informational or Shutdown)
4. Station zero flow (Informational or Shutdown)
5. Main line overflow
6. Unscheduled flow
7. Electrical current violations
8. Open circuits

9. Max station violation
10. Power failures
11. Decoder communication failures
12. Stations in programs
13. Stations in rain hold
14. Station runtime since day change
15. Soil moisture readings
16. Soil temperature readings
17. Soil salinity readings
18. Soil Sensor battery voltage
19. Program status based on moisture levels
20. Communication status of moisture sensors

Q. The central software will be capable of automatically creating and storing reports in an RTF format with specific date stamps in a user-defined location and include:
1. Station alarms
2. Station runtime since last day change
3. Stations in programs
4. Downloaded ET and rainfall
5. Daily water use
6. Weekly water use
7. Monthly water use
8. Yearly water use

R. The central software will be capable of exporting the following controller data to an Excel spreadsheet:
1. Monthly water usage
2. Monthly accumulated ET
3. Monthly accumulated rainfall

S. The central software will be capable of automatically sending Controller and System Activity/Alarm reports to specific email addresses

T. The central software shall come standard with the following support:
1. Central computers provided by the manufacture shall come with two years of software support, computer warranty, remote access and an internet-based ET service

The central software will be capable of exporting the following controller data to an Excel spreadsheet The central software will be capable of accessing and displaying real time maps of each Cloud Connected Controller showing Irrigation status, Cloud Connectivity Status, and alarm and rain hold status.

U. The central software will be capable of accessing and displaying real time maps of each Cloud Connected Controller showing Irrigation status, Cloud Connectivity Status, and alarm and rain hold status.

Central Computer Minimum Specifications
A. The central computer shall have the following minimum features:
1. Windows 11 operating system
2. Microsoft Net Framework 4.8
3. Intel® Core™ i3-6100 Processor (3M Cache, 370 GHz)
4. 8G RAM

5. 500 GB Hard Drive
6. 3 USB Ports
7. Microsoft Excel (used for some reports)

PART 2 - COMPUTER TO CONTROLLER COMMUNICATIONS

A. The central computer shall be capable of multiple communication modes and must allow for mixed modes within the same system
B. Computer to controller communications methods can be:
1. Cloud-connected to Toro DXi servers (Cellular, Ethernet, WIFI)
2. Cellular – Static IP
3. Ethernet – Static IP
4. WIFI
5. Narrowband, UHF data radio
6. Spread Spectrum radio
7. Serial Cable
C. All communications, regardless of mode, will be true two-way and will provide visual and/or audio confirmation of receipt
D. The field controller shall be capable of uninterrupted operation in the event that the central computer is not operational or communication failure with one or more controllers has occurred
E. A field radio site survey shall be conducted when using UHF radio and/or Spread Spectrum radio

PART 3 – TORO DXi Controller (Conventional Wired or AC Two-Wire Controller)

A. General Features include:
1. Central control capable with Toro DXi WMS software (Version 4.0.x.x)
2. Operational as standalone
3. Learn mode for individual station flow
4. Communicates via cloud-connection, cellular, UHF radio, 900MHz radio, Ethernet and WIFI
5. Cellular communication to include 10-year data plan
6. ProMax Connect™ smartphone application compatible for cellular, Ethernet and WIFI connected controllers
7. Compatible with up to (3) Toro AC flow decoders (TW-DAC-FLOW) per two-wire controller. Compatible with a total of (16) flow decoders via two-wire path, controller terminal connections, and wireless output boards
8. Compatible with up to (16) toro wired (TW-DAC-SOIL) or wireless Toro soil moisture sensors via two-wire path or wireless via Toro DXi wireless base station
9. Programmable omit days by individual programs
10. Flow sharing allowing multiple locations (Toro DXi and WOB's) share pumps, master valves and flow meter information for mainline, station high, low and zero flow identification and shutdown
11. EPA WaterSense®™ certified
12. Underwriters Laboratories (UL) listed
13. 5-year limited warranty
B. Hardware Features
1. The field controller shall be available in painted or stainless-steel wall-mount cabinet, stainless steel single or double wide pedestal and plastic pedestal

2. Conventional station configurations shall be available from (8) to (204) via (8) station output modules or wireless boards
3. Two-wire station configuration shall be available from (1) to (204)
4. The field controller shall include (1) output dedicated for a configurable Normally Open or Normally Closed master valve and another output for pump start
5. The field controller shall allow for a total of (16) master valves and (16) pump starts via dedicated station outputs
6. The field controller shall include connections for (2) flow sensors, (1) pulse input devices, e.g., rain bucket, and (2) alarm input contact devices for either normally open or normally closed
7. The field controller shall have a 4.4" QVGA high resolution liquid crystal monochrome display and include back lighting
8. The field controller shall include a built-in remote jack for ProMax™ remote control. A permanent internal remote mount shall be available
9. The field controller shall include built-in transient and lightning protection
10. The field controller shall have lifetime retention of the user's program data without battery backup
11. The field controller shall include protection from field wiring short circuits and have a built-in amperage meter to measure and diagnose valve solenoid electrical problems
12. The field controller shall include a built-in port for 900MHz radio and communicate to up to (4) 900MHz wireless output boards

C. Scheduling Capabilities shall include:
1. (16) programs and (8) start times per program
2. (6) week rolling schedule of operating days
3. Continuous cycles of programs based on start and end times, with program delay and soak time
4. Water budget from 10% to 250% in 1% increments
5. Programable stations from (1) second to (4)hours and (15) minutes
6. Volumetric water totals by program and by water window and indicate (or shutdown) if exceeds user set limits
7. Programable water window, repeat cycles, cycle delay, rain delay and rain shut-off
8. Rain sensor assignment by program
9. Non-irrigation program assignment independent of automatic rain shutdowns

D. Maintenance and Alarm Diagnostics to include:
1. Flow monitoring with alarm processing including station and master valve shut down and station advance as required Under flow and zero flow reporting by station
2. Electrical field solenoid monitoring including alarm processing and reporting of power outages, station over current, station open conditions and short circuits
3. Diagnostic lights (LED's) for system power and all station outputs. Terminal board light activation via 24 VAC
4. Built-in test functions for selected controller circuitry
5. Manual test modes automatically advance for station-to-station operation indicating actual flow and solenoid amperage
6. Manual station and multi-manual station modes via software, controller keypad, ProMax remote and (ProMax Connect app for Cloud Connected Controllers)
7. Manual program activation via software, controller keypad, ProMax remote and ProMax Connect app
8. Interior lighting (fridge light) for enhanced service and maintenance
9. Pivoting brackets (Pivotech™) for ease of field wiring connections

E. Electrical Specifications
1. Input power required: 120 VAC +/- 15%, 60Hz

2. Maximum load current per station, master valve or pump output: 2.5 Amps
3. Maximum combined load current: 2.75 Amps
4. No batteries required

PART 4 – TORO DXi FIELD CONTROLLER HARDWARE (Conventional Wired Field Controllers)

A. The field controller shall use solid-state control technology and be capable of automatic, semi-automatic and manual operations
B. The field controller shall be programmable by the built-in keyboard and rotary dial with back-lit LCD
C. The field controller shall have built-in diagnostics indicating specific field controller or field alarms, network settings and testing of field stations
D. The field controller shall be in a locking stainless steel or powder-coated metal wall mount, stainless steel pedestal or plastic pedestal cabinet
E. The field controller shall have secured access with multiple user logins
F. Access to high voltage and 24-volt field wire shall be through a front door panel with a keyed lock
G. The pedestal model shall bolt into a concrete footing that has mounting bolts embedded in the concrete pad The concrete pad shall be sloped away from the pedestal to prevent water accumulation around the base of the cabinet
H. The field controller shall be capable of operating up to (204) stations
I. The field controller shall be capable of activating station output boards (8 stations each) via attached ribbon cables or short-range and/or long-range spread spectrum radios
J. The field controller shall be capable of operating at 115 VAC (+/- 10%) 50/60Hz and be capable of withstanding an incoming surge or electrical spike or 4.5 kV on the input side
K. Each 24-volt station output shall be capable of delivering 0.5 amperes at (12VA) at 24 VAC
L. The field controller shall be capable of operating (8) multiple stations for a total output current of 2.5 amperes at 24 VAC
M. The field controller shall have a built-in Ethernet port for optional network connectivity
N. The field controller shall have a built-in wireless soil moisture sensing port for optional Wireless Soil Sensing Base Station connection
O. The field controller shall have a built-in USB port for field firmware updates and program back-up
P. The field controller shall have (2) built-in nine pin serial ports
Q. The field controller shall have status lights indicating alarms, current irrigation and rain holds
R. The field controller shall have the ability to read (2) flow inputs connected directly to a data-retrieval terminal connection inside the field controller cabinet and read, display and record real-time gallons per minute
S. The field controller shall have the ability to read an additional (14) flow inputs via optional wireless output remote modules
T. The surge testing shall conform to the following standards:
    a. ICE 61000 Standard for Lighting Surge, 1089 Bellcore Testing, UL 1449
U. The 24-volt output board with full surge shall be capable of withstanding field surges in excess of 20 KV
V. The field controller shall have manual activation switches and LEDs indicating station operation for each station
W. The field controller shall have the capability to activate (16) separate master valves via mirrored master valve designation

X.   The field controller shall come standard with back-up battery for real-time clock retention in the event of a power failure The field controller shall maintain the time-of-day, day-of-week and user defined programs

Y. The field controller control module components shall be enclosed in a weather resistant plastic case

Z. The field controller shall be grounded according to the *ASIC 100-2002 Grounding Guidelines*

AA.   The field controller shall come with a 5-year hardware warranty

PART 5 – TORO DXi FIELD CONTROLLER HARDWARE (Wireless Output Board Modules)

A. The wireless output board module shall use solid-state control technology and be capable of automatic, semi-automatic and manual operations

B. The wireless output board module shall be programmable by a separate field controller with on-board keyboard with rotary dial with back-lit LCD

C. The wireless output board module shall be in a locking stainless steel, powder-coated metal wall mount, stainless steel pedestal or plastic pedestal

D. Access to high voltage and field wire shall be through a front door panel with a keyed lock

E. The pedestal model shall bolt into a concrete footing that has mounting bolts embedded in the concrete pad The concrete pad shall be sloped away from the pedestal to prevent water accumulation around the base of the cabinet

F. The wireless output board module shall be capable of operating up to (48) stations via conventional wired valves

G. The wireless output board module shall operate 24VAC solenoids and be able to activate (6) individual valves simultaneously

H. The wireless output board module shall be capable of operating at 115 VAC (+/- 10%) 60Hz and be capable of withstanding an incoming surge or electrical spike or 4.5 kV on the input side

I. The wireless output board module shall have the ability to read (1) flow input connected directly to a data-retrieval terminal connection inside the wireless output remote module cabinet

J. The wireless output board module shall have the capability to operate (1) master valve from the on-board master valve terminal. The master valve shall be normally closed

K. The wireless output board module shall come with a 5-year hardware warranty

PART 6 – TORO DXi FIELD CONTROLLER PROGRAMMING CAPABILITIES

A. Time-of-day, day-of-week, expected flow, actual flow and operational status shall be shown in LCD display

B. The field controller shall have a real-time clock with adjustable day change hour

C. The field controller shall have (16) independent programs

D. Each station shall be assigned independently to any or all of the (16) programs

E. Each program shall be assigned to any of (16) independent watering schedules

F. Each program shall have (8) start times, (99) repeat cycles with a programmable delay between cycles from 0-255 minutes

G. Each program shall have a programmable water window where watering will only take place between a start and end time

H. The field controller shall be capable of running any one or combination of programs simultaneously

I. The field controller shall have a program adjust feature that allows for independent percent-adjust feature that allows for independent percentage adjustment of each program from 10% to 250% in 1% increments

J. The field controller shall have the ability to monitor up to (16) wireless soil moisture sensors. Each sensor shall be able to learn low and high moisture levels and control program starts based on both moisture levels Sensor readings will be in volumetric values and can be scaled from 0% to 100%
   1. Threshold settings shall allow for start on low moisture, stop on high
   2. Start on low threshold and run pre-set time
   3. Start when below high moisture and run to high threshold
   4. Start on low threshold and run based on evapotranspiration calculated time
K. The field controller shall be capable of running irrigation programs based on Evapo-Transpiration (ET) input. When the ET functions are activated, the field controller automatically adjusts program run times according to the ET data
L. The field controller shall have a non-volatile memory that can maintain time and all programming functions
M. When the field controller is operating in either manual or automatic modes, the remaining run time shall be displayed
N. The field controller shall have the following additional standard features in a stand-alone mode:
   1. Alarm alerts
   2. Ability to create and store programs for future use
   3. Ability to read and react to low, high and zero flow
   4. Ability to store water usage by day, week, month and year
   5. Ability to view soil moisture readings
   6. Ability to read and react to current draw of all AC powered stations
   7. Ability to test decoders for communication
   8. Ability to set field controller to static or dynamic IP address
   9. Ability to program decoder addresses
   10. Ability to test UHF radio with a bounce-back signal

PART 7 – TORO DXi FIELD REMOTE ACCESS

Promax Connect App
A. The field controller when cloud-connected shall be accessible via the Promax Connect App
B. The Promax Connect App shall be free to download from IOS or Android App Stores
C. The Promax Connect App shall display all online and offline field controllers associated with an Organization
D. The Promax Connect App shall display all current activities with individual controllers including:
   1. Alerts
   2. Current Irrigation
   3. Rain Holds
   4. Current Flow
   5. Required Firmware Updates
E. The Promax Connect App shall allow for individual station operation, program operation, all station test and syringe of individual stations
F. The Promax Connect App shall allow for full controller shutdown and controller rain hold from (1) day to indefinite time
G. The Promax Connect App shall allow for GPS location of the field controller viewable via Google Maps

Promax Maintenance Remote
A. An optional Promax Remote shall be compatible with the field controller

B. The Promax Remote receiver shall be either factory installed or manually plugged into each field controller via a receiver port on the field controller faceplate
C. The Promax Remote shall communicate via VHF wireless signals
D. The Promax Remote shall allow for individual station and program level control
E. If factory installed the Promax receiver shall come with a unique receive number to prevent cross-communication across multiple controller sites

PART 8 – TORO DXi ACCESSORY EQUIPMENT

Flow Sensors
A. The flow sensor shall be an in-line type with a non-magnetic, spinning impeller (paddle wheel) as the only moving part or ultrasonic type
B. The electronics housing shall be glass-filled PPS
C. The impeller shall be glass-filled nylon or Tefzel® with a UHMWPE or Tefzel sleeve bearing
D. The shaft material shall be tungsten carbide
E. The electronics housing shall have two ethylene propylene O-Rings and shall be easily removed from the meter body The sensor electronics will be potted in an epoxy compound designed for prolonged immersion
F. Electrical connections shall be 2 single conductor 18 AWG leads 48 inches long Insulation shall be direct burial "UF" type colored red for the positive lead and black for the negative lead
G. The sensor shall operate in line pressures up to 100 psi and liquid temperatures up to 140° F and operate in flows of 1⁄2 foot per second to 20 feet per second with linearity of ± 1% and repeatability of ± 1%
H. The sensor body shall be fabricated from Schedule 80 PVC Tees, available in 11⁄2", 2", 3, and 4" with socket end connections
I. The flow sensor shall come with a 2-year warranty

Flow Decoder
A. The flow decoder shall have true two-way communication using a 9-byte packet for commands and replies
B. The flow decoder shall be programmed to a recognizable address via the Toro DXi AC two-wire mother board to flow sensor 3 to 16. Only (3) flow decoders can be programmed per Toro DXi controller
C. The flow decoder shall include 24" of 16-guage PVC jacketed solid core wire to connect to the two-wire and 24" of 18-guage PVC jacketed stranded core wire to connect to the pulse output flow sensor
D. The flow decoder shall be able to read a pulse-output flow sensor up to 1000 feet from the decoder connection on the two-wire path
E. The flow decoder shall use DBR-6, DBG or equivalent direct bury splice suitable for full submersion and seal all moisture out
F. Electrical connector shall have a minimum voltage rating of 600 volts
G. No loose or unshielded wire shall touch the soil, water or any other copper conductor
H. All electrical splices shall be made inside the valve box with the flow decoder

Cable for Flow Sensors
A. Approved flow sensors may be located up to 2000' from the field controller

B. All data communications wire connecting flow sensors to the electronics that are buried below grade, with or without conduit, shall be constructed to direct burial specifications similar to Telecommunications Exchange Cable (REA PE-89)

C. The cable shall be constructed of 20 AWG, or larger, copper conductors twisted into pairs of varying lengths to prevent cross talk and include a drain wire for optional field grounding. Conductors shall be insulated with polyethylene or propylene with a suggested working voltage of 350 volts

D. The cable shall feature an aluminum-polyester shield and be finished with a black high-density polyethylene jacket Cable should be equivalent to AT&T PE-39 or PE-89

    1. Communication cable shall be installed in a separate trench a minimum of 12" per 100 volts away from power cable and a minimum of 12" from any two-wire communication cable

Splices for Flow Sensors

A. All wire connections shall be watertight with no leakage to ground or shorting from one conductor to another

B. All splices shall be made in accordance with National Electrical Code® Articles 3005 (Underground Installations) and 11014 (Electrical Connections) using 3M DBY-6 or DBR-6 connectors, which are UL listed under "UL 486D-Direct Burial", for wet or damp locations, 600 volts

Grounding for Flow Sensors

A. The flow sensor shall be grounded via the drain wire in the communication cable to a ground rod either at the flow sensor location or the controller, but not at both ends

Weather Stations and Rain Collectors

A. The weather station shall be located in an area "representing" the typical landscape to be irrigated

B. The weather station shall be available in both wireless and cabled versions. The station shall include a sensor suite combining rain, temperature, humidity, solar radiation and anemometer in one package. A desktop console/data logger shall be included that provides "at a glance" weather information. The rain collector shall read rainfall amounts in .001" increments and accumulate up to 200" of annual rainfall. The anemometer shall be able to read wind speeds up to 150 mph. The temperature gauge shall be able to read outside temperature readings from -40 degrees to +150 degrees. The station shall record daily ET (Evapotranspiration) and log monthly and yearly amounts up to a total of 200" of ET

C. The station shall provide software that runs locally on the same PC and OS running the irrigation control equipment. The software shall provide screens for viewing current dynamic weather conditions from all weather sensors. The software shall allow for generation of reports in table or graph format. Graphing shall be in either line or bar graph formats

D. The weather station shall connect to the central computer via direct cable, spread spectrum radio, Ethernet or cell data modem

E. The weather stations shall be installed as per manufacturer's specifications

F. Virtual weather stations shall be setup via the Toro WMS software and include a specific latitude and longitude reference

G. Virtual weather stations shall provide a daily (ET) evapotranspiration value and rain value

Wired Rain Collector

A. Rain collector sensors shall be magnetic type tipping bucket with reed switch

B. Rain collector housing shall be constructed of aluminum or high-density UV resistant plastic

C. Rain Collector sensors may be located no farther than 500' from the field controller

D. All data communications wire connecting rain collectors to the electronics that are buried below grade, with or without conduit, shall be constructed to direct burial specifications similar to Telecommunications Exchange Cable (REA PE-89)
E. The cable shall be constructed of 20 AWG, or larger, copper conductor twisted into pairs of varying lengths to prevent cross talk. Conductors shall be insulated with polyethylene or propylene with a suggested working voltage of 350 volts
F. The cable shall feature an aluminum-polyester shield and be finished with a black high-density polyethylene jacket. Cable should be equivalent to AT&T PE-39 or PE-89
      1. Communication cable shall be installed in a separate trench a minimum of 12" per 100 volts away from power cable and a minimum of 12" from any two-wire communication cable

Splices for Rain Collector
A. All wire connections shall be watertight with no leakage to ground or shorting from one conductor to another
B. All splices shall be made in accordance with National Electrical Code® Articles 3005 (Underground Installations) and 11014 (Electrical Connections) using 3M DBY-6 or DBR-6 connectors, which are UL listed under "UL 486D-Direct Burial", for wet or damp locations, 600 volts

Soil Moisture Sensing
A. The soil moisture sensors shall be located in typical areas representing the controlled program. Sensors shall be installed by removing enough soil to insert the sensor below grade before installing the moisture sensor into undisturbed soil
B.   Equipment:
     a. Wireless (TG-S2-R)
        i. Sensor shall measure upper and lower soil moisture, soil temperature and soil salinity and display on controller LCD and central software
        ii. Sensor shall use a wireless base station (TS-TGB) utilizing spread spectrum communications to the sensor
        iii. Sensors shall be waterproof and have a body dimension of 2" x 3" x 5" with three or six spikes at 2" x 3/16". Sensors shall have an operating temperature of 32° to 140°F
        iv. Sensor transmitter shall have a line-of-sight range of up to 500 feet from the buried location and shall operate at 902-928 MHz band (unlicensed in the United States)
        v. Sensors shall not exceed 500' from a wireless base station unless repeaters are added to the system
        vi. Repeaters shall be used in areas to increase wireless range. Repeaters shall be installed up to 1500' from a wireless base station and 500' from wireless soil moisture sensor
        vii. If the Toro DXi controller is installed inside a building, then a base station extension cable shall be used up to 100' to mount the base station on an outside wall
        viii. Sensors shall have a battery life of 3 to 5 years from date of installation
        ix. Sensors shall come with a 2-year manufacture warranty
     b. Wired (TW-DAC-SOIL)
        i. Sensor shall be constructed of a multi-layered fiberglass stick measuring 32" x 325" x 075" and connect and communicate only through the Toro DXi AC two-wire path

ii. Sensor shall measure moisture using Time Domain Transmission technology
iii. Sensor shall measure soil temperature in addition to soil moisture
iv. Sensor shall include 50' of 18-gauge (UL) direct burial lead wire for connection to the two-wire path (voltage rating: 300V, temp rating: 167°F)
v. Sensor shall be buried 2" to 3" from finished grade surface and installed horizontally where the .75" dimension of the sensor is facing up
vi. Sensor splices shall be 3M™ DBR/Y-6 or equivalent direct burial moisture resistant connector and installed in an accessible valve box
vii. Sensors shall come with a 2-year manufacture warranty

END OF SECTION