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Sentinel® WMS Design Guide:
Bidding Specifications

PART 1 - CENTRAL SOFTWARE

General Overview

A. The Water Management System shall be a Toro Sentinel Water Management System (WMS).

B. The System shall include the following general components:
   1. Sentinel WMS Software
   2. Sentinel Field Satellites with conventional wiring terminals, wireless output board terminals or two-wire (each satellite capable of up to 204-stations)
   3. Sentinel Communications Hardware
   4. Central Computer utilizing Windows 7® or Windows 8® 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 satellites through PC-based Central software.
   2. Controls up to 999 field satellites.
   3. Group field satellites into "Systems" for system-wide adjustment of:
      a. Rain Shut Downs
      b. Percent Scale (Percent Adjust)
      c. ET adjustment from shared weather source
   4. Separate each field satellite into 16 unique programs. Each program shall have the following setup options:
      a. Specified start times (1-8)
      b. 6-week Active Water Days scheduling
      c. Hour/minute runtime format
      d. Percent Scale
      e. Cycle Delay
      f. Program Repeats
      g. Continuous Run (Continuous Program Repeat)
      h. Water Window
      i. Activate Auxiliary Pump.
      j. ET-based Run Time
      k. Soil Moisture based operation
      l. Percent Scale from 0–255% by field satellite, program or station, across the system
   5. Separate each field satellite into 16 watering day schedules. Each schedule shall have the following:
      a. Rolling 6-week format
      b. Ability to overlay on current calendar
      c. Multiple standard Odd/Even or Interval options
   6. Adjustment of station runtimes by:
      a. Manual runtime adjustment
      b. Manual percentage adjustments
      c. Automatic acquisition of evapotranspiration data
      d. Historical evapotranspiration
      e. Soil moisture sensor readings

B. The central software shall have the ability to import maps and have interactive symbols representing field locations of valves. 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

C. The central software shall have the ability to monitor up to (2) flow inputs directly connected to each field satellite. 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

D. The central software shall be able to automatically schedule program start times based on flow of individual stations. 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 satellites

E. The central software shall be able to monitor (1) alarm switch inputs, 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

F. The central software shall have the ability to monitor (16) wireless soil moisture sensors per field satellite (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%.
   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

G. The central software shall have the ability to connect to an unlimited quantity of weather stations:
   1. 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.
   2. The central shall automatically communicate ET data to field satellites for recalculation of watering times.

H. 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

I. 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 shut downs activate when threshold reached
   4. System to affect
   5. Reset condition

J. The central software shall provide a Satellite Activity/Alarm Report. This report will display and print satellite alarm and warning events that show various field anomalies. Such events include:
   1. Failed communications
   2. Station high flow
   3. Station low flow
   4. Station zero flow
   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

K. 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

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

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

N. 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.

PART 2 - COMPUTER TO SATELLITE 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 satellite communications methods can be:
   1. Narrowband, UHF data radio
   2. Spread Spectrum radio
   3. Cellular Technology
   4. Ethernet
   5. WIFI
   6. Fiber Optics
   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 satellite shall be capable of uninterrupted operation in the event that the central computer is not operational or communication failure with one or more satellites has occurred.

E. A field radio site survey shall be conducted when using UHF radio and/or Spread Spectrum radio.

F. The site survey shall be conducted by a factory-trained service representative.

G. The site survey shall include in writing, verification of communications from base radios to field satellite controllers, suitable UHF radio frequency for operations and locations of any external antennas.

H. When using UHF radio as the means of central computer to field satellite communications, an FCC license will be provided by the factory trained service representative conducting the site survey.

PART 3 - COMPUTER TO SATELLITE HARDWARE (Communication Termination Module)

A. The central computer shall communicate to the field satellites via a Communication Termination Module (CTM).

B. The module will be housed in a locking stainless steel cabinet for indoor or outdoor mount.

C. The Communication Termination Module (CTM) will include (2) 9-pin serial ports and Ethernet port for communication.

D. The Communication Termination Module (CTM) shall include a 2-watt UHF radio with a BNC connector for external antenna connection.

E. The Communication Termination Module shall come with a 5-year hardware warranty.

PART 4 - FIELD SATELLITE HARDWARE (Conventional Wired Field Satellites)

A. The field satellite shall use solid-state control technology and be capable of automatic, semi-automatic and manual operations.

B. The field satellite shall be programmable by the built-in keyboard and rotary dial with back-lit LCD. (*Remove this feature if using Sentinel Faceless field satellites.*)

C. The field satellite shall have built-in diagnostics indicating specific field satellite or field alarms, network settings and testing of field stations.

D. The field satellite shall be in a locking stainless steel or powder-coated metal wall mount, stainless steel pedestal or plastic pedestal cabinet.

E. Access to high voltage and 24-volt field wire shall be through a front door panel with a keyed lock.

F. 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.

G. The field satellite shall be capable of operating up to 204 stations.

H. The field satellite shall be capable of activating station output boards via attached ribbon cables or short-range and/or long-range spread spectrum radios.

I. The field satellite shall be capable of operating at 115 V a.c. (+/- 10%) 50/60Hz and be capable of withstanding an incoming surge or electrical spike or 4.5 kV on the input side.

J. Each 24-volt station output shall be capable of delivering 0.5 amperes at (12VA) at 24 V a.c.

K. The field satellite shall be capable of operating (6) multiple stations for a total output current of 2.0 amperes at 24 V a.c.

L. The field satellite shall have a built-in Ethernet port for optional network connectivity.

M. The field satellite shall have a built-in wireless soil moisture sensing port for optional Wireless Soil Sensing Base Station connection.

N. The field satellite shall have a built-in USB port for field firmware updates and program back-up.

O. The field satellite shall have (2) built-in nine pin serial ports.

P. The field satellite shall have status lights indicating alarms, current irrigation and rain holds. *(Remove this feature if using Sentinel Faceless field satellites.)*

Q. The field satellite shall have the ability to read (2) flow inputs connected directly to a data-retrieval terminal connection inside the field satellite cabinet and read, display and record real-time gallons per minute.

R. The field satellite shall have the ability to read an additional (14) flow inputs via optional wireless output remote modules.

S. The surge testing shall conform to the following standards: ICE 61000 Standard for Lighting Surge, 1089 Bellcore Testing, UL 1449.

T. The 24-volt output board with full surge shall be capable of withstanding field surges in excess of 20 KV.

U. The field satellite shall have manual activation switches and LEDs indicating station operation for each station.

V. The field satellite shall have the capability to activate (16) separate master valves via mirrored master valve designation.

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

X. The field satellite control module components shall be enclosed in a weather resistant plastic case.

Y. The field satellite shall be grounded according to the ASIC 100-2002 Grounding Guidelines.

Z. The field satellite shall come with a 5-year hardware warranty.

PART 5 - FIELD SATELLITE HARDWARE (Two Wire – DC Solenoids)

A. The field satellite shall use solid-state control technology and be capable of automatic, semi-automatic and manual operations.

B. The field satellite shall be programmable by the on-board keyboard with rotary dial with back-lit LCD.

C. The field satellite shall have built-in diagnostics indicating specific field satellite or field alarms, network settings and testing of field stations.

D. The field satellite shall be in a locking stainless steel, powder-coated metal wall mount, stainless steel pedestal or plastic pedestal.

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

F. 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.

G. The field satellite shall be capable of operating up to 204 stations.

H. The field satellite shall be capable of connecting either a short-range and/ or long-range spread spectrum radio for activation of wireless output remote modules.

I. The field satellite shall have a built-in Ethernet port for optional network connectivity

J. The field satellite shall have a built-in wireless soil moisture sensing port for optional Wireless Soil Moisture Sensing Base Station connection.

K. The field satellite shall have a built-in USB port for field firmware updates and program back-up.

L. The field satellite shall have (2) built-in nine pin serial ports.

M. The field satellite shall operate DC latching solenoids and be able to activate (16) decoders, and (32) individual valves simultaneously.

N. The field satellite shall have non-volatile memory and self-diagnostics to identify decoder communication and open circuits.

O. The field satellite shall be able to run all decoders on #14 AWG cable up to 15,000 feet in any direction from the field satellite.

P. The field satellite shall have the ability to read (2) flow inputs connected directly to a data-retrieval terminal connection inside the field satellite cabinet and read, display and record real-time gallons per minute.

Q. The field satellite shall have the ability to read an additional (14) flow inputs via optional wireless output remote modules.

R. The field satellite shall have the capability to activate (16) separate master valves via mirrored master valve designation.

S. The field satellite shall come standard with a backup battery for real-time clock retention in the event of a power failure. The field satellite shall maintain the time-of-day, day-of-week .

T. The field satellite control module components shall be enclosed in a weather resistant plastic case.

U. Valve Communications:
   1. Communication between field satellite and the decoders shall be accomplished by a twisted pair of #14 AWG decoder cables for direct burial within a red HDPE outer jacket.
   2. Decoders shall have 'Integrated Surge Protection' rated to 20 KV (20,000 volts) secondary surge.
   3. Decoders shall be pre-addressed with a five-digit address and not programmable.
   4. All splices shall be made in accordance with National Electrical Code® Articles 300.5 (Underground Installations) and 110.14 (Electrical Connections) using 3M DBYR-6 connectors, which are UL listed under "UL 486D-Direct Burial", for wet or damp locations, 600 volts.
   5. Decoder communication cable shall be installed in a separate trench a minimum of 12" per 100 volts away from any power cable.

V. Grounding
   1. Decoder communication cable shall connect a line surge-protector to 4"x 36" ground plate and communication cable no more than 500 feet

from any decoder location along the two-wire path and be installed according to ASIC guidelines. Grounding of 20 ohms, or less, will be required.

2. The field satellite shall be grounded according to the ASIC 100-2002 Grounding Guidelines.

W. The field satellite shall come with a 5-year hardware warranty.

PART 6 - FIELD SATELLITE HARDWARE (Two Wire – AC Solenoids)

A. The field satellite shall use solid-state control technology and be capable of automatic, semi-automatic and manual operations.

B. The field satellite shall be programmable by the on-board keyboard with rotary dial with back-lit LCD.

C. The field satellite shall have built-in diagnostics indicating specific field satellite or field alarms, network settings and testing of field stations.

D. The field satellite shall be in a locking stainless steel, powder-coated metal wall mount, stainless steel pedestal or plastic pedestal.

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

F. 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.

G. The field satellite shall be capable of operating up to 204 stations.

H. The field satellite shall be capable of connecting either a short-range and/ or long-range spread spectrum radio for activation of wireless output remote modules.

I. The field satellite shall have a built-in Ethernet port for optional network connectivity

J. The field satellite shall have a built-in wireless soil moisture sensing port for optional Wireless Soil Moisture Sensing Base Station connection.

K. The field satellite shall have a built-in USB port for field firmware updates and program back-up.

L. The field satellite shall have (2) built-in nine pin serial ports.

M. The field satellite shall have the ability to communicate and control up to a total of 204 field decoders.

N. The field satellite shall operate 24VAC solenoids and be able to activate (8) decoders, and (8) individual valves simultaneously.

O. The field satellite shall have non-volatile memory and self-diagnostics to identify decoder communication and open circuits.

P. The field satellite shall be able to run all decoders on #14 AWG cable up to 10,000' when wire is looped from the field satellite and 5000' in a straight run.

Q. The field satellite shall have the ability to read (2) flow inputs connected directly to a data-retrieval terminal connection inside the field satellite cabinet and read, display and record real-time gallons per minute.

R. The field satellite shall have the ability to read an additional (14) flow inputs via optional wireless output remote modules.

S. The field satellite shall have the capability to activate (16) separate master valves via mirrored master valve designation.

T. The field satellite shall come standard with a backup battery for real-time clock retention in the event of a power failure. The field satellite shall maintain the time-of-day, day-of-week .

U. The field satellite control module components shall be enclosed in a weather resistant plastic case.

V. Valve Communications:

1. Communication between field satellite(s) and the decoders shall be accomplished by a polyethylene double-jacketed or UF-B UL PVC double-jacketed two-conductor solid core for direct burial with insulation 3/16 inch (.060") thick, high density, sunlight resistant incased in an outer jacket of Polyethylene or PVC conforming to ICEA S-GL-402 or NEMA WC5, having a minimum wall thickness of .045 inches.
2. All splices shall be made in accordance with National Electrical Code® Articles 300.5 (Underground Installations) and 110.14 (Electrical Connections) using 3M DBYR-6 connectors, which are UL listed under "UL 486D-Direct Burial", for wet or damp locations, 600 volts.
3. Decoder communication cables shall be installed in a separate trench a minimum of 12" per 100 volts away from power cable.

W. Grounding

1. Decoder communication cable shall connect a line surge-protector to 4"x 36" ground plate and communication cable no more than 500 feet from any decoder location along the two-wire path and be installed according to ASIC guidelines. Grounding of 20 ohms, or less, will be required.
2. The field satellite shall be grounded according to the ASIC 100-2002 Grounding Guidelines.

X. The field satellite shall come with a 5-year hardware warranty.

PART 7 – FIELD SATELLITE HARDWARE (Wireless Output Remote Modules)

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

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

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

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

H. The wireless output remote module shall be capable of operating at 115 V a.c. (+/- 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 remote 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 remote 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 remote module shall come with a 5-year hardware.

PART 8 – FIELD SATELLITE 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 satellite shall have a real-time clock with adjustable day change hour.

C. The field satellite 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 sixteen 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 satellite shall be capable of running any one or combination of programs simultaneously.

I. The field satellite 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 satellite 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 satellite shall be capable of running irrigation programs based on Evapo-Transpiration (ET) input. When the ET functions are activated, the field satellite automatically adjusts program run times according to the ET data.

L. The field satellite shall have a non-volatile memory that can maintain time and all programming functions.

M. When the field satellite is operating in either manual or automatic modes, the remaining run time shall be displayed.

N. The field satellite 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 satellite to static or dynamic IP address
   9. Ability to program decoder addresses
   10. Ability to test UHF radio with a bounce-back signal

PART 9 - HAND-HELD REMOTE

A. The field satellite shall have the ability to accept and execute commands from a portable UHF hand-held radio remote having an output power of 5 watts.

B. The hand-held remote radio shall not require the installation of a central computer or any radio receiver and shall have the ability to communicate directly to a field satellite in a stand-alone mode.

C. The remote shall have the ability to execute the following commands:
   1. On/Off of individual stations
   2. On/Off of individual programs
   3. Quick station advance
   4. Set stations in rain hold
   5. Run a station sequence

D. The handheld will provide the ability for two-way voice communications.

E. The field satellite when connected via Ethernet, cell data modem or WIFI shall have the ability to accept and execute commands from a web-enabled smart phone.

F. The web-enabled smart phone shall have the ability to execute the following commands:
   1. On/Off of individual stations
   2. On/Off of individual programs
   3. Quick station advance

PART 10 - 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.

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 ethylenepropylene 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 1 1⁄2", 2", 3, and 4" with socket end connections.

I. The flow sensor shall come with a 2-year warranty.

Cable for Flow Sensors

A. Approved flow sensors may be located up to 2000' from the field satellite.

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 300.5 (Underground Installations) and 110.14 (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.

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 0.01" 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.

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 up to 500' from the field satellite.

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 300.5 (Underground Installations) and 110.14 (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 body below grade before pressing the moisture sensor spikes into undisturbed soil.

B. Equipment:

1. Wireless base station utilizing spread spectrum communications
2. Wireless soil moisture sensors with built-in spread spectrum transmitter
3. Wireless repeaters utilizing spread spectrum communications
4. All 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.
5. Sensors shall measure and transmit real time moisture minimum every 5 minutes and be displayed in central software.
6. The 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).
7. Sensors shall not exceed 500' from a wireless base station unless repeaters are added to the system.
8. 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.

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Form Number 373-0865 Rev. A