5. 120VAC Control

   120 VAC control wire shall be RED except for a wire entering a motor control center compartment or control panel which is an interlock. This interlock conductor shall be color coded YELLOW.

6. 24VAC Control

   All wiring - ORANGE

7. Equipment Grounding Conductor

   All wiring - GREEN

B. Individual conductors No. 2 AWG and smaller shall have factory color coded insulation. It is acceptable for individual conductors larger than No.2 AWG to be provided with factory color coded insulation as well, but it is not required. Individual conductors larger than No.2 AWG that are not provided with factory color coded insulation shall be identified by the use of colored tape in accordance with the requirements listed in Part 3 herein. Insulation colors and tape colors shall be in accordance with the color coding requirements listed above.

C. Conductors that are a part of multi-conductor control cable assemblies shall have black insulation. The conductor number shall be printed on each conductor's insulation in accordance with ICEA S-58-679, Method 4. Each conductor within the cable assembly shall also be identified with a heat shrink tag with color coded background in accordance with the requirements listed in Part 3 herein. Background color shall be in accordance with the color coding requirements listed above.

D. Conductors that are a part of multi-conductor power cable assemblies shall have black insulation. The conductor number shall be printed on each conductor's insulation in accordance with ICEA S-58-679, Method 4. Each conductor No.2 AWG and smaller within the cable assembly shall also be identified with a heat shrink tag with color coded background. Each conductor larger than No.2 AWG within the cable assembly shall also be identified by the use of colored tape. Heat shrink tags and colored tape shall be in accordance with the requirements listed in Part 3 herein. Tape color and heat shrink tag background color shall be in accordance with the color coding requirements listed above.

2.07 CABLE PULLING LUBRICANTS

A. Cable pulling lubricants shall be non-hardening type and approved for use on the type of cable installed. Lubricant shall be Yellow 77 Plus by Ideal, Cable Gel by Greenlee, Poly-Gel by Gardner Bender, or equal.

<u>PART 3 - EXECUTION</u>

3.01 POWER, CONTROL, AND LIGHTING/RECEPTACLE WIRE AND CABLE INSTALLATION

A. The wire and cable shall be installed as specified herein and indicated on the Drawings.

B. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

C. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Burndy Electrical, or equal.

D. Splices shall not be allowed in the underground manhole and handhole systems. If splices are required, the Contractor shall obtain approval in writing from the Engineer prior to splicing. Splicing materials shall be barrel type butt splice connectors and heat shrink tubing as manufactured by 3M, Ideal, or equal. No splicing of instrumentation cable is allowed. The use of screw-on wire connectors (wire nuts) shall only be permitted for lighting and receptacle circuits.

E. Wire and Cable Sizes

1. The sizes of wire and cable shall be as indicated on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop measured from source to load does not exceed 2-1/2%.

F. Additional Conductor Identification

1. In addition to the color coding identification requirements specified in Part 2 herein, individual conductors shall be provided with heat shrinkable identification tags. Identification tags for individual conductors shall have a white background where the conductor insulation is colored. Identification tags for individual conductors shall have a colored background where the conductor insulation is black. Background color shall match that of the taping provided on the individual black conductors.

2. Multi-conductor cables shall be provided with heat shrinkable identification tags in accordance with Part 2 herein.

3. All wiring shall be identified at <u>each</u> point of termination. This includes but is not limited to identification at the source, load, and in any intermediate junction boxes where a termination is made. The Contractor shall meet with the City and Engineer to come to an agreement regarding a wire identification system prior to installation of any wiring. Wire numbers shall not be duplicated.

4. Wire identification shall be by means of a heat shrinkable sleeve with appropriately colored background and black text. Wire sizes #14 AWG through #10 AWG shall have a minimum text size of 7 points. Wire sizes #8 AWG and larger shall have a minimum text size of 10 points. Sleeves shall be of appropriate length to fit the required text. The use of handwritten text for wire identification shall not be permitted.

5. Sleeves shall be suitable for the size of wire on which they are installed. Sleeves <u>shall not be heat-shrunk</u> onto control cables. Tags shall remain loose on cable to promote easier identification. For all other applications, sleeves shall be tightly affixed to the wire and shall not move. Sleeves shall be heat shrunk onto wiring with a heat gun approved for the application. Sleeves shall not be heated by any

means which employs the use of an open flame. The Contractor shall take special care to ensure that the wiring insulation is not damaged during the heating process.

6. Sleeves shall be installed prior to the completion of the wiring terminations and shall be oriented so that they can be easily read.

7. Sleeves shall be polyolefin as manufactured by Brady, Seton, Panduit, or equal.

8. Wire identification in manholes, handholes, pull boxes, and other accessible components in the raceway system where the wiring is continuous (no terminations are made) shall be accomplished by means of a tag installed around the bundled group of individual conductors or around the outer conductor jacket of a multi-conductor cable. Identification shall utilize a FROM-TO system. Each group of conductors shall consist of all of the individual conductors in a single conduit or duct. The tag shall have text that identifies the bundle in accordance with the 'FROM' and 'TO' column for that particular conduit number in the conduit and wire schedule. Minimum text size shall be 10 point. The tag shall be affixed to the wire bundle by the use of nylon wire ties, and shall be made of polyethylene as manufactured by Brady, Seton, Panduit, or equal.

9. Where colored tape is used to identify cables, it shall be wrapped around the cable with a 25% overlap and shall cover at least 2 inches of the cable.

G. Wiring Supplies

1. Only electrical wiring supplies manufactured under high standards of production and meeting the approval of the Engineer shall be used.

2. Rubber insulating tape shall be in accordance with ASTM Des. D119. Friction tape shall be in accordance with ASTM Des. D69.

H. Training of Cable

1. The Contractor shall furnish all labor and material required to train cables around cable vaults within buildings and in manholes and handholes in the outdoor underground duct system. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. The training shall be done in such a manner as to minimize chaffing. Reference Section 16118.

2. Instrumentation cable shall be racked separate from other AC and DC wiring to maintain the required separation as follows:

   a. 18 inches for 480/277VAC wiring

   b. 12 inches for 208/120VAC wiring

   c. 6 inches for 24VDC wiring

I. Conductor Terminations

1. Where wires are terminated at equipment which requires lugs, connections shall be made by solderless mechanical lug, crimp type ferrule, or irreversible compression

type lugs. Reference individual equipment specification sections as applicable for additional termination requirements.

2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make terminations impractical due to the size of the field wiring, the Contractor shall terminate field wiring in an adjacent junction per the requirements of Section 16130, Boxes, complete with terminal strips. Contractor shall install the smaller wiring from the device to the junction box in a conduit, using the terminal strip as the means for joining the two different wire sizes. Splicing of wires in lieu of using terminal strips is not acceptable.

3. All spare conductors shall be terminated on terminal blocks mounted within equipment or junction boxes. Unless otherwise noted, coiling up of spare conductors within enclosure is not acceptable.

□. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature of 40°F or less within a three (3) day period prior to pulling, the cable reels shall be stored three (3) days prior to pulling in a protected storage area with an ambient temperature of 55°F or more. Cable pulling shall be completed during the work day for which the cable is removed from the protected storage. Any remaining cable reels shall be returned to storage at the completion of the workday.

3.02 INSTRUMENTATION CABLE INSTALLATION

A. The Contractor shall install all cable or conductors used for instrumentation wiring (4-20 mA DC, etc.) in conduit as specified in Section 16111 - Conduit. Only instrumentation cable as specified herein shall exclusively occupy these conduits. No other wiring for AC or discrete DC circuits shall be installed in these conduits.

B. All shielding shall be continuous and shall be **<u>grounded at one point only</u>**.

C. Where instrumentation cables are installed in panels, manholes, handholes, and other locations, the Contractor shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.

D. Special instrument cable shall be as specified or recommended by the manufacturer of the equipment or instruments requiring such wiring. Installation, storage, and terminations, shall be per manufacturer's recommendations.

3.03 TESTING

A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Shop Test

a. Ca□le and wiring shall □e tested in accordance with the applica□le ICEA Standards. Wire and ca□le shall □e ph□sicall□ and electricall□ tested in accordance with the manufacturer's standards.

2. Field Tests

a. After installation, all wires and ca□les shall □e tested for continuit□. Testing for continuity shall be "test light" or "buzzer" style.

□. After installation, some wires and ca□les shall □e tested for insulation levels. Insulation resistance □etween conductors of the same circuit and □etween conductor and ground shall □e tested. Testing for insulation levels shall □e as follows:

1□ For □8 AWG and larger □00V power and control ca□le, appl□ 1,000 VDC from a Megaohmeter for one □1□ minute for <u>all</u> □00V wires and ca□les installed in lighting, control, power, indication, alarm and motor feeder circuits. Resistance shall □e no less than 100 Megaohms. Insulation testing is not re□uired for power and control ca□les smaller than □8 AWG.

2□ □00V instrumentation signal ca□le shall □e tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 2□0 volt-ohmmeter, or approved e□ual. The resistance value shall □e 200 Megaohms or greater.

B. Wires and ca□les shall □e tested □efore □eing connected to motors, devices or terminal □locks.

C. If tests reveal defects or deficiencies, the Contractor shall make the necessar□ repairs or shall replace the ca□le as directed □□ the Engineer, without additional cost to the Cit□.

D. All tests shall □e made □□ and at the e□pense of the Contractor who shall suppl□ all testing e□uipment. Test reports shall □e su□mitted to the Engineer.

□E□HIBIT A□
TEST DATA - MEGOHMS
TEST NO. □□□□

Date:	Compan□:
Time:	Location:

Circuit:	Circuit Length:	Aerial:	Duct:	Buried:	No. of Conduc-tors	Size:	AMG MCM Shld:

Insulation Material:	Insulation Thickness:	Voltage Rating:	Age:

T□pe: □□□□□Pothead □□□□□□Terminal	Location: Indoors□□□□□□□ Outdoors□□□□□

Num□er and T□pe of □oints:
Recent Operating Histor□:
Manufacturer:
State if Potheads or Terminals were grounded during test:
List associated e□uipment included in test:
Miscellaneous Information:

□E□HIBIT A□
TEST DATA - MEGOHMS
TEST NO. □□□□□

Part Tested:Test Made:□□□□□□□□□□□□□□□□□
Hours/Da□s:□□□□□□□□□□□□□□□□□
After Shutdown:□□□□□□□□□□□□□□□□□

Grounding Time:Dr□Bul□ Temperature:□□□□□□□□□□□
Wet Bul□ Temperature:□□□□□□□□□□□

Test Voltage:	E□uipment Temperature: □□□□□□□□□□□□ How O□tained: □□□□□□□□□□□□ Relative Humidit□: □□□□□□□□□□□□ A□solute Humidit□: □□□□□□□□□□□□ Dew Point: □□□□□□□□□□□□

Megohmmeter: Serial Num□er: □□□□□□□□□□□ Range: □□□□□□□□□□□□
Voltage: □□□□□□□□□□□□□□□□□□ Cali□ration Date□□□□□□□□□□□□

Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground	Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground
□ Minute				5 Minutes			
□ Minute				□ Minutes			
3/4 Minute				7 Minutes			
1 Minute				8 Minutes			
2 Minutes				9 Minutes			
3 Minutes				10 Minutes			
4 Minutes				10/1 Minutes			
				Ratio			

Remarks:

END OF SECTION

SECTION 16130

BOXES

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The scope of work under this Section includes furnishing and installing all pull boxes, junction boxes, and outlet boxes.

B. Requirements for other boxes and enclosures are not included in this Section. Reference each specific Division 16 equipment Section for requirements related to that equipment's respective enclosure.

C. Reference Section 16000, Basic Electrical Requirements, and Section 16111, Conduit.

1.02 CODES AND STANDARDS

A. Boxes shall be designed, manufactured, and/or listed to the following standards as applicable:

1. UL 514A - Metallic Outlet Boxes
2. UL 514C - Standard for Non-metallic Outlet Boxes, Flush Device Boxes, and Covers
3. UL 50 – Enclosures for Electrical Equipment, Non-environmental Considerations
4. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations
5. UL 1203 – Standard for Explosion-proof and Dust-ignition-proof Electrical Equipment for use in Hazardous (Classified) Locations.
6. NEMA 250 – Enclosures for Electrical Equipment

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer(s) and submit the following:

1. Shop Drawings

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegi□le Su□mittals will □e returned to the Contractor without review for resu□mittal.

C. Shop drawings shall include □ut not □e limited to:

1. Product data sheets for □o□es, terminal strips, and all accessories

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall su□mit operation and maintenance manuals in accordance with the procedures and re□uirements set forth in the General Conditions and Division 1.

B. As-□uilt drawings showing dimensions, internal □o□la□out, terminal strip information, and terminal strip identification information shall □e provided for all □unction □o□es. As-□uilt drawings are not re□uired for pull □o□es or outlet □o□es.

1.0□ IDENTIFICATION

A. Each pull and □unction □o□ shall □e identified with the □o□ name as indicated on the Contract Drawings or as directed □□ the Engineer. A nameplate shall □e securel□ affi□ed in a conspicuous place on each □o□. Nameplates shall □e as specified in Section 1□195, Electrical – Identification.

<u>PART 2 -</u> <u>PRODUCTS</u>

2.01 MANUFACTURERS

A. The e□uipment covered □□ this Specification is intended to □e standard e□uipment of proven performance as manufactured □□ reputa□le concerns. E□uipment shall □e designed, constructed, and installed in accordance with the □est practices of the trade, and shall operate satisfactoril□ when installed as shown on the Drawings.

2.02 PULL AND □UNCTION BO□ES

A. General

1. All pull and □unction □o□es shall □e UL listed and la□eled.

2. Pull and □unction □o□es shall not □e provided with eccentric or concentric knockouts.

3. Pull and □unction □o□es mounted em□edded in concrete shall □e UL listed for em□edment.

4. Where metallic □o□es are used the□ shall □e of all welded construction. Tack welded □o□es are not accepta□le.

B. Pull Bo□es

1. All pull □o□es shall □e provided with a matching gasketed cover. For covers with dimensions of 24 inches □□ 24 inches or less, the cover shall □e held in place □□

machine screws. Other screw t□pes are not accepta□le. For covers with dimensions greater than 24 inches □□24 inches, the cover shall □e hinged and held in place □□ screw-operated clamp mechanisms. Hinge pins shall □e remova□le. Clamp mechanism material of construction shall match that of the associated □o□.

2. Pull □o□es shall not have an□wire terminations inside, other than those for grounding/□onding. A ground □ar shall □e provided with the necessar□num□er of screw t□pe terminals. Twent□□20□percent of the total amount of terminals otherwise re□uired for the pull □o□□minimum of two□shall □e provided as spare terminations. Bo□es re□uiring an□other wire terminations shall □e furnished and installed in accordance with the re□uirements for □unction □o□es herein.

3. Pull □o□es shall □e □inches wide □□□inches tall □□4 inches deep, minimum. For applications re□uiring larger □o□es, the □o□shall □e sized in accordance with the fill re□uirements and dimensional re□uirements of the NEC.

4. Barriers shall □e provided in pull □o□es to isolate conductors of different voltages, t□pes, and functions. Barrier material of construction shall match that of the □o□. Isolation shall □e provided □etween the following groups:

   a. Power wiring

   □. AC control wiring

   c. DC control wiring

   d. Instrumentation wiring

C. □unction Bo□es

1. □unction □o□es used for lighting and receptacle circuits onl□shall □e provided with a matching gasketed cover held in place □□ machine screws. Other screw t□pes are not accepta□le.

2. □unction □o□es for all uses other than lighting and receptacle circuits shall □e provided with a hinged, gasketed cover. Hinge pins shall □e remova□le. Cover shall □e held in place □□ screw-operated clamp mechanisms. Clamp mechanism material of construction shall match that of the associated □o□.

3. Barriers shall □e provided in □unction □o□es to isolate conductors and terminal □locks of different voltages, t□pes, and functions. Barrier material of construction shall match that of the □o□. Isolation shall □e provided □etween the following groups:

   a. Power wiring

   □. AC control wiring

   c. DC control wiring

   d. Instrumentation wiring

4. Junction boxes used for lighting and receptacle circuits only shall be allowed to have screw-on (wire nut) type connectors for wire terminations/junctions.

5. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with terminal strips, consisting the necessary number of screw type terminals. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected, with a 10A minimum capacity. Terminal strips shall be rated for the voltage of the circuits connected. A separate ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the junction box (minimum of two) shall be provided as spare terminations. When barriers are provided within the box, separate terminal strips shall be provided in each barrier area. Terminals shall be lettered and/or numbered to conform to the wiring labeling scheme in place on the project.

6. Junction boxes shall be 6 inches wide x 6 inches tall x 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC. Terminal blocks (including spare terminals) shall be considered when sizing the junction box.

D. Enclosure Types and Materials

1. In non-hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
Indoor Type 1 Chemical Storage/Transfer Area	NEMA 4X, Fiberglass or PVC
Indoor Type 2 Chemical Storage/Transfer Area	NEMA 4X, Type 304 Stainless Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

2. In hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the classification of the area in which they are to be installed. Area classifications are indicated on the Drawings.

AREA CLASSIFICATION	ENCLOSURE TYPE AND MATERIAL
Class 1, Division 1, Group D	NEMA 7, Die Cast Aluminum
Class 1, Division 2, Group D	NEMA 4X, Type 304 Stainless Steel
Class 2, Division 1, Group F	NEMA 9, Die Cast Aluminum
Class 2, Division 2, Group F	NEMA 4X, Type 304 Stainless Steel

3. Non-metallic enclosures, and NEMA 7 enclosures enclosures shall □e provided with threaded integral conduit hu□s.

2.03 OUTLET BO□ES

A. General

1. Outlet □o□es shall □e provided with a trim appropriate for the wiring device installed inside. Reference Section 1□141, Wiring Devices, for outlet □o□trim re□uirements. An appropriate outlet □o□trim is re□uired to achieve the NEMA rating of the outlet □o□es as specified herein.

B. Surface Mount Outlet Bo□es

1. Outlet □o□es shall □e the deep t□pe, no less than 2.5 inches deep.

2. Outlet □o□es shall □e provided in single or multi-gang configuration as re□uired, sized in accordance with the re□uirements of the NEC.

3. In non-hazardous locations, outlet □o□es shall □e furnished with the following enclosure t□pe and material of construction, dependent upon the designation of the area in which the□are to □e installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE T□PE AND MATERIAL
Indoor Wet Process Area	NEMA 4□, PVC Coated Steel
Indoor Dr□Process Area	NEMA 1, Cast Aluminum
Indoor Dr□Non-process Area	NEMA 1, Cast Aluminum
All Outdoor Areas	NEMA 4□, PVC Coated Steel

4. Outlet □o□es shall □e provided with integral threaded conduit hu□s mounted e□ternal to the □o□. Bo□es with threaded conduit hu□s mounted internal to the □o□ or as a part of the □o□wall are not accepta□le.

C. Flush Mount Outlet Bo□es

1. Outlet □o□es shall □e no less than 2-1/8 inches deep, and 4-11/1□inches s□uare. Bo□es shall □e UL listed and la□eled. Pre-punched single diameter conduit knockouts are accepta□le, however, concentric and eccentric knockouts are not accepta□le.

2. Outlet □o□es mounted flush in CMU walls shall □e made of galvanized, tack welded steel, and suita□le for installation in masonr□walls. Sectional t□pe □o□es are not accepta□le for this application.

3. Outlet □o□es mounted flush in g□psum walls shall □e made of galvanized pressed steel. Tack welded □o□es are not accepta□le for this application. Sectional t□pe □o□es are not accepta□le for this application.

4. Outlet boxes mounted cast into concrete shall be concrete tight, and shall be made of galvanized steel or PVC.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Pull and Junction Boxes

1. Pull boxes and junction boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.

2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.

3. Box penetrations for conduits shall be made with a punch tool, and penetrations shall be of the size required for the conduit entry and/or hub. Oversized penetrations in boxes are not acceptable.

4. Watertight conduit hubs shall be provided for boxes where a NEMA 4X enclosure rating is specified. Reference Section 16111, Conduit, for conduit hub requirements.

5. Pull and junction boxes may be installed flush mounted in concrete or CMU walls where appropriate provided that covers are easily removed or opened.

6. Pull and junction boxes shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

B. Outlet Boxes

1. Outlet boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.

2. Wooden plugs are not permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.

3. Flush mounted outlet boxes shall be arranged and located so that tile and grout lines fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.

4. Outlet boxes shall be flush mounted in finished areas and other areas where practical. Flush mounted outlet boxes shall not be installed in hazardous areas.

5. For the below-named items, mounting heights from finished floor, or finished grade to top is applicable, depending on the type of wiring device to be installed in the outlet box. Mounting heights for outlet boxes shall be as follows, unless otherwise

specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):

a. Light switches, 48 inches

b. Receptacles in indoor dry areas, 16 inches

c. Receptacles in outdoor locations, 24 inches

6. Outlet boxes shall be provided in the material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

END OF SECTION

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SECTION 1□141

WIRING DEVICES

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish and install all switches and receptacles of the t□pe and at the locations as shown on the Drawings.

B. All switches and receptacles shall □e furnished and installed in outlet □o□es. Reference Section 1□130, Bo□es, for outlet □o□ re□uirements.

C. Reference Section 1□000, Basic Electrical Re□uirements, and Section 1□123, Low Voltage Wire and Ca□le.

1.02 CODES AND STANDARDS

A. Wiring devices shall □e designed, manufactured, and/or listed to the following standards as applica□le:

1. UL 20 – General Use Snap Switches
2. UL 498 – Standard for Attachment Plugs and Receptacles
3. UL 943 – Ground Fault Circuit Interrupters
4. UL 1203 – Standard for E□plosion-proof and Dust-ignition-proof Electrical E□uipment for use in Hazardous □Classified□Locations.

1.03 SUBMITTALS

A. In accordance with the procedures and re□uirements set forth in the General Conditions and Section 01300, Su□mittals, the Contractor shall o□tain from the e□uipment manufacturer and su□mit shop drawings. Each su□mittal shall □e identified □□the applica□le specification section.

1.04 SHOP DRAWINGS

A. Each su□mittal shall □e complete in all respects, incorporating all information and data listed herein and all additional information re□uired for evaluation of the proposed e□uipment□s compliance with the Contract Documents.

B. Partial, incomplete, or illegi□le su□mittals will □e returned to the Contractor without review for resu□mittal.

C. Shop drawings shall include, □ut not □e limited to:

1. Product data sheets.

1.05 SPARE PARTS

A. The Contractor shall furnish 10% (minimum of 1) spare of each receptacle, switch, and plug furnished and installed for this project.

B. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.06 IDENTIFICATION

A. Each switch and receptacle shall be identified with the equipment item number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these Specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The Contractor shall use the products of a single manufacturer for each type of wiring device.

C. The Contractor shall use the products of a single manufacturer for all device plates. Plate variations are allowed for the following devices:

1. Where the selected plate manufacturer does not manufacture a suitable finish plate.

2. For heavy-duty receptacles rated at more than 30A.

3. Where non-standard plates are required, specified, or shown.

D. The Contractor shall furnish and install all wiring devices and device plates.

E. In non-hazardous areas, provide specification grade devices manufactured by Appleton, Crouse-Hinds, Leviton, Hubbell, Pass & Seymour, or Engineer approved equal.

F. In hazardous areas, provide devices manufactured by Appleton, Cooper Crouse-Hinds, Hubbell-Killark, or Engineer approved equal.

2.02 WIRING DEVICES

A. Wall switches for non-hazardous areas shall be rated for the current required to suit the application, but not less than 20A. Three-way switches shall be provided where indicated on the Drawings, and as required. Switches shall be rated for 120-277VAC, and shall be UL 20 Listed.

B. Convenience receptacles for non-hazardous areas shall be rated for 20A at 125VAC. Convenience receptacles shall be UL 498 Listed. Tamper resistant receptacles are not acceptable.

C. Ground fault circuit interrupter receptacles shall be rated for 20A at 125VAC. Ground fault circuit interrupter receptacles shall be UL 943 Listed. Tamper resistant receptacles are not acceptable.

D. Wall switches for hazardous areas shall be the factory sealed type, UL 1203 Listed for use in the hazardous area. Wall switches shall be rated for 120-277VAC, and shall be rated for the current required to suit the application, but not less than 20A

E. Receptacles for hazardous areas shall be rated 20A at 120-240VAC. Receptacles shall be UL 1203 listed for use in the hazardous area, utilizing delayed-action construction.

F. All wiring devices shall be approved for use with stranded conductors, if stranded conductors are to be used with the device. Reference Section 16123, Low Voltage Wire and Cable for conductor requirements

2.03 DEVICE PLATES

A. Device plates for outdoor installations shall be Appleton Type FSK, Crouse-Hinds #DS185, or equal for wall switches. Device plates for receptacles shall be “in-use” style. “In-use” weatherproof covers shall be rugged, minimum 3 ¼” depth, die-cast aluminum as manufactured by Thomas & Betts "Red Dot," Intermatic International, Inc., or equal.

B. Device plates for indoor areas with surface mounted boxes shall be Crouse-Hinds DS32, or equal for switches, and Crouse-Hinds DS23 or equal for receptacles.

2.04 PROCESS INSTRUMENTS

A. The Contractor shall furnish and install a local disconnect switch at each process instrument (e.g., level transmitter, flow transmitter, analytical instrument etc.,) to disconnect the 120VAC power supply to the instrument. The device shall be a NSSC series manual motor starting switch without overload protection as manufactured by Crouse-Hinds, Appleton equivalent, or equal. For hazardous locations, the device shall be UL 1203 Listed.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All device plates shall be set true and plumb, and shall fit tightly against the finished wall surfaces and outlet boxes.

B. Wiring device box (outlet box) mounting heights shall be as specified in Section 16130, Boxes.

C. When indicated height would place any of the equipment at an unsuitable location such as at a molding or break in wall finish, the Contractor shall bring it to the attention of the Engineer for a decision.

D. Ground fault circuit interrupter receptacles shall be furnished and installed in locations where indicated on the Drawings, and as required by the NEC.

E. All receptacles shall have a self-adhesive label installed on the top at the respective device plate that indicates which panel and which circuit number the receptacle is supplied from. Labels shall have a white background and black lettering in 14 point font.

3.02 CIRCUITING

A. Convenience receptacles shall be grouped on circuits separate from the lighting circuits. A maximum of eight (8) convenience receptacles are permitted per 20A, 120V circuit, unless otherwise indicated on the Drawings.

END OF SECTION

SECTION 1□190

SUPPORTING DEVICES

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish and install structural supports for mounting and installing all conduit, electrical e□uipment, lighting, alarm s□stems, instrumentation, and communications e□uipment furnished under this Contract.

B. E□uipment shall □e installed strictl□in accordance with recommendations of the manufacturer and □est practices of the trade resulting in a complete, opera□le, and safe installation. The Contractor shall o□tain written installation manuals from the e□uipment manufacturer prior to installation.

C. Reference Section 1□000, Basic Electrical Re□uirements.

1.02 SUBMITTALS

A. In accordance with the procedures and re□uirements set forth in the General Conditions and Section 01300, Su□mittals, the Contractor shall o□tain from the e□uipment manufacturer and su□mit the following:

1. Shop drawings
2. Structural support calculations □if re□uired□

B. Each su□mittal shall □e identified □□the applica□le Specification section.

1.03 SHOP DRAWINGS

A. Each su□mittal shall □e complete in all respects, incorporating all information and data listed herein and all additional information re□uired for evaluation of the proposed e□uipment□s compliance with the Contract Documents.

B. Partial, incomplete, or illegi□le su□mittals will □e returned to the Contractor without review for resu□mittal.

C. Shop drawings shall include □ut not □e limited to:

1. Product data sheets.
2. Complete assem□l□, la□out, installation, and foundation drawings with clearl□ marked dimensions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 MATERIALS

A. Support channel shall be 1-5/8” by 1-5/8” minimum, with 12 gage material thickness.

B. Support channel, support channel fittings, and threaded rod shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	MATERIAL OF CONSTRUCTION
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Hot Dipped Galvanized Steel
Indoor Dry Non-process Area	Hot Dipped Galvanized Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

C. Fastening hardware (bolts, nuts, washers, and screws) shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	MATERIAL OF CONSTRUCTION
Indoor Wet Process Area	Type 304 Stainless Steel
Indoor Dry Process Area	Type 304 Stainless Steel
Indoor Dry Non-process Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel
All Hazardous Areas	Type 304 Stainless Steel

PART 3 - EXECUTION

3.01 INSTALLATION

A. Concrete or Masonry Inserts

1. The Contractor shall be responsible for the furnishing and installation of all conduit sleeves, anchor bolts, masonry inserts, and similar devices required for installation of equipment furnished under this Contract.

2. If a time delay for the arrival of any special inserts or equipment drawings, etc. occurs, the Contractor may, if permitted by the Engineer, make arrangements for providing approved recesses and openings in the concrete or masonry and, upon subsequent installation, the Contractor shall be responsible for filling in such recesses and openings. Any additional costs that may be incurred by this procedure shall be borne by the Contractor.

3. The Contractor shall furnish leveling channels for all switchgear, switchboards, and similar floor mounted equipment. The leveling channels shall be provided for embedment in the equipment housekeeping pads. Coordination of the installation of these channels with the concrete pad is essential and required. Pad height shall be as required to maintain concrete coverage of the reinforcement bars while not causing associated equipment to exceed the maximum mounting height requirements of the NEC.

B. Support Fastening and Locations

1. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel.

2. Support channel shall be provided wherever required for the support of starters, switches, panels, and miscellaneous equipment.

3. All equipment, devices, and raceways that are installed on the dry side of a water bearing wall shall not be installed directly onto the wall. Support channel shall be used to allow ventilation air to pass behind the equipment, devices, or raceway.

4. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework.

5. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.

6. Actual designs for supporting framework should take the nature of a picture frame of support channels and bracket with a plate for mounting the components. The Contractor is responsible for the design of supporting structure; he shall submit design details to the Engineer for acceptance before proceeding with the fabrication.

7. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

8. For all installations where fiberglass supporting materials are required, the Contractor shall submit structural calculations and the details of the proposed system of support. Structural calculations shall be signed and sealed by a registered professional engineer in the State of Florida.

9. For the following installations where conduits are provided with a support system suspended from the above or attached to a vertical structure, the Contractor shall submit structural calculations and details of the proposed system of support.

Structural calculations shall be signed and sealed by a registered professional engineer in the State of Florida.

a. A quantity of twelve (12) or more conduits trade size 1” and smaller are proposed for a conduit support rack.

b. A quantity of eight (8) or more conduits trade sizes 1 ½” to 2 1/2” are proposed for a conduit support rack.

c. A quantity of four (4) or more conduits trade sizes 3” and larger are proposed for a conduit support rack.

END OF SECTION

SECTION 16195

ELECTRICAL - IDENTIFICATION

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All switchgear, switchboards, motor starters, lighting and distribution panelboards, combination starters, control panels, pull and junction boxes, enclosures, disconnect switches, control stations, and similar equipment shall be identified in the manner described, or in an equally approved manner.

B. The types of electrical identification specified in this section include, but are not limited to, the following:

1. Operational instructions and warnings.
2. Danger signs.
3. Equipment/system identification signs.
4. Nameplates.

1.02 SIGNS

A. "DANGER-HIGH-VOLTAGE" signs shall be securely mounted on the entry doors of all electrical rooms.

1.03 LETTERING AND GRAPHICS

A. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

1.05 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The material covered by these Specifications is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

2.02 NAMEPLATES

A. Nameplates shall be engraved, high pressure plastic laminate, white with black lettering.

B. Nameplates shall be attached to NEMA 4X enclosures utilizing UL-recognized mounting kits designed to maintain the overall UL Type rating of the enclosure. Mounting kit fasteners shall be stainless steel Type AHK10324□ as manufactured by Hoffman, or equal.

2.03 HIGH VOLTAGE SIGNS

A. Standard "DANGER" signs shall be of baked enamel finish on 20 gage steel□of standard red, black and white graphics□14 inches by 10 inches size except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where a larger size is needed for adequate identification.

2.04 CONDUIT IDENTIFICATION

A. Conduit identification shall be as specified in Section 16111, Conduit.

2.05 WIRE AND CABLE IDENTIFICATION

A. Field installed wire and cable identification shall be as specified in Section 16123, Low Voltage Wire and Cable.

B. A plastic laminate nameplate shall be provided at each panelboard, switchgear assembly, and switchboard assembly. This nameplate shall be used to clearly convey the conductor identification means used at that piece of equipment (i.e. Phase A□Brown, Phase B□Orange, C □ Yellow).

C. Wiring identification for factory installed wiring in equipment enclosures shall be as specified in the respective section.

2.0□ BO□ IDENTIFICATION

A. Pull, □unction and device □o□identification shall □e as specified in Section 1□130 – Bo□es.

<u>PART 3 - E□ECUTION</u>

3.01 NAMEPLATES

A. Nameplates shall □e attached to the e□uipment enclosures with □2□two stainless steel sheet metal screws for nameplates up to 2-inches wide. For nameplates over 2-inches wide, four □4□stainless steel sheet metal screws shall □e used, one □1□in each corner of the nameplate. The utilization of adhesives is not permitted.

3.02 OPERATIONAL IDENTIFICATION AND WARNINGS

A. Wherever reasona□l□re□uired to ensure safe and efficient operation and maintenance of the electrical s□stems and electricall□connected mechanical s□stems and general s□stems and e□uipment, including prevention of misuse of electrical facilities □□ unauthorized personnel, install plastic signs or similar e□uivalent identification, instruction, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or e□planations are needed, provide plasticized tags with clearl□written messages ade□uate for the intended purposes. Signs shall □e attached as specified a□ove for nameplates.

3.03 POWER SOURCE IDENTIFICATION

A. After installation of all field e□uipment □i.e. valves, motors, fans, unit heaters, instruments, etc□install nameplates at each power termination for the field e□uipment. Nameplate data shall include e□uipment designation □tag num□er□, power source □switch□oard, panel□oard, etc□, circuit num□er, conduit num□er from schedule and voltage/phase.

B. Contractor to coordinate with the Engineer and the Cit□regarding e□act nameplate placement during construction.

C. Nameplates shall □e as specified herein.

END OF SECTION

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SECTION 1□2□7

REDUCED VOLTAGE SOLID STATE STARTERS - LOW VOLTAGE

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. Reduced voltage solid state □RVSS□starters.

B. Related Specification Sections include □ut are not necessaril□limited to:

1. Section 1□195 – Electrical - Identification.
2. Section 1□000 – Basic Electrical Re□uirements.
3. Section 17950 – Functional Control Descriptions.
4. Section 1107□ - Pumping E□uipment - Su□mersi□le End-Suction Pumps.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. American National Standards Institute □ANSI□.
2. ETL Testing La□oratories □ETL□.
3. Institute of Electrical and Electronics Engineers, Inc. □IEEE□:
   a. C□2.41.1, Guide on the Surge Environment in Low-Voltage □1000 V and Less□ AC Power Circuits
4. National Electrical Manufacturer□s Association □NEMA□:
   a. 250, Enclosures for Electrical E□uipment □1000 Volts Ma□imum□.
5. National Fire Protection Association □NFPA□:
   a. 70, National Electrical Code □NEC□.
□. Nationall□Recognized Testing La□orator□□NRTL□.
7. Occupational Safet□and Health Administration □OSHA□.
8. Underwriter□s La□orator□, Inc. □UL□:
   a. 508, Standard for Safet□Industrial Control E□uipment.

B. □ualifications:

1. Provide drives that are listed and labeled by UL, ETL, or other NRTL as defined by OSHA regulations, or that have been inspected and subsequent field-labeled by such NRTL.

   a. Where listed drives and other components are installed in a common enclosure, the assembly shall be listed and labeled per UL 508 or equivalent NRTL standard.

2. RVSS Supplier shall maintain an authorized service organization within 300 miles of the project site.

C. Coordination:

1. RVSS manufacturer shall verify that the RVSS is compatible with the driven equipment motor over its required operating range and will do so without exceeding the motor or RVSS safety factors.

2. RVSS shall be supplied complete with all required control components.

   a. RVSS manufacturer shall review the application and provide, at no additional cost to the Buyer, the hardware and software necessary to allow the RVSS to control the driven equipment motor over its required operating range.

      1) These may include, but are not limited to, analog and digital interface modules, communication interface modules, switches, lights and other devices.

   b. Coordinate control devices with devices furnished with driven equipment such as vibration switches, thermal sensors, leak detectors, etc.

1.03 SUBMITTALS

A. Shop Drawings:

1. Schedule of RVSS's for the project listing for each RVSS:

   a. Equipment Tag Number.

   b. RVSS Complete Catalog Number.

   c. RVSS Frame Size.

   d. Rated Input Current.

   e. Rated Continuous Output Current.

   f. Rated Short Circuit Current.

   g. Motor Manufacturer.

   h. Motor Frame Size.

   i. Motor Full Load Amps.

   j. Motor Service Factor.

2. Product technical data:

   a. Complete electrical ratings and performance specifications confirming compliance with specified ratings and performance.

   b. Manufacturer’s installation instructions.

   c. Manufacturer’s programming and operating instructions.

3. Fabrication and/or layout drawings:

   a. Top, front and side exterior views, with details showing maximum overall dimensions of enclosure, mounting provisions and conduit/cable entry provisions.

   b. Identify minimum clearances from other RVSS’s or electrical equipment required for proper cooling at top, bottom, sides and back of enclosure.

   c. Three (3) line diagrams showing AC schematic of RVSS, input, output and bypass devices including device ratings.

   d. Interior layout drawings showing location of all components within enclosure, field wiring terminal boards, and power and grounding connections.

   e. Field wiring diagrams showing locations and sizes of all electrical connections, ground terminations, and requirements for shielded wire usage or any other special installation considerations.

   f. Short Circuit Current Rating (SCCR) nameplate marking per NFPA 70, include any required calculations.

4. Certifications:

   a. Submit with Shop Drawings:

      1) Letter from the RVSS manufacturer stating that the specific application has been reviewed and that the RVSS will satisfy the drive duties required with the actual motor furnished.

      2) Identification and location of closest authorized service organization.

   b. Submit prior to shipment:

      1) Certified factory test reports confirming compliance with specified requirements.

   c. Submit after installation:

      1) Certified field service reports showing:

         a) Each RVSS is operational.

         b) Each RVSS and its driven equipment motor is compatible.

         c) Each RVSS responds correctly to the input control signals.

B. Contract Closeout Information:

1. Operation and Maintenance Data:

   a. See Specification Section 01430 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

2. Approved copy of RVSS schedule per Submittals Article.

3. Manufacturer's instruction manuals.

4. Troubleshooting procedures with a cross-reference between symptoms and corrective recommendations.

5. Connection data to permit removal and installation of recommended smallest field-replaceable parts.

6. Recommended spare parts list.

7. Commissioning sheets showing “as-left” values of all user-programmable or adjustable drive parameters.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Basis of design: Square D Company

2. Other acceptable manufacturers include:

   a. Allen Bradley.

   b. ABB.

   c. Eaton.

   d. Danfoss.

   e. Halmar Robicon Group.

2.02 GENERAL

A. The RVSS shall consist of a six SCR power section with two SCRs per phase connected inverse parallel for variable AC output voltage with minimal motor and starter heating.

B. The RVSS power section shall be capable of providing maximum torque per amp throughout the motor’s speed-torque curve.

C. The logic control shall consist of a power section for gating the drive SCRs and a control section for performing all the necessary starter functions.

D. A snubber circuit shall be used to prevent false firing of SCRs due to dV/dt effects.

E. The RVSS shall be provided with a by-pass contactor that will effectively “short” the SCR power section to the incoming line to the motor load without the SCR voltage drop.

   1. Be a thermal rated contact to bypass the soft starter.

F. RVSS's shall constitute complete combination motor controllers per NEC Article 430 and shall provide the following per the requirements of that article without the addition of any external components or devices.

   1. Motor control.

   2. Motor overload protection.

   3. Motor and motor branch circuit short circuit and ground fault protection.

   4. Motor and controller disconnecting means.

G. RVSS's shall be “engineered” or “configured” drive packages in which the RVSS chassis, all input, output and bypass power devices, RVSS accessories, ancillary switches, contactors, relays, and related control devices are selected, furnished, factory assembled and tested by the RVSS manufacturer in a single enclosure requiring only connection of the power supply circuit, motor branch circuit, and external control wiring in the field.

2.03 PERFORMANCE AND DESIGN REQUIREMENTS

A. Application:

   1. RVSS's shall be designed to operate successfully under the following site conditions:

      a. Ambient:

         1) Temperature: 0-40 DEGC.

         2) 95% non-condensing relative humidity.

      b. Elevation: 3300 FT above MSL.

      c. Power supply characteristics:

         1) 480V, 3 PH, 3-wire, ±10%.

         2) Effectively grounded.

      d. Available short circuit current:

         1) 22,000 A RMS SYM.

B. Ratings and Performance Specifications:

   1. Voltage rating:

a. Nominal: 4□0 or 480 VAC, 3 PH, □0 Hz.

□. Range for continuous full load operation: 432-528 VAC.

c. Voltage im□alance tolerance for full load operation: 3□ minimum.

2. Current ratings:

a. Continuous: E□ual to or greater than the motor nameplate full load current multiplied □□the motor service factor.

□. Short-term overload: 500□ for 30 seconds.

c. Short circuit:

1□ 22,000 A RMS S□M, minimum.

3. Efficienc□: 98□, minimum, at full speed and full load.

C. Operational Features:

1. Pump control functions.

2. Insensitive to input phase se□uence.

3. Continued operation with momentar□voltage dips of 25□ of rated voltage, or single phase condition: 3 SEC, minimum.

4. Controls power loss ride-through: 500 MSEC, minimum.

5. Anti-windmilling□a□ilit□to safel□start into turning motor, forward or reverse.

D. The RVSS shall □e provided with the following minimum user-programma□le parameters:

1. Selecta□le tor□ue ramp start or current limit start.

2. Starts per hour.

3. Time □etween starts.

4. Initial current, ma□imum current and ramp time.

5. Kick current and time.

□. Tor□ue ramp.

7. Motor deceleration time.

8. Rela□outputs.

E. The RVSS shall □e designed such that the power circuit components are full□ protected from line side distur□ances and load side faults:

1. General:

a. Shutdown conditions associated with supply circuit conditions which can be corrected external to the RVSS motor system shall be provided with automatic reset, with shutdown cause logged in memory:

1) Input under/over voltage.

2) Input under/over frequency.

3) Input phase loss.

b. Shutdown conditions which indicate overload or fault within the RVSS, the output circuit, or the motor shall require local manual reset at the RVSS, requiring operator intervention.

1) Shorted SCR.

2) Component failure.

3) Under/over current.

a) Coordinate under current set points with Section 17950 or the Engineer.

4) Overload.

5) Short circuit

6) Ground fault.

7) Logic fault.

c. When automatic shutdown occurs, RVSS shall restart immediately upon reset, whether the drive is in automatic or manual mode.

d. RVSS shall hold cause of trip data for a minimum of four shutdowns in memory.

1) Data to be accessible through the keypad, local communication link and remotely.

e. Common alarm contact.

2. Input protection:

a. Input circuit breaker or current-limiting fuses with externally operable disconnect:

1) Fault current interrupting rating equal to or greater than the specified withstand rating of the RVSS.

2) Handle padlockable in the OFF position.

b. Incoming line transient suppression:

1) 6000 V peak per IEEE C62.41.1.

2) Phase-to-phase and phase-to-ground protection.

3. Internal protection:

   a. Surge suppression and power device snu□□ers.

   □. SCR peak inverse voltage □PIV□: 2.5 times line voltage.

   c. Instantaneous overcurrent trip.

   d. Power device overtemperature trip.

   e. Control logic circuit malfunction trip.

4. Output protection:

   a. Inverse-time overload trip:

      1□ UL Class 10 characteristic.

   □. Overvoltage trip.

   c. Overfre□uenc□ trip.

   d. Short circuit trip:

      1□ Line to line and line to ground.

   e. Ground fault trip.

2.04 OPERATOR AND REMOTE CONTROL INTERFACE

A. Drive controls shall □e microprocessor-□ased with on-□oard human machine interface and □oth local and remote digital communications capa□ilit□.

   1. All monitoring and control functions, other than those shutdowns specified to □e manual reset onl□, shall □e availa□le □oth locall□ and remotel□.

B. Control circuits shall □e 115 VAC:

   1. 115 VAC supplied □□ CPT in the RVSS.

      a. CPT shall have minimum additional capacit□ of □0 VA greater than that re□uired □□ control devices.

      □. CPT shall have two fuses on the primar□ side and one fuse on the secondar□ side.

      c. CPT shall have surge protection on the primar□ side independent of an□ other surge protection in the RVSS.

C. Operator Interface:

   1. Door mounted sealed ke□pad, mem□rane t□pe with LED or LCD displa□.

      a. Messages shall □e in English and engineering units.

      □. Drive operating parameters shall □e programma□le.

c. Menu driven.

d. Password security.

e. Display fault and diagnostic data.

f. Operating parameters, fault and diagnostic data maintained in non-volatile memory with historic log of fault and diagnostic data.

1) Fault descriptions shall be in plain text.

2) Fault codes are not acceptable.

g. Gold plated plug-in contacts.

2. HAND-OFF-AUTO selector switch.

3. Status indication:

a. POWER ON.

b. RUN STATUS.

c. RVSS FAULT.

4. Metering indications (minimum):

a. Amperes.

b. Voltage.

c. Frequency.

5. Diagnostic indicators located externally on the face of the drive shall show the type of fault responsible for drive warning, shutdown or failure.

a. On occurrence of more than one condition each shall be recorded or indicated by the diagnostics.

D. Remote Control Interface:

1. Contacts:

a. Contacts shall be rated 2 A inductive at 120 VAC.

b. All contacts shall be wired to field wiring terminal boards.

c. Refer to Section 17950 for additional requirements.

2.05 EQUIPMENT CONSTRUCTION

A. Fabrication and Assembly:

1. Each RVSS system shall be factory-assembled in an enclosure for remote mounting and shall utilize interchangeable plug-in printed circuit boards and power conversion components wherever possible.

a. Factory assembly shall be performed by the RVSS manufacturer or authorized agent.

b. Systems fabricated or assembled in whole or in part by parties other than the RVSS manufacturer or authorized agent will not be acceptable.

2. Cooling fans shall be provided, as required, to run when drive is running.

3. Enclosures for separately mounted RVSS's:

a. NEMA Type 1 for installation in Electrical Rooms.

B. Wiring:

1. The wiring in the RVSS shall be neatly installed in wire ways or with wire ties where wire ways are not practical.

a. Where wire ties are used, the wire bundles are to be held at the back panel with a screw-mounted wire tie mounting base.

b. Bases with a self-sticking back will not be allowed.

2. All plug-in contacts shall be gold-plated.

3. Provide terminal boards for all field wiring and inter-unit connections.

4. Terminal blocks shall be complete with marking strip, covers and pressure connectors.

a. They shall be non-brittle, interlocking, track-mounted type.

b. Screw terminals will not be allowed.

c. A terminal shall be provided for each conductor of external circuits plus one ground for each shielded cable.

d. For free-standing panels, 8 IN of clearance shall be provided between terminals and the panel base for conduit and wiring space.

e. Not less than 25% spare terminals shall be provided.

f. Terminals shall be labeled to agree with identification indicated on the supplier's submittal drawings.

g. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.

5. All grounding wires shall be attached to the enclosure sheet metal with a ring tongue terminal.

a. The surface of the sheet metal shall be prepared to assure good conductivity and corrosion protection.

6. Wiring shall not be kinked or spliced and shall have markings on both ends or be color coded.

a. Markings or color code shall match the manufacturer's drawings.

7. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, type MTW or SIS, insulated for not less than □00 V, with a moisture-resistant and flame-retardant covering rated for not less than 90 DEGC.

C. Nameplates:

1. RVSS enclosure shall be provided with a suitable nameplate as specified in Specification Section 1□195.

2. Push buttons, selector switches, and pilot lights shall have the device manufacturer's standard legend plate.

3. Relays, terminals and special devices inside the control enclosure shall have permanent markings to match identification used on manufacturer's wiring diagrams.

4. Use stainless steel screws to attach nameplates.

D. Factory Painting: Enclosure, after being phosphate washed, shall be thoroughly cleaned and given at least one coat of rust-inhibiting primer on all inner surfaces prior to fabrication.

2.0□ SOURCE QUALITY CONTROL

A. Factory Tests:

1. Conduct all standard tests in accordance with NEMA and ANSI standards to ensure conformance to Specification requirements.

2. Prior to final assembly:

a. Inspect incoming components.

b. Test and inspect power devices.

c. Circuit cards:

1) Component and functional tests:

2) Burn-in chamber or temperature cycling test.

3) System test after burn-in, or temperature cycling.

3. After final assembly:

a. Continuity and insulation test of 480 VAC circuits.

1) Test voltage shall be 2500 VDC.

b. Continuity and insulation test of 120 VAC circuits.

1) Test voltage shall be 500 VDC.

c. Drive tests:

1) Burn-in complete drive at full load for 24 HRS.

2) Verify all auxiliary circuits operation.

3) Monitor output variables.

d. Systems test:

1) Provide inputs to field connections and simulate on-site operation.

2) Test all auxiliary equipment.

2.07 MAINTENANCE MATERIALS

A. Provide manufacturer's recommended renewable spare parts (e.g., power and control fuses).

B. Spare parts utilized during pre-start-up or start-up and demonstration testing shall be immediately restocked, at no cost to the Owner.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions and as indicated on the Drawings.

B. Provide separately mounted RVSS enclosure with Short Circuit Current Rating (SCCR) labeling as required by NFPA 70 and other applicable codes.

1. Determine the SCCR rating by one of the following methods:

a. Method 1: SCCR rating meets or exceeds the available fault current of the source equipment when indicated on the Drawings.

b. Method 2: SCCR rating meets or exceeds the source equipment's Amp Interrupting Current (AIC) rating as indicated on the Drawings.

c. Method 3: SCCR rating meets or exceeds the calculated available short circuit current at the control panel.

2. The source equipment is the switchboard, panelboard, motor control center or similar equipment where the equipment or control panel circuit originates.

3. For Method 3, provide calculations justifying the SCCR rating. Utilize source equipment available fault current or AIC rating as indicated on the Drawings.

C. Verify the installed motor nameplate electrical requirements do not exceed the RVSS capacity.

3.02 START-UP

A. Pre-Start-up Services:

1. Shall be completed a minimum of 30 days prior to the start-up and demonstration period.
    a. Shall consist of physical and electrical installation check.
2. Final adjustments and calibration of drive parameters.
3. Shall be complete when RVSS's are fully operational.

B. Start-up and Demonstration Services:
1. Provide services of manufacturer's representative to perform start-up services.
2. Supervise start-up of all units including recheck of settings made during the pre-start-up tests.
    a. Perform all work in the presence of the Owner's designated representatives.
3. Simulate operation of the RVSS and its associated control and instrumentation system in both the manual and automatic modes.
    a. Ensure compatibility of RVSS with associated control and instrumentation signals.
4. Simulate RVSS failures and demonstrate troubleshooting aids.

C. Instruct Owner's Designated Personnel:
1. Minimum of 4 HRS at the jobsite.
2. Include both field and classroom instruction.
3. Instructions shall include proper operation and maintenance procedures including, but not limited to:
    a. Lubrication.
    b. Troubleshooting.
    c. Repair and replacement.
    d. Parts inventory.
    e. Maintenance records.

END OF SECTION

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SECTION 1□412

SEPARATEL□ MOUNTED CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. Separatel□mounted circuit □reakers.

B. Related Sections include □ut are not necessaril□limited to:

1. Section 1□000 – Basic Electrical Re□uirements.

2. Section 1□490 - Overcurrent and Short Circuit Protective Devices.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. National Electrical Manufacturers Association □NEMA□:

a. 250, Enclosures for Electrical E□uipment □1000 Volts Ma□imum□.

2. Underwriters La□oratories, Inc. □UL□:

a. 489, Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures.

□. 1203, Standard for E□plosion-Proof and Dust-Ignition-Proof Electrical E□uipment for Use in Hazardous □Classified□Locations.

1.03 SUBMITTALS

A. Shop Drawings:

1. Product technical data:

a. Provide su□mittal data for all products specified in PART 2 of this Specification Section.

□. Provide a ta□le that associates e□uipment model num□er with e□uipment tag num□er.

c. See Specification Section 1□000 for additional re□uirements.

B. Contract Closeout Information:

1. Operation and Maintenance Data:

a. See Specification Section 01430 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the basis of design is Square D by Schneider Electric.

B. Other acceptable manufacturers include:

1. Eaton.
2. GE by ABB.
3. Siemens Corporation.

2.02 COMPONENTS

A. Ratings:

1. Voltage, number of phases, number of wires, and current rating as indicated on the Drawings.
2. Assembly short circuit current and interrupting device rating as indicated on the Drawings.
3. Service Entrance Equipment rated when indicated on the Drawings.

B. Standards: UL 489.

C. Overcurrent and short circuit protective devices:

1. Molded case circuit breaker.
2. See Section 16490 for overcurrent and short circuit protective device requirements.
3. Factory installed.

D. NEMA 1 rated:

1. Body and cover: Sheet steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
2. With or without knockouts, hinged or unhinged cover.
3. Breaker is front operable and padlockable in the OFF position.
4. Suitable for service entrance.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Permitted uses of NEMA 1 enclosure:

   1. Surface mounted in electrical building.

C. Equipment Marking and Documentation:

   1. Provide labeling per NFPA 70 and other applicable codes.

   2. Service equipment:

      a. Arc-flash hazard warning label. (Ref. NFPA 70 Article 110.16(A) and (B))

      b. Available fault current label and documentation of the calculations made for compliance with marking requirements. (Ref. NFPA 70 Article 110.24)

   3. Other than service equipment:

      a. Arc-flash hazard warning label. (Ref. NFPA 70 Article 110.16(A))

      b. Available fault current label. (Ref. NFPA 70 Article 408.6)

   4. Identify (tag) all equipment and equipment components.

   5. Provide labels and tags in accordance with Section 16195.

   6. Available fault current and other required label data from Coordinated Power System Study as required by the contract documents.

END OF SECTION

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SECTION 1□440

SAFET□ SWITCHES

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish and install separatel□mounted, individual safet□switches as specified herein and indicated on the Drawings.

B. Safet□switches for process instruments are not included in the scope of this Section and shall □e as specified in Specification Section entitled “Wiring Devices.”

1.02 CODES AND STANDARDS

A. Safet□switches shall □e designed, manufactured, and/or listed to the following standards as applica□le:

1. UL 98 – Enclosed and Dead-Front Switches
2. UL 1203 – Standard for E□plosion-proof and Dust-ignition-proof Electrical E□uipment for use in Hazardous □Classified□Locations.
3. NEMA 250 – Enclosures for Electrical E□uipment
4. NEMA KS 1 – Heav□Dut□Enclosed and Dead-Front Switches

1.03 SUBMITTALS

A. In accordance with the procedures and re□uirements set forth in the General Conditions and Specification Section entitled “Su□mittals,” the Contractor shall o□tain from the e□uipment manufacturer and su□mit the following:

1. Shop Drawings
2. Spare Parts List

B. Each su□mittal shall □e identified □□the applica□le specification section.

1.04 SHOP DRAWINGS

A. Each su□mittal shall □e complete in all respects, incorporating all information and data listed herein and all additional information re□uired for evaluation of the proposed e□uipment□s compliance with the Contract Documents.

B. Partial, incomplete or illegi□le su□mittals will □e returned to the Contractor without review for resu□mittal.

C. Shop drawings shall include □ut not □e limited to:

1. Product data sheets.
2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of safety switch.
3. Assembled weight of each unit.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

1.05 SPARE PARTS

A. The equipment shall be furnished with all spare parts as recommended by the equipment manufacturer.

B. One (1) complete set of spare fuses for each ampere rating installed shall be furnished and delivered to the City at the time of final inspection.

C. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.06 IDENTIFICATION

A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the circuit number and equipment name with which it is associated. Equipment identification shall be in accordance with Specification Section entitled “Electrical - Identification.”

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Switches shall be manufactured by the Square D Company, Eaton, the General Electric Company, or Siemens Energy and Automation, Inc.

2.02 GENERAL

A. Safety switches shall be heavy-duty type, and shall be furnished and installed as shown on the Drawings and as required by the NEC.

B. Safety switches for non-hazardous areas shall be UL 98 Listed. Safety switches for hazardous areas shall be UL 1203 Listed.

C. Switches shall meet NEMA Standard KS 1 type HD requirements, be externally operable, and be fused or non-fused as indicated on the Drawings. Switches shall have the number of the poles, voltage, and ampere ratings as shown on the Drawings.

D. Double-throw safety switches shall have an “OFF” position in which the load is disconnected from both sources simultaneously.

E. In non-hazardous locations, safety switches shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

F. Safety switches shall be quick-make, quick-break and shall be equipped with a defeatable door interlock which prevents the door from being opened when switch is in the "ON" position. Safety switches shall be capable of being padlocked in the "OPEN" position.

G. A complete set of fuses for all switches shall be furnished and installed as required. Time-current characteristic curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have voltage rating not less than the circuit voltage.

H. Safety switches shall be furnished with a factory installed internal barrier kit that helps prevent accidental contact with live parts and provides “finger-safe” protection when the door of the enclosed switch is open.

I. Safety switches shall be furnished with a manufacturer-supplied ground lug kit for termination of equipment grounding conductors. Where a grounded (neutral) conductor is shown on the Drawings in the conduits connected to the safety switch, a manufacturer-supplied neutral bar shall be furnished for termination of the grounded conductors. Third party ground lug and neutral lug kits not supplied by the safety switch manufacturer are not acceptable.

J. Where indicated, safety switches shall be suitable for use as service entrance equipment and shall bear a U.L label indicating suitability.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All safety switches shall be mounted five (5) feet above the floor or finished grade, at the equipment height where appropriate, or where shown otherwise.

B. Safety switches shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Field Tests

    a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

END OF SECTION

SECTION 1□442

MOTOR CONTROL E□UIPMENT

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. Separatel□mounted motor starters □including those supplied with e□uipment□.
2. Manual motor starters.

B. Related Specification Sections include □ut are not necessaril□limited to:

1. Section 1□000 – Basic Electrical Re□uirements.
2. Section 1□080 - Acceptance Testing.
3. Section 1□2□7 - Reduced Voltage Solid State Starters - Low Voltage.
4. Section 1□49□ – Automatic Transfer Switch.
5. Section 1□470 - Panel□oards.
□. Section 1□4□0 - Dr□-T□pe Transformers.
7. Section 1□492 - Electrical Metering Devices.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. International Electrotechnical Commission □IEC□.
2. National Electrical Manufacturers Association □NEMA□:
   a. 250, Enclosures for Electrical E□uipment □1000 Volt Ma□imum□.
   □. ICS 2, Controllers, Contactors and Overload Rela□s Rated □00 V.
3. Underwriters La□oratories, Inc. □UL□:
   a. 508, Standard for Industrial Control E□uipment.

B. Miscellaneous:

1. Verif□motor horsepower loads, other e□uipment loads, and controls from approved shop drawings and notif□Engineer of an□discrepancies.
2. Verif□the re□uired instrumentation and control wiring for a complete s□stem and notif□Engineer of an□discrepancies.

1.03 SUBMITTALS

A. Shop Drawings:

1. Product technical data:

a. Provide su□mittal data for all products specified in PART 2 of this Specification Section.

□. See Specification Section 1□000 for additional re□uirements.

2. Fa□rication and/or la□out drawings:

a. Separatel□ mounted com□ination starters:

1□ Unit ladder logic wiring for each unit depicting electrical wiring and identification of terminals where field devices or remote control signals are to □e terminated including industr□ standard s□m□olog□ of the field devices as indicated on the Drawings, specification and/or loop descriptions. Drawings indicate □asic control functionalit□, provide diagrams for the manufacturer's product(s) meeting the required functionality.

2□ Short Circuit Current Rating □SCCR□ nameplate marking per NFPA 70, include an□ re□uired calculations.

B. Contract Closeout Information:

1. Operation and Maintenance Data:

a. See Specification Section 01430 for re□uirements for the mechanics, administration, and the content of Operation and Maintenance Manual su□mittals.

□. Fa□rication and/or la□out drawings updated with as-□uilt conditions.

C. Informational Su□mittals:

1. E□uipment marking and documentation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Su□□ect to compliance with the Contract Documents, the following manufacturers are accepta□le:

1. Allen-Bradle□ □□ Rockwell Automation, Inc.
2. c3controls.
3. Eaton.
4. GE □□ ABB.
5. S□uare D □□ Schneider Electric.

□. Siemens Corporation.

2.02 SEPARATELY MOUNTED COMBINATION STARTERS

A. Standards:

1. NEMA 250, NEMA ICS 2.
2. UL 508.

B. Enclosure:

1. NEMA 4X rated:
    a. Body and cover: Type 304 or 316 stainless steel.
    b. No knockouts, external mounting flanges, hinged and gasketed door.
2. NEMA 7 rated:
    a. Cast gray iron alloy or copper-free aluminum with manufacturer's standard finish.
    b. Drilled and tapped openings or tapered threaded hub.
    c. Gasketed cover bolted-down with stainless steel bolts.
    d. External mounting flanges.
    e. Front operating handle padlockable in the OFF position.
    f. Accessories: 40 MIL PVC exterior coating.

C. Operating Handle:

1. With the door closed the handle mechanism allows complete ON/OFF control of the unit disconnect and clear indication of the disconnect status.
2. Circuit breaker and MCP operators includes a separate TRIPPED position.
3. Mechanical interlock to prevent to prevent the opening of the door when the disconnect is in the ON position with a defeater mechanism for use by authorized personnel.
4. Mechanical interlock to prevent the placement of the disconnect in the ON position with the door open with a defeater mechanism for use by authorized personnel.
5. Padlockable in the OFF position.
6. Exceptions: NEMA 7 enclosures.

D. External mounted overload relay pushbutton.

E. Control Devices:

1. Provide control devices as indicated on the Drawings per Specification Section 17550.

2. Devices will □e accessi□le with the door closed.

F. Control Power Transformer:

1. 120V secondar□.

2. Fused on primar□ and secondar□ side.

3. Sized for 140□ of re□uired load.

G. Fault Current Withstand Rating: E□ual to the rating of the electrical gear from which it is fed.

H. Motor Starters: See re□uirements within this Specification Section.

I. Disconnect Switch, Overcurrent and Short Circuit Protective Devices:

1. Motor circuit protector.

2. Factor□ installed.

2.03 MOTOR STARTERS

A. Standards:

1. NEMA ICS 2.

2. UL 508.

B. Reduced Voltage Solid State □RVSS□ Starters:

1. See Specification Section 1□2□7.

2.04 MANUAL MOTOR STARTERS

A. Standards:

1. NEMA 250, NEMA ICS 2.

2. UL 508.

B. □uick-make, □uick-□reak toggle mechanism that is locka□le in the OFF position.

C. T□pes:

1. Horsepower rated, for ON/OFF control.

2. Horsepower rated, for ON/OFF control and thermal overload protection.

   a. Switch to clearl□ indicate ON, OFF, and TRIPPED position.

D. Voltage and current ratings and num□er of poles as re□uired for the connected motor.

E. Enclosures:

1. NEMA 4□ rated:

a. T□pe 304 or 31□ stainless steel.

□. No knockouts, e□ternal mounting flanges.

2. NEMA 7 rated:

a. Cast gra□ iron allo□ or copper-free aluminum with manufacturer□s standard finish.

□. Drilled and tapped openings or tapered threaded hu□, e□ternal mounting flanges.

c. Accessories: 40 MIL PVC e□terior coating.

3. NEMA 12 rated:

a. Bod□ and cover: Sheet steel finished with rust inhi□iting primer and manufacturer□s standard paint inside and out.

□. No knockouts, e□ternal mounting flanges.

PART 3 - E□ECUTION

3.01 INSTALLATION

A. Install as indicated on the Drawings and in accordance with manufacturer□s recommendations and instructions.

B. Mounting height for surface mounted e□uipment: See Specification Section 1□000.

C. E□uipment Marking and Documentation:

1. Provide la□eling per NFPA 70 and other applica□le codes.

2. Other than service e□uipment:

a. Arc-flash hazard warning la□el. □Ref. NFPA 70 Article 110.1□□A□□

□. Availa□le fault current la□el. □Ref. NFPA 70 Article 408.□□

3. Identif□ □tag□ all e□uipment and e□uipment components.

4. Provide la□els and tags in accordance with Section 1□195.

5. Availa□le fault current and other re□uired la□el data from Coordinated Power S□stem Stud□ as re□uired □□ the contract documents.

D. Provide separatel□ mounted com□ination starters with Short Circuit Current Rating □SCCR□ la□eling as re□uired □□ NFPA 70 and other applica□le codes.

1. Determine the SCCR rating □□ one of the following methods:

a. Method 1: SCCR rating meets or e□ceeds the availa□le fault current of the source e□uipment when indicated on the Drawings.

□. Method 2: SCCR rating meets or e□ceeds the source equipment’s Amp Interrupting Current □AIC□rating as indicated on the Drawings.

c. Method 3: SCCR rating meets or e□ceeds the calculated availa□le short circuit current at the control panel.

2. The source e□uipment is the switch□oard, panel□oard, motor control center or similar e□uipment where the e□uipment or control panel circuit originates.

3. For Method 3, provide calculations □ustif□ing the SCCR rating. Utilize source e□uipment availa□le fault current or AIC rating as indicated on the Drawings.

E. Overload Heaters:

1. Size for actual motor full load current of the connected motor.

2. For motors with power factor correction capacitors, size to compensate for the capacitors effect on load current.

F. Com□ination and Manual Starter Enclosures:

1. Permitted uses of NEMA 4□ enclosure:

a. Surface mounted in areas designated as wet and/or corrosive.

2. Permitted uses of NEMA 7 enclosure:

a. Surface mounted in areas designated as Class I hazardous.

□. Provide PVC coating in corrosive and highl□corrosive areas when PVC coated conduit is used.

3. Permitted uses of NEMA 12 enclosure:

a. Surface mounted in areas designated as dr□.

3.02 FIELD □UALIT□ CONTROL

A. Acceptance Testing: See Specification Section 1□080.

END OF SECTION

SECTION 1□4□0

DR□-T□PE TRANSFORMERS

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. Dr□-t□pe transformers, 1000 kVA and less.

B. Related Sections include □ut are not necessaril□ limited to:

1. Section 1□000 – Basic Electrical - Re□uirements.
2. Section 1□0□0 – Grounding and Bonding.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. Department of Energ□ □DOE□:
   a. 10 CFR 431, Energ□ Conservation Program: Energ□ Conservation Standards for Distri□ution Transformers.
2. Institute of Electrical and Electronics Engineers, Inc. □IEEE□:
   a. C57.9□, Guide for Loading Dr□-T□pe Distri□ution and Power Transformers.
3. National Electrical Manufacturers Association □NEMA□:
   a. 250, Enclosures for Electrical E□uipment □1000 Volts Ma□imum□.
   □. ST 20, Dr□ T□pe Transformers for General Applications.
4. Underwriters La□oratories, Inc. □UL□:
   a. 50□, Standard for Specialt□ Transformers.
   □. 15□1, Standard for Dr□-T□pe General Purpose and Power Transformers.

1.03 SUBMITTALS

A. Shop Drawings:

1. Product technical data:
   a. Provide su□mittal data for all products specified in PART 2 of this Specification Section.
   □. See Specification Section 1□000 for additional re□uirements.

2. Fabrication and/or layout drawings.

    a. Nameplate drawing.

3. Certifications:

    a. Sound level certifications.

B. Contract Closeout Information:

1. Operation and Maintenance Data:

    a. See Specification Section 01430 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Eaton.
2. GE by ABB.
3. Square D by Schneider Electric.
4. Siemens.
5. SolaHD by Emerson Electric Co.

2.02 GENERAL PURPOSE DRY-TYPE TRANSFORMERS

A. Ventilated or non-ventilated, air cooled, two winding type.

B. Cores:

1. High grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses.
2. Magnetic flux densities are to be kept well below the saturation point.

C. Coils: Continuous wound with electrical grade aluminum.

D. Ventilated Units:

1. Core and coils assembly impregnated with non-hygroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture and completely isolated from the enclosure by means of vibration dampening pads.
2. Dripproof, NEMA 1, steel enclosure finished with a weather-resistant enamel and ventilation openings protected from falling dirt.

E. Furnish Taps for Transformers as follows:

   1. 3 PH, 15 kVA and a□ove: Two, 2.5□ FCAN and four, 2.5□ FCBN.

F. Sound Levels:

   1. Manufacturer shall guarantee not to e□ceed the following:

      a. 10 to 50 kVA: 45 dB.

G. Efficienc□ □minimum□:

   1. Ventilated:

      a. 3 PH, 15 - 1000 kVA: DOE 201□ Efficienc□.

H. Insulating Material □□00 V and □elow□:

   1. 15 kVA and a□ove units: 220 DEGC insulation s□stem with a 150 DEGC rise.

I. Ratings: □0 Hz, voltage, KVA and phase, as indicated on the Drawings.

□. Finish: Rust inhi□ited primer and manufacturers standard paint inside and out.

K. Standards: IEEE C57.9□, NEMA ST 20, UL 50□, UL 15□1.

PART 3 - E□ECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer□s instructions.

B. Indoor Locations:

   1. Provide ventilated t□pe for 15 kVA units and a□ove.

   2. Mount 15 kVA units and a□ove on chamfered □IN high concrete housekeeping pad.

   3. Provide ru□□er vi□rations isolation pads.

C. Enclosures: Painted steel in all areas.

D. Ground in accordance with Section 1□0□0.

END OF SECTION

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SECTION 1□470

PANELBOARDS

<u>PART 1 -</u> <u>GENERAL</u>

1.01 THE RE□UIREMENT

A. The Contractor shall furnish and install panel□oards of voltage and current ratings as specified herein and indicated on the Drawings. Panel□oards shall □e furnished with circuit □reaker ratings, num□er of □reakers, num□er of poles and locations conforming to the panel□oard schedules on the Drawings.

B. Reference Section 1□000, Basic Electrical Re□uirements□Section 1□195, Electrical Identification□Section 1□490, Overcurrent and Short Circuit Protective Devices□Section 1□491, Surge Protection Devices for Low-Voltage Electrical Power Circuits.

1.02 CODES AND STANDARDS

A. Panel□oards shall □e designed, manufactured, and/or listed to the following standards as applica□le:

1. Underwriters La□oratories
    a. UL 50 – Enclosures for Electrical E□uipment, Non-environmental Considerations
    □. UL □7 – Standard for Panel□oards
    c. UL 489 - Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures
    d. UL 943 – Ground Fault Circuit Interrupters
    e. UL 1449 – Standard for Surge Protective Devices
2. NEMA PB1 - Panel□oards
3. National Electrical Contractors Association □NECA□Standard 407 – Standard for Installing and Maintaining Panel□oards

1.03 SUBMITTALS

A. In accordance with the procedures and re□uirements set forth in the General Conditions and Section 01300, Su□mittals, the Contractor shall o□tain from the e□uipment manufacturer and su□mit the following:

1. Shop Drawings.
2. Spare Parts List.
3. Operation and Maintenance Manuals.

4. Reports of Field Tests.

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions for each panelboard.

3. Complete panelboard schedules indicating circuit designations as shown on the Drawings for each panelboard.

D. The submittal information shall reflect the specific equipment identification number as indicated on the Drawings.

1.05 OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1. The manuals shall include:

1. Instruction books and/or leaflets.

2. Recommended spare parts list.

3. Final as-built construction drawings included in the shop drawings incorporating all changes made in the manufacturing process and during field installation.

1.06 SPARE PARTS

A. For each panelboard, the Contractor shall furnish to the City all spare parts as recommended by the equipment manufacturer. All spaces in the panelboards shall be furnished with a spare breaker as indicated in the panelboard schedules shown on the Drawings.

B. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.07 IDENTIFICATION

A. Each panelboard shall be identified with the identification name/number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each panelboard. Nameplates shall be as specified in Section 16195, Electrical - Identification.

<u>PART 2 - PRODUCTS</u>

2.01 MANUFACTURERS

A. The Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 CONDUCTORS (MAIN BUS AND BRANCH CONNECTORS)

A. All main bus shall be copper sized in accordance with UL standards to limit the temperature rise on any current carrying part to a maximum of 50 degrees C above a maximum ambient temperature of 40 degrees C.

2.03 LIGHTING PANELBOARDS

A. General

1. Lighting panelboards shall be dead-front type with automatic trip-free, non-adjustable, thermal-overload, branch circuit breakers. Panelboards shall be of the configuration and rating as specified herein and indicated on the Drawings. Panelboards shall be UL 67 Listed and shall be constructed to NEMA PB1 standards. Panelboards shall be service entrance rated where indicated on the Drawings.

2. Lighting panelboards shall be equipped with a main breaker or main lugs complete with branch circuit breakers, as indicated on the Drawings. The panelboards shall be suitable for flush or surface mounting.

3. Lighting panelboards shall be fully rated and shall have a minimum short circuit rating of 22,000 amperes symmetrical, unless otherwise indicated on the Drawings.

4. Lighting panelboards shall be Eaton Pow-R-Line Series, the Square D Company equivalent, the General Electric Company equivalent, or Siemens Energy and Automation, Inc. equivalent.

5. Provide feed through lugs as indicated on the drawings.

B. Enclosures

1. Enclosures shall have a NEMA rating as indicated on the Drawings, shall be UL 50 Listed, and shall be constructed of No. 12 U.S.S. code gauge galvanized steel. The door shall be fastened to the enclosure with concealed hinges and shall be equipped with flush-type catches and locks. The Contractor shall equip cabinet doors exceeding 40 inches in height with vertical bolt three point locking mechanism. All locks shall be keyed alike. The panelboard trim shall have a

remova□le hinge assem□l□, in addition to the door hinge, that allows work inside the enclosure without the need to remove the trim. The enclosure shall have wiring gutters on sides and shall □e at least 5-3/4 inches deep. The panel□oard shall □e provided with an information la□el. The information la□el shall include the panel□oard designation, voltage, phase, wires, and □us rating.

2. All metal surfaces of the panel□oard enclosures shall □e thoroughl□cleaned and given one prime of zinc chromate primer. All interior surfaces shall then □e given one shop finishing coat of a lac□uer of the nitro-cellulose enamel variet□. All e□terior surfaces shall □e given three coats of the same lac□uer. The color of finishing coats shall □e light gra□ANSI □□1.

3. An Underwriter□s La□oratories, Inc. inspection la□el shall appear on the interior of the ca□inet.

C. Bus Work

1. Main □us □ars shall □e of ample size so that a current densit□of not more than 1000 amperes per s□uare inch of cross section will □e attained. This current densit□shall □e □ased on the application of the full load connected to the panel plus appro□imatel□25□ of the full load for spare capacit□. The main □us shall □e full capacit□as □ased on the preceding for the entire length of the panel so as to provide full fle□i□ilit□of circuit arrangement.

2. Solid neutral □us □ars are re□uired and neutral □us ampacit□shall □e the same as the main □us □ars unless otherwise noted. Ratings shall □e in accordance with applica□le standards.

3. A separate ground □us shall □e provided with lugs for termination of e□uipment grounding conductors.

4. Branch □us work shall □e rated to match the ma□imum □ranch circuit □reaker which ma□ □e installed in the standard space.

5. All □us shall □e tin plated copper and shall e□tend the entire usea□le length of the panel□oard, including spaces.

D. Circuit Breakers

1. See specification section 1□490 for Overcurrent and Short Circuit Protective Devices.

E. Directories

1. Approved directories with noncom□usti□le plastic cover, and with t□pewritten designations of each □ranch circuit, shall □e furnished and installed in each panel□oard. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten director□clearl□indicating the circuit □reakers in service. This director□shall □e updated as work progresses, and final, t□pewritten directories, as specified a□ove, shall □e installed at the end of the pro□ect. Designations and circuit locations shall conform to the panel□oard schedules on the Drawings, e□cept as otherwise authorized □□the Engineer.

2.04 POWER DISTRIBUTION PANELBOARDS

A. General

1. Power distri□ution panel□oards shall □e of the configuration and rating as specified herein and as indicated on the Drawings. The panel□oards shall □e dead-front t□pe with automatic trip-free, non-ad□usta□le, thermal overload □ranch circuit □reakers. Panel□oards shall □e UL □7 Listed and shall □e constructed to NEMA PB1 standards. Panel□oards shall □e service entrance rated where indicated on the Drawings.

2. Power panel□oards shall □e e□uipped with a main □reaker or main lugs complete with □ranch circuit □reakers as indicated on the Drawings. The panel□oards shall □e suita□le for flush or surface mounting.

3. Power distri□ution panel□oards shall □e full□rated and shall have a minimum short circuit rating as indicated on the Drawings.

4. Power distri□ution panel□oards shall □e Eaton Pow-R-Line Series, the S□uare D Compan□e□uivalent, the General Electric Compan□e□uivalent, or Siemens Energ□ and Automation, Inc. e□uivalent.

5. Provide feed through lugs as indicated on the drawings.

B. Enclosures

1. Enclosures shall have a NEMA rating as indicated on the Drawings, shall □e UL 50 Listed, and shall □e constructed of No. 12 U.S.S. code gauge galvanized steel. The door shall □e fastened to the enclosure with concealed hinges and shall □e e□uipped with flush-t□pe catches and locks. The Contractor shall e□uip ca□inet doors e□ceeding 40 inches in height with vertical □olt three point locking mechanism. All locks shall □e ke□ed alike. The panel□oard trim shall have a remova□le hinge assem□l□, in addition to the door hinge, that allows work inside the enclosure without the need to remove the trim. The enclosure shall have wiring gutters on sides and shall □e at least 5-3/4 inches deep. The panel shall □e provided with an information la□el. The information la□el shall include the panel□oard designation, voltage, phase, wires, and □us rating.

2. All metal surfaces of the panel□oard enclosures shall □e thoroughl□cleaned and given one prime of zinc chromate primer. All interior surfaces shall then □e given one shop finishing coat of a lac□uer of the nitro-cellulose enamel variet□. All e□terior surfaces shall □e given three coats of the same lac□uer. The color of finishing coats shall □e light gra□ANSI □□1.

3. An Underwriter□s La□oratories, Inc. inspection la□el shall appear on the interior of the ca□inet.

C. Bus Work

1. Main □us □ars shall □e of ample size so that a current densit□of not more than 1,000 amperes per s□uare inch of cross section will □e attained. This current densit□shall □e □ased on the application of the full load connected to the panel plus appro□imatel□25□ of the full load for spare capacit□. The main □us shall □e

full capacit□as □ased on the preceding for the entire length of the panel so as to provide full fle□i□ilit□of circuit arrangement.

2. Solid neutral □us □ars, where re□uired, shall □e provided. Neutral □us shall have the same ampacit□as the main □us, unless otherwise indicated. Ratings shall □e in accordance with applica□le standards.

3. A separate ground □us shall □e provided with lugs for termination of e□uipment grounding conductors.

4. Branch □us work shall □e rated to match the ma□imum □ranch circuit □reaker which ma□ □e installed in the standard space.

5. All □us shall □e tin plated copper and shall e□tend the entire usea□le length of the panel□oard, including spaces. Panel□oards Listed and La□eled as a four-wire panel shall not □e used in place of a three-wire panel where a neutral conductor does not e□ist in the suppl□conductors to that panel.

D. Circuit Breakers

1. See specification section 1□490 for Overcurrent and Short Circuit Protective Devices.

E. Directories

1. Approved directories with noncom□usti□le plastic cover, and with t□pewritten designations of each □ranch circuit, shall □e provided in each panel. The Contractor shall maintain in each panel, during the duration of the Contract, a handwritten director□clearl□indicating the circuit □reakers in service. This director□shall □e updated as work progresses, and final, t□pewritten directories, as specified a□ove, shall □e installed at the end of the pro□ect. Designations and circuit locations shall conform to the panel□oard schedules on the Drawings, e□cept as otherwise authorized □□the Engineer.

2.05 SURGE PROTECTIVE DEVICES

A. See specification Section 1□491 for Surge Protection re□uirements.

PART 3 - E□ECUTION

3.01 INSTALLATION

A. Panel□oards shall □e furnished and installed as shown on the Drawings and as recommended □□the e□uipment manufacturer, and as re□uired □□NECA 407.

B. Panel□oards shall □e set true and plum□in locations as shown on the Drawings. The top of panel□oard enclosure shall not e□ceed si□ □□feet a□ove finished floor elevation.

C. Enclosures shall not □e fastened to concrete or masonr□surfaces with wooden plugs. Appropriate cadmium plated or galvanized steel □olts shall □e used with e□pansion shields or other metallic t□pe concrete insert for mounting on concrete or solid masonr□ walls. Cadmium plated or galvanized steel toggle □olts shall □e used for mounting on concrete block or other hollow masonry walls. Bolt diameter shall be as required considering the size and weight of the completed panelboard and enclosure to provide adequate structural support.

D. The Contractor shall not use factory furnished knockouts with surface mounted back boxes. The Contractor shall punch or drill required openings during installation and shall equip flush mounted back boxes with manufacturer's standard pattern of knockouts.

E. The Contractor shall install cabinets (and other enclosure products) in plumb with the building construction. Flush mounted enclosures shall be installed so that the trim will rest against the surrounding surface material and around the entire perimeter of the enclosure.

F. Bus loads in all panelboards shall be balanced between phases to within a tolerance of one (1) KVA. Convenience receptacles shall be distributed evenly among all phase buses as much as practical.

G. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same lacquer as used for shop finishing coats.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Field Tests

a. Prior to termination of any conductors to the circuit breakers, all bus work and circuit breakers shall be tested from phase to phase and phase to ground with a 1000 VDC megaohmeter for 1 minute in accordance with NECA 407. Resistance values shall be recorded and shall not be less than 100 megohms.

b. Prior to terminating any wires to the circuit breakers, the resistance of the connection between the bus work and each circuit breaker shall be tested through the use of a low-resistance ohmmeter. Record the resistance values for each circuit breaker.

END OF SECTION

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SECTION 1□490

OVERCURRENT AND SHORT CIRCUIT PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. Low voltage circuit □reakers.

B. Related Specification Sections include □ut are not necessaril□limited to:

1. Section 1□000 - Basic Electrical Re□uirements.
2. Section 1□080 - Acceptance Testing.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronics Engineers, Inc. □IEEE□:
    a. C37.13, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
    □. C37.1□, Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Re□uirements, and Application Recommendations.
    c. C37.17, Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers.
2. National Fire Protection Association □NFPA□:
    a. 70, National Electrical Code □NEC□.
3. Underwriters La□oratories, Inc. □UL□:
    a. 489, Standard for Safet□Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
    □. 943, Standard for Safet□for Ground-Fault Circuit-Interrupters.
    c. 10□□, Standard for Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures.

1.03 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:

a. Provide su□mittal data for all products specified in PART 2 of this Specification Section.

□. See Specification Section 1□000 for additional re□uirements.

B. Informational Su□mittals:

1. Reports:

a. Short circuit stud□ report.

□. Protective coordination stud□ report.

c. As-left condition of all circuit □reakers that have ad□usta□le settings.

<u>PART 2 -</u> <u>PRODUCTS</u>

2.01 MANUFACTURERS

A. Su□□ect to compliance with the Contract Documents, the following manufacturers are accepta□le:

1. Circuit □reakers:

a. Eaton.

□. GE □□ ABB.

c. S□uare D Compan□.

d. Siemens.

2.02 CIRCUIT BREAKERS

A. Molded Case T□pe:

1. General:

a. Standards: UL 489.

□. Unit construction.

c. Over-center, toggle handle operated.

d. □uick-make, □uick-□reak, independent of toggle handle operation.

e. Manual and automatic operation.

f. All poles open and close simultaneousl□.

g. Three position handle: On, off and tripped.

h. Molded-in ON and OFF markings on □reaker cover.

i. One-, two- or three-pole as indicated on the Drawings.

b. Current and interrupting ratings as indicated on the Drawings.

2. Thermal magnetic type:

   a. Inverse time overload and instantaneous short circuit protection by means of a thermal magnetic element.

   b. Frame size 150 amp and below:

      1) Non-interchangeable, non-adjustable thermal magnetic trip units.

   c. Frame sizes 225 to 400 amp (trip settings less than 400A):

      1) Interchangeable and adjustable instantaneous thermal magnetic trip units.

   d. Ground Fault Circuit Interrupter (GFCI) Listed:

      1) Standard: UL 943.

      2) One- or two-pole as indicated on the Drawings.

      3) Class A ground fault circuit.

      4) Trip on 5 mA ground fault (4-6 mA range).

3. Solid state trip type:

   a. Inverse time overload, instantaneous short circuit and ground fault protection by means of a solid state trip element, associated current monitors and flux shunt trip mechanism.

   b. Frame size 400 amp to 1200 amp (trip settings between 400 and 1200A):

      1) Standard rating.

      2) Interchangeable current sensor or rating plug.

      3) Adjustable long time pick-up setting.

         a) Adjustable from 50 to 100% of the current sensor or rating plug.

      4) Adjustable short time pick-up setting.

      5) Adjustable instantaneous pick-up.

      6) Fixed ground fault pick-up, when indicated on the Drawings.

4. Motor circuit protector:

   a. Adjustable instantaneous short circuit protection by means of a magnetic or solid state trip element.

   b. Sized for the connected motor.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Current and interrupting ratings as indicated on the Drawings.

B. Series rated systems not acceptable.

C. Devices shall be ambient temperature compensated.

D. Circuit Breakers:

1. Molded case circuit breakers shall incorporate the following, unless indicated otherwise on the Drawings:

   a. Frame sizes 400 amp and less with trip setting less than 400A shall be thermal magnetic type.

   b. Frame sizes 400 amp and larger shall be solid state trip type.

   c. Motor circuit protectors sized for the connected motor.

3.02 FIELD QUALITY CONTROL

A. Coordinated Power System Protection:

1. Prepare a study to demonstrate that the equipment and system constructed meet the specified requirements for equipment ratings, coordination and protection.

2. Perform the studies in accordance with IEEE 242 and IEEE 399.

3. Include the name of the software developer, software package and software version number in the computer generated studies.

4. System short circuit study report:

   a. Begin the study at the main service electrical gear and extend down the system through all buses.

      1) Perform a balanced three-phase fault, bolted line-to-line fault and line-to-ground fault study.

   b. Prepare a one-line diagram to show the electrical system buses, transformers and all sources of fault current including generators and motors.

   c. Utilize manufacturer's data for the actual proposed equipment (e.g., transformer impedance).

   d. Coordinate the available utility fault current with the power utility company.

   e. Show input data in tabular form in the report and/or on the one-line diagram.

      1) Input data shall include but is not limited to:

         a) Utility fault current or MVA and X/R ratio.

b) Bus voltages.

c) Conductor sizes and type of conduit.

d) Generator and motor sizes and contributions.

e) Transformer sizes and impedances.

f. Show available fault current at each bus in tabular form in the report and/or on the one-line diagram.

g. Perform studies for both normal power and emergency/standby power scenarios.

5. System protective coordination study report:

a. Begin the study at the main service electrical gear and extend down the system through all buses as required to ensure a coordinated power system.

b. Demonstrate that the maximum possible degree of selectivity has been obtained between devices specified for the protection of equipment and conductors from damage from overloads and fault conditions.

1) Where necessary, an appropriate compromise shall be made between system protection and service continuity.

2) Consider system protection and service continuity to be of equal importance.

c. Prepare a one-line diagram to show the electrical system buses, transformers and protective devices.

d. Utilize manufacturer's data for the actual proposed protective devices.

e. Summarize the coordination study, conclusions and recommendations.

1) As a minimum, include the following:

a) The manufacturer's information used to prepare the study.

b) Assumptions made during the study.

c) Recommended taps and settings of all adjustable devices in tabulated form.

d) Composite coordination time-current curves on log-log paper showing:

(1) That the settings for each protective device will provide protection and selectivity.

(2) Identify each curve.

(3) Cable and equipment damage points.

(4) Circuit interrupting device operating and interrupting times.

(5) One-line sketch of the part of the system being investigated.

(6) Include as many curves as possible on a graph while maintaining readability.

e) Position time-current curves for each device to provide for maximum selectivity to minimize system disturbances during fault clearing.

f) Advise the Engineer of potential coordination problems discovered during the study and include recommendations to resolve the problem.

(1) Provide time-current curves for the "as found" and "proposed" conditions for upgrade/retrofit projects.

g) Submit the report for approval 90 days prior to equipment energization.

B. Adjustable Circuit Breakers:

1. Set all circuit breaker adjustable taps as defined on the Drawings, except adjust motor circuit protectors per the motor nameplate and NFPA 70 requirements.

C. Testing:

1. Acceptance testing: See Specification Section 1□080.

END OF SECTION

SECTION 1□491

SURGE PROTECTION DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. T□pe PC1 SPD - High e□posure locations □switchgear, switch□oard, panel□oard or motor control center□, integrall□ mounted.
2. T□pe PC2 SPD - High e□posure locations □switchgear, switch□oard, panel□oard or motor control center□, e□ternall□ mounted.
3. T□pe PC4 SPD - Medium e□posure location □switch□oard, panel□oard and motor control center□, e□ternall□ mounted.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronics Engineers, Inc. □IEEE□:
   a. C□2.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
   □. C□2.41.1, Guide on the Surge Environment in Low-Voltage □1000V and Less□ AC Power Circuits.
   c. C□2.41.2, Recommended Practice on Characterization of Surges in Low-Voltage □1000 V and Less□AC Power Circuits.
   d. C□2.45, Recommended Practice on Surge Testing For E□uipment Connected to Low-Voltage □1000V and Less□AC Power Circuits.
2. National Electrical Manufacturers Association □NEMA□:
   a. 250, Enclosures for Electrical E□uipment □1000 Volts Ma□imum□.
3. National Fire Protection Association □NFPA□:
   a. 70, National Electrical Code □NEC□.
4. Underwriters La□oratories, Inc. □UL□:
   a. 1283, Standard for Electromagnetic Interference Filters.
   □. 1449, Standard for Surge Protective Devices.

B. □ualifications:

1. Provide devices from a manufacturer who has been regularly engaged in the development, design, testing, listing and manufacturing of SPDs of the types and ratings required for a period of 10 years or more and whose products have been in satisfactory use in similar service.

    a. Upon request, suppliers or manufacturers shall provide a list of not less than three customer references showing satisfactory operation.

1.03 DEFINITIONS

A. Clamping Voltage:

1. The applied surge shall be induced at the 90 degrees phase angle of the applied system frequency voltage.

2. The voltage measured at the end of the □ inches output leads of the SPD and from the zero voltage reference to the peak of the surge.

B. Let-Through Voltage:

1. The applied surge shall be induced at the 90 degrees phase angle of the applied system frequency voltage.

2. The voltage measured at the end of the □ inches output leads of the SPD and from the system peak voltage to the peak of the surge.

C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which the SPD device can operate and meet its specification within its rated temperature.

D. Maximum Surge Current:

1. The maximum 8/20 microsecond surge current pulse the SPD device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10% deviation of clamping voltage at a specified surge current.

2. Listed □□ mode, since number and type of components in any SPD ma□ver□ □□ mode.

E. Protection Modes: This parameter identifies the modes for which the SPD has directly connected protection elements, i.e., line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

F. Surge Current per Phase:

1. The per phase rating is the total surge current capacity connected to a given phase conductor.

    a. For example, a wye system surge current per phase would equal L-N plus L-G□ a delta system surge current per phase would equal L-L plus L-G.

    b. The N-G mode is not included in the per phase calculation.

G. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e., for a 480/277 V system the L-L peak voltage is 679V and the L-N peak voltage is 392 V).

1.04 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:

a. Manufacturer's qualifications.

b. Standard catalog cut sheet.

c. Electrical and mechanical drawing showing unit dimensions, weights, mounting provisions, connection details and layout diagram of the unit.

d. Testing procedures and testing equipment data.

e. Create a Product Data Sheet for each different model number of SPD provided (i.e., Model XYZ with disconnect and Model XYZ without disconnect, each require a Product Data Sheet).

1) Data in the Product Data Sheet heading:

a) SPD Type Number per PART 2 of the Specification.

b) Manufacturer’s Name.

c) Product model number.

2) Data in the Product Data Sheet body:

a) Column one: Specified value/feature of every paragraph of PART 2 of the Specification.

b) Column two: Manufacturer’s certified value confirming the product meets the specified value/feature.

c) Name of the nationally recognized testing laboratory that preformed the tests.

d) Warranty information.

3) Data in the Product Data Sheet closing:

a) Signature of the manufacturer’s official (printed and signed).

b) Title of the official.

4) Date of signature.

B. Operation and Maintenance Manuals:

1. Warranty.

1.05 WARRANTY

A. Minimum of a five year Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable: Eaton, Schneider Electric, Siemens or equivalent.

2.02 GENERAL

A. Standards: IEEE C62.41.1, IEEE C62.41.2, IEEE C62.45, MIL-STD 220B, UL 1283, UL 1449.

2.03 TYPE PC1 SPD

A. Product:

1. SPD tag number or electrical equipment tag number SPD is connected to □□□□□□.
2. Integrally mounted in switchgear, switchboards or MCCs.
3. Hybrid solid-state high performance suppression system.
   a. Do not use a suppression system with gas tubes, spark gaps or other components which might short or crowbar the line resulting in interruption of normal power flow to connected loads.
4. Do not connect multiple SPD modules in series to achieve the specified performance.
5. Designed for parallel connection.
6. Field connection: Use mechanical or compression lugs for each phase, neutral and ground that will accept bus bar or #10 through #1/0 conductors.
7. Device monitor:
   a. Long-life, solid state, externally visible indicators and Form C dry contact(s) that monitors the on-line status of each mode of the units suppression filter system and power loss in any of the phases.
   b. A fuse status only monitor system is not acceptable.

B. Operating Voltage: The nominal unit operating voltage and configuration as indicated on Drawings.

C. Modes of Protection: All modes.

1. Three phase (delta): L-L, L-G.

2. Three phase □w□e□: L-N, L-L, L-G and N-G.

3. Single phase □2-pole□: L-L, L-N, L-G and N-G.

4. Single phase: L-N, L-G and N-G.

D. Ma□imum Continuous Operating Voltage: Less than 130□ of s□stem peak voltage.

E. Operating Fre□uenc□: 45 to □5 Hz.

F. Short Circuit Rating: E□ual to or greater than rating of e□uipment SPD is connected to.

G. Ma□imum Surge Current: 240,000 A per phase, 120,000 A per mode minimum.

H. Minimum Repetitive Surge Current Capacit□: 4000 IEEE C High waveform impulses with no degradation greater than 10□ deviation of the clamping voltage.

I. SPD Protection:

1. Integral unit level and/or component level overcurrent fuses and sustained overvoltage thermal cutout device.

2. An IEEE C High waveforms shall not cause the fuse to open and render the SPD inopera□le.

□. Ma□imum Clamping Voltages: D□namic test at the 90 degree phase angle including □ inches lead length and measured from the zero voltage reference:

System Voltage	Test Mode	IEEE C62.41		UL 1449
		C High V & I Wave	B Combination Wave	
L-L < 250 V **L-N < 150 V**	L-L	1470 V	1000 V	800 V
	L-N	850 V	□00 V	500 V
	L-G	1150 V	800 V	□00 V
	N-G	1150 V	800 V	□00 V
L-L > 250 V **L-N > 150 V**	L-L	2700 V	2000 V	1800 V
	L-N	1500 V	1150 V	1000 V
	L-G	2000 V	1550 V	1200 V
	N-G	2000 V	1550 V	1200 V

K. EMI-RFI Noise Re□ection: Attenuation greater than 30 dB for fre□uencies □etween 100 kHz and 100 MHz.

2.04 T□PE PC2 SPD

A. Product:

1. SPD tag num□er or electrical e□uipment tag num□er SPD is connected to □□□□□□.

2. E□ternall□ mounted ne□t to switchgear, switch□oards or MCCs.

3. Hybrid solid-state high performance suppression system.
    a. Do not use suppression system with gas tubes, spark gaps or other components which might short or crowbar the line resulting in interruption of normal power flow to connected loads.
4. Do not connect multiple SPD modules in series to achieve the specified performance.
5. Designed for parallel connection.
6. Enclosure:
    a. Metallic NEMA 4 or 12 for interior locations.
    b. Metallic NEMA 4 or 4X for exterior locations.
7. Field connection:
    a. Mechanical or compression lugs for each phase, neutral and ground that will accept #10 through #1/0 conductors.
8. Device monitor:
    a. Long-life, solid state, externally visible indicators and Form C dry contact(s) that monitor the on-line status of each mode of the units suppression filter system or power loss in any of the phase.
    b. A fuse status only monitor system is not acceptable.
9. Accessories (when specifically specified): Unit mounted disconnect switch.

B. Operating Voltage: Nominal unit operating voltage and configuration as indicated on the Drawings.

C. Modes of Protection: All modes.
1. Three phase (delta): L-L, L-G.
2. Three phase (wye): L-N, L-L, L-G and N-G.
3. Single phase (2 pole): L-L, L-N, L-G and N-G.
4. Single phase: L-N, L-G and N-G.

D. Maximum Continuous Operating Voltage: Less than 130% of system peak voltage.

E. Operating Frequency: 45 to 65 Hz.

F. Short Circuit Rating: Equal to or greater than rating of equipment SPD is connected to.

G. Maximum Surge Current: 240,000 A per phase, 120,000 A per mode minimum.

H. Minimum Repetitive Surge Current Capacity: 4000 IEEE C High waveform impulses with no degradation of more than 10% deviation of the clamping voltage.

I. SPD Protection:

1. Integral unit level and/or component level overcurrent fuses and sustained overvoltage thermal cutout device.

2. An IEEE C High waveforms shall not cause the fuse to open and render the SPD inoperable.

J. Maximum Clamping Voltages: Dynamic test at the 90 degrees phase angle including □ inches lead length and measured from the zero voltage reference:

System Voltage	Test Mode	IEEE C62.41 C High V & I Wave	IEEE C62.41 B Combination Wave	UL 1449
L-L < 250 V **L-N < 150 V**	L-L	1470 V	1000 V	800 V
	L-N	850 V	□00 V	500 V
	L-G	1150 V	800 V	□00 V
	N-G	1150 V	800 V	□00 V
L-L > 250 V **L-N > 150 V**	L-L	2700 V	2000 V	1800 V
	L-N	1500 V	1150 V	1000 V
	L-G	2000 V	1550 V	1200 V
	N-G	2000 V	1550 V	1200 V

K. EMI-RFI Noise Rejection: Attenuation greater than 30 dB for frequencies between 100 kHz and 100 MHz.

2.05 TYPE PC4 SPD

A. Product:

1. SPD tag number or electrical equipment tag number SPD is connected to □□□□□□.

2. Externally mounted next to Switchgear, Switchboards or Motor Control Centers.

3. Hybrid solid state high performance suppression system.

   a. Do not use gas tubes, spark gaps or other suppression system components which might short or crowbar the line resulting in interruption of normal power flow to connected loads.

4. Do not connect multiple SPD modules in series to achieve the specified performance.

5. Designed for parallel connection.

6. Enclosure:

   a. Metallic NEMA 4 or 12 for interior locations.

   b. Metallic NEMA 4 or 4X for exterior locations.

7. Field connection:

    a. Mechanical or compression lugs for each phase, neutral and ground that will accept □10 through □1/0 conductors.

8. Device monitor:

    a. Long-life, solid state, e□ternall□ visi□le indicators and Form C dr□ contact□s□ that monitor the on-line status of each mode of the units suppression filter s□stem or power loss in an□ of the phase.

    □. A fuse status onl□ monitor s□stem is not accepta□le.

9. Accessories □when specificall□ specified□: Unit mounted disconnect switch.

B. Operating Voltage: Nominal unit operating voltage and configuration as indicated on the Drawings.

C. Modes of Protection: All modes.

1. Three phase □delta□: L-L, L-G.
2. Three phase □w□e□: L-N, L-L, L-G and N-G.
3. Single phase □2 pole□: L-L, L-N, L-G and N-G.
4. Single phase: L-N, L-G and N-G.

D. Ma□imum Continuous Operating Voltage: Less than 130□ of s□stem peak voltage.

E. Operating Fre□uenc□: 45 to □5 Hz.

F. Ma□imum Surge Current: 1□0,000 A per phase, 80,000 A per mode minimum.

G. Minimum Repetitive Surge Current Capacit□: 4000 IEEE C High or B com□ination waveform impulses with no degradation of more than 10□ deviation of the clamping voltage.

H. SPD Protection:

1. Integral unit level and/or component level overcurrent fuses and sustained overvoltage thermal cutout device.
2. An IEEE B com□ination wave shall not cause the fuse to open and render the SPD inopera□le.

I. Ma□imum Clamping Voltages: D□namic test at the 90 degrees phase angle including □ inches lead length and measured from the zero voltage reference:

System Voltage	Test Mode	IEEE C62.41		UL 1449
		B Comb. Wave	B Ring Wave	
L-L < 250 V **L-N < 150 V**	L-L	1000 V	700 V	800 V
	L-N	600 V	400 V	500 V
	L-G	800 V	550 V	600 V
	N-G	800 V	550 V	600 V
L-L > 250 V **L-N > 150 V**	L-L	2000 V	1400 V	1800 V
	L-N	1150 V	800 V	1000 V
	L-G	1550 V	1000 V	1200 V
	N-G	1550 V	1000 V	1200 V

□. EMI-RFI Noise Rejection: Attenuation greater than 30 dB for frequencies between 100 kHz and 100 MHz.

2.06 SOURCE QUALITY CONTROL

A. SPD approvals and ratings shall be obtained by manufacturers from nationally recognized testing laboratories.

B. The SPD are to be tested as a complete SPD system including:

1. Integral unit level and/or component level fusing.
2. Neutral and ground shall not be bonded during testing.
3. 6 inches lead lengths.
4. Integral disconnect switch when provided.

C. The "as installed" SPD system including the manufacturers recommended circuit breaker, the SPD is connected to, will not open when tested with a IEEE C3 combination waveform.

D. Tests to be performed in accordance with IEEE C62.45:

1. Clamping voltage performance testing using IEEE C62.41 Category waveforms.
2. Single pulse surge current capacity test.
3. Repetitive surge current capacity testing.
4. Spectrum analysis for EMI-RFI noise rejection.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Type PC1 and PC3 SPD:

1. Connected in parallel to the equipment.

2. Install in dedicated electrical equipment compartment, bucket or panelboard box at the factory before shipment.

3. Provide leads that are as short and straight as possible.

4. Maximum lead length: 12 inches.

5. Minimum lead size: #2 stranded AWG or bus bar.

6. Connect leads to the equipment to be protected by one of the following means:

   a. Through a circuit breaker or molded case switch mounted in the equipment.

   b. Use manufacturer recommended circuit breaker size.

   c. Circuit breaker or switch to be operable from the equipment exterior or from behind a hinged door.

C. Type PC2, PC4 and PC5 SPD:

1. Mounting options:

   a. Nipple connection directly to the equipment to be protected.

2. Install leads as short and straight as possible.

3. Maximum lead length: 5 feet.

4. Minimum lead size:

   a. Type PC2 and PC4 SPD: #2 stranded AWG.

   b. Type PC5: #10 stranded AWG.

5. When conduit connection is used, provide a minimum of four twists per foot in the lead conductors and install in NFPA 70 sized conduit.

6. Connect leads to the equipment to be protected by one of the following means:

   a. Through a circuit breaker or molded case switch mounted in the equipment.

      1) Use manufacturer recommended circuit breaker size.

   b. Directly to the protected equipment bus, when SPD has integral disconnect switch.

   c. To the load side of field mounted equipment's local disconnect switch.

      1) Provide taps or lugs as required to provide a UL and NFPA 70 compliant connection.

END OF SECTION

SECTION 1□492

ELECTRICAL METERING DEVICES

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. Digital metering e□uipment.

B. Related Sections include □ut are not necessaril□ limited to:

1. Section 1□000 – Basic Electrical Re□uirements.
2. Section 1□080 - Acceptance Testing.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. National Electrical Manufacturers Association □NEMA□:
   a. 250, Enclosures for Electrical E□uipment □1000 Volts Ma□imum□.
2. National Electrical Manufacturers Association/American National Standards Institute □NEMA/ANSI□:
   a. C12.20, For Electricit□ Meter - 0.2 and 0.5 Accurac□ Classes.
3. Underwriters La□oratories, Inc. □UL□:
   a. 508, Standard for Safet□ Industrial Control E□uipment.

1.03 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Provide su□mittal data for all products specified in PART 2 of this Specification:
   □. See Section 1□000 for additional re□uirements.
2. Fa□rication and/or la□out drawings.
   a. Electrical wiring/connection diagrams.

B. Contract Closeout Information:

1. Operation and Maintenance Data:

a. See Specification Section 01430 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

b. Content of Operation and Maintenance Manual:

1) Data sheet of the meters electrical parameters, configuration and characteristics including a complete model number and associated equipment connected too.

2) Operating instructions of the meter(s) supplied.

3) Operating instructions of the Power Management software.

4) Maintenance instructions.

5) As-constructed electrical wiring/connection diagrams.

6) Acceptance testing data.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Allen-Bradley.
2. Eaton.
3. Electro Industries.
4. GE / ABB.
5. Power Measurement.
6. Square D Company.
7. Siemens.

2.02 DIGITAL METERING DEVICES

A. General:

1. Direct reading metered or calculated values.
2. Microprocessor based.
3. Integral LED or LCD display.
4. Current and potential transformers as required.
5. Integral fusing.

□. Operating temperature: 0 DEGF to 150 DEGF.

7. Standards:

   a. NEMA/ANSI C12.20.

   □. UL 508.

B. T□pe □A□ Low Range Meter:

1. Displa□ the following minimum electrical parameters □accurac□□:

   a. RMS current per phase □□0.3□ full scale□.

   □. RMS voltage line-to-line and line-to-neutral □□0.3□ full scale□.

2. Communication ports and protocols: Ethernet TCP/IP.

3. Suppl□ voltage: 120 VAC.

C. T□pe □B□ Midrange Meter:

1. Displa□ the following minimum electrical parameters □accurac□□:

   a. RMS current per phase □□0.3□ full scale□.

   □. RMS voltage line-to-line and line-to-neutral □□0.3□ full scale□.

   c. Real power □W□: 3 PH total □□0.□□ full scale□.

   d. Apparent power □VA□: 3 PH total □□0.□□ full scale□.

   e. Reactive power □VAR□: 3 PH total □□0.□□ full scale□.

   f. Power factor □□1.0□ □.

   g. Fre□uenc□ □□0.17□ □.

   h. Percent current total harmonic distortion □31st□.

   i. Percent voltage total harmonic distortion □31st□.

2. Data logging:

   a. 128 KB.

   □. Selecta□le for parameters listed a□ove for displa□.

   c. Software for configuration, retrieval, and trending.

3. Communication ports and protocols: Ethernet TCP/IP.

4. Suppl□ voltage: 120 VAC.

D. T□pe □C□ High Range Meter:

1. Displa□ the following minimum electrical parameters □accurac□□:

a. RMS current per phase (±0.2% full scale).

b. RMS voltage line-to-line and line-to-neutral (±0.2% full scale).

c. Real power (W): 3 PH total (±0.4% full scale).

d. Apparent power (VA): 3 PH total (±0.4% full scale).

e. Reactive power (VAR): 3 PH total (±0.4% full scale).

f. Power factor (±1.0%).

g. Frequency (±0.04%).

h. Percent current individual harmonic and total harmonic distortion (50th).

i. Percent voltage individual harmonic and total harmonic distortion (50th).

j. Watt-hours (0.5%).

k. VAR-hours (1.0%).

l. VA-hours (0.5%).

m. Ampere demand (±0.2% full scale).

n. Watt demand (±0.4% full scale).

o. VAR demand (±0.4% full scale).

p. VA demand (±0.4% full scale).

2. Data logging:

   a. 128 KB.

   b. Selectable for parameters listed above for display.

   c. Software for configuration, retrieval, and trending.

3. NEMA/ANSI C12.20, Class 0.2 revenue accuracy.

4. Communication ports and protocols: Ethernet TCP/IP.

5. Supply voltage: 120 VAC.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

1. Provide all equipment as necessary to provide a complete and functioning system.

2. Coordinate with the Owner on final computer screen layouts, trending requirements and printouts.

B. Meter Type Application:

1. Type A meters: Integral to equipment as indicated on the Drawings.
2. Type B meters: Integral to equipment as indicated on the Drawings.
3. Type C meters: Integral to equipment as indicated on the Drawings.

C. Communication Configuration:

1. As indicated on the Drawings.

D. Computer Screen Configuration:

1. Each Type A, B and C meter shall have a data screen with the following minimum data as applicable for the capabilities of that type of meter:

a. Voltage line-to-line for each phase and an average.

b. Voltage line-to-neutral for each phase and an average.

c. Current for each phase, neutral and average and peak demands.

d. Kilowatts (kW) for each phase, total, demand and peak demand.

e. Kilovolt-amperes (kVA) for each phase, total, demand and peak demand.

f. Kilovolt-amperes reactive (kVAR) for each phase, total, demand and peak demand.

g. Power factor for each phase and total.

h. Frequency.

i. Voltage total harmonic distortion for each phase.

j. Current total harmonic distortion for each phase.

k. Energy (kWhr) for each phase and total.

l. A seven day kW, kVA and kVAR trend average.

m. Peak demands shall be resettable by the operator.

3.02 FIELD QUALITY CONTROL

A. Acceptance Testing: See Section 16080.

3.03 TRAINING

A. A qualified factory-trained manufacturer's representative shall provide the Owner with 8 HRS of on-site training in the operation and maintenance of the metering system and its components.

END OF SECTION

SECTION 1□49□

AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, install, connect, test and place in satisfactor□operation automatic transfer switches as specified herein and indicated in Drawings.

B. All devices and components of the automatic transfer switch shall □e NEMA rated. IEC rated devices are unaccepta□le and shall □e cause for re□ection of the su□mittals/e□uipment.

1.02 TESTING

A. All tests shall □e performed in accordance with the re□uirements of the General Conditions and Division 1. The following tests are re□uired:

1. Witnessed Shop Tests

    a. Shall □e made availa□le at manufacturing facilities if re□uested.

2. Certified Shop Tests and Reports

    a. Automatic transfer switches shall □e given routine factor□tests. The factor□ tests shall demonstrate that the completed switches function correctl□and that the re□uired timing has □een set. Certification of these settings shall □e su□mitted to the Engineer upon re□uest.

    □. Test procedures shall □e in accordance with UL-1008. During the 3-c□cle withstand tests, there shall □e no contact welding or damage.

    c. The three c□cle tests shall □e performed without the use of current limiting fuses.

    d. Oscillograph traces across the main contacts shall verif□that contact separation has not occurred and there is contact continuit□across all phases after completion of the test.

    e. When conducting temperature rise tests in accordance with UL-1008, include post-endurance temperature rise tests to verif□the a□ilit□of the transfer switch to carr□full rated current after completing the overload and endurance tests.

    f. Manufacturer shall su□mit test reports upon re□uest.

3. Field Tests

    a. Field testing shall □e done in accordance with the re□uirements specified in the General Conditions, Division 1, and Section 1□000, Basic Electrical Re□uirements.

□. Prior to acceptance of the installation, load test the equipment with all available motor load, but do not exceed the generator's or automatic transfer switch's nameplate rating. Correct defects which become evident during this test.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings
2. Operation and Maintenance Manuals
3. Spare Parts Lists
4. Special Tools List
5. Reports of certified shop tests shall be submitted which indicates a closing and withstand ampere rating as required based on short circuit study requirements. Rating shall be symmetrical, 3 cycles at 480 VAC.
6. Guarantee/Warranty Program

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.

C. Shop drawings for <u>each automatic transfer switch</u> shall include but not be limited to:

1. Product data sheets.
2. Complete assembly, layout, and installation drawings with clearly marked dimensions and conduit entrance locations.
3. Example equipment nameplate data sheet.
4. Complete internal schematic and interconnecting wiring diagrams.
5. Nameplate schedule.
6. Manufacturer's standard installation instructions.
7. Manufacturer's standard warranty.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each automatic transfer switch. These final drawings shall be plastic laminated and securely placed inside each transfer switch and included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

A. The automatic transfer switches shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the City by the Contractor.

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the City.

D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the City's operating personnel in its maintenance and operation as outlined elsewhere in Division 1. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One trip of one (1) working day during installation of the equipment for <u>each</u> automatic transfer switch.
2. One trip of one (1) working day after acceptance of the equipment.
3. One trip of one (1) working day during the warranty period.

B. An□additional time re□uired to achieve successful installation and operation shall □e at the e□pense of the Contractor. The manufacturer□s representative shall sign in and out at the office of the Engineer□s Field Representative on each da□he is at the pro□ect.

C. The manufacturer shall have an esta□lished network of service centers capa□le of servicing the specified e□uipment.

D. Service center personnel shall □e on call 24 hours a da□, 3□5 da□s a □ear. Personnel shall □e factor□-trained and certified in the maintenance and repair of the specified e□uipment.

E. After-warrant□service contracts shall □e made availa□le to the Cit□ □□the manufacturer, through the service centers, to provide periodic maintenance and/or repair of the specified e□uipment.

1.08 IDENTIFICATION

A. Each automatic transfer switch shall □e identified with the identification num□er indicated on the Drawings. A nameplate shall □e securel□affi□ed in a conspicuous place on each switch. Nameplates shall □e as specified in Section 1□195, Electrical - Identification.

1.09 TRAINING

A. The Contractor shall provide training for Cit□personnel. Training shall □e conducted □□the manufacturer□s factor□trained specialists who shall instruct Cit□personnel in operation and maintenance of all e□uipment provided under this Section. Training shall □e in accordance with the re□uirements of Section 11005, E□uipment-Basic Re□uirements.

B. Provide the services of an e□perienced, factor□trained technician or service engineer of the switch manufacturer at the □o□site for minimum of one □1□da□for training of Cit□ personnel, □eginning at a date mutuall□agreea□le to the Contractor and the Cit□. The technician shall □e on dut□at the site for at least 8 hours per da□and shall □e availa□le 24 hours per da□when re□uired to advise concerning special pro□lems with e□uipment and s□stems.

1.10 WARRANT□

A. The manufacturer shall warrant each automatic transfer switch for a minimum of five □5□□ears from date of shipment. In addition, the manufacturer shall repair or replace e□uipment found fault□under the terms of the warrant□. The manufacturer shall su□mit data outlining the guarantee/warrant□program.

1.11 CONSTRUCTION SE□UENCING

A. The Contractor shall reference Section 01520, Maintenance of Utilit□Operations During Construction, of these Specifications.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The equipment described herein, as a minimum, shall meet all of the requirements specified in this Section and shall be a product of a manufacturer who has produced automatic transfer switches for a period of at least five (5) years. The equipment shall be compatible with the loads to be served. Assembly of the switches by a fabricator is not acceptable.

C. The manufacturer of the automatic transfer switch shall verify that the switches are listed by Underwriters Laboratories, Inc., standard UL-1008, with 3-cycle withstand and close-in values as indicated on the Drawings or specified herein.

D. The automatic transfer switches shall be Open Transition with bypass isolation type. The basis of design is ASCO by Schneider Electric. Other acceptable manufacturers are Eaton, Siemens Energy and Automation Inc. equivalent, or equal.

2.02 AUTOMATIC TRANSFER SWITCH

A. General

1. Switches shall have ampere ratings and number of poles as indicated on the Drawings and shall be suitable for 480 VAC, three-phase, 60 Hertz operation.
2. The transfer switch shall be housed in a NEMA 1 (gasketed) free-standing enclosure fabricated from 12-gauge steel suitable for floor mounting. The enclosure shall exceed the UL-1008 minimum wire bending space requirements. The enclosure shall be equipped with an internal, welded steel, door-mounted print pocket.
3. The transfer switch shall have both top and bottom mounted cable access.
4. The switch shall be capable of switching all classes of load and rated for continuous duty when installed in a non-ventilated enclosure.
5. The three-cycle closing and withstand current rating of the switch shall be 22,000 amperes RMS (minimum). This rating shall not be restricted by the use of a specific manufacturer's circuit breaker.
6. This switch shall be complete with all accessories and listed by UL under Standard UL-1008 for use on emergency systems.
7. All bolted bus connections shall have Belleville compression type washers. Switches for four-wire systems shall be furnished with a fully rated solid neutral bus.

8. The switch shall be equipped with 90°C rated copper/aluminum solderless mechanical type lugs of the proper quantity and size to accommodate the termination of field wiring.

B. Design Requirements

1. Switches shall be capable of transferring successfully in either direction with 70 percent of rated voltage applied to the terminals.

2. The time delay between the opening of the closed contacts and the closing of the open contacts shall allow for voltage decay before transfer, allowing the motor and transformer loads to be re-energized after transfer with normal in-rush current. Switches using in-phase monitors are not acceptable.

3. Normal and standby contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts to be of silver-tungsten alloy, mechanically locked in position in both the normal and standby positions without the use of hooks, latches, or magnets. Provide separate arcing contacts, with magnetic blowouts on each pole. Interlocked molded case circuit breakers switches or contactors are not acceptable.

4. Equip the transfer switch with a permanently attached, safe, manual operator designed to prevent injury to personnel in the event the electrical operator should become energized during manual transfer. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flashover from slowly switching the main contacts.

C. Sequence of Operation

1. Should the voltage on any phase of the normal source drop below 80 percent or increase to 120 percent, or frequency drops below 90 percent, or increase to 110 percent, or 20 percent voltage differential between phases occur, after a programmable time delay period of 0-9999 seconds factory set at three (3) seconds to allow for momentary dips, the engine starting contact(s) shall close to start the standby plant.

2. Transfer to the standby power source shall occur when 90 percent of rated voltage and frequency has been reached by the standby power source.

3. After restoration of normal power on all phases to a preset value of 90 percent to 110 percent of rated voltage, at least 95 percent to 105 percent of rated frequency, and voltage differential is below 20 percent between phases, an adjustable time delay period of 0-9999 seconds factory set at 300 seconds shall delay the transfer to allow stabilization of the normal source. Should the standby source fail during this time delay period, the switch shall automatically retransfer to the normal source.

4. After retransfer to the normal power source, the standby plant shall operate at no load for a programmable period of 0-9999 seconds factory set at 300 seconds. Should the normal power source fail during this time delay period, the transfer switch shall automatically return to the standby source.

D. Controls

1. The transfer switch shall be equipped with a microprocessor-based control system to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real time clock with Nicad battery back-up.

2. The CPU shall be equipped with self diagnostics which perform periodic checks of the memory, I/O, and communication circuits with a watchdog power fail circuit.

3. The controller shall have password protection to limit access to authorized personnel.

4. The controller shall include a 20 character LCD display with a keypad, which allows access to the system.

5. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection, and phase differential monitoring on both normal and standby sources.

6. The controller shall be capable of storing the following records in memory for access either locally or remotely:

    a. Number of hours the transfer switch is in the standby position (total since record reset).

    b. Number of hours standby power source is available (total since record reset).

    c. Total transfer in either direction (total since record reset).

    d. Date, time, and description of the last four source failures.

    e. Date of the last exercise period.

    f. Date of record reset.

7. Light emitting diodes shall be mounted on the controller to indicate:

    a. Switch is in normal position

    b. Switch is in standby position.

    c. Controller is running.

8. A digital LCD frequency readout with 1% accuracy shall display frequency for both the normal and standby source.

9. An LCD readout shall display both normal source and standby source availability.

10. The microprocessor controller shall meet the following requirements:

    a. Storage conditions - 25°C to 85°C

    b. Operation conditions - 20°C to 70°C ambient

    c. Humidity 0 to 99% relative humidity, non-condensing

d. Capable of withstanding infinite power interruptions

e. Surge withstand per ANSI/IEEE C-37.90A-1978

11. All control wiring shall be 18 gauge (minimum), 600 VAC, SIS switchboard type. All control wiring shall be identified at each termination (both ends) using tubular, sleeve-type wire markers.

12. The automatic transfer switch controller shall be manufactured by ASCO by Schneider Electric, or equal. The controller shall be programmed by the manufacturer at the factory.

E. Accessories

1. Programmable three phase sensing (each phase separately) of the normal source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.

2. Programmable three phase sensing (each phase separately) of the standby source set to pickup at 90% and dropout at 80% of rated voltage and overvoltage to pickup at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pickup at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.

3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds.

4. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds, with overrun to provide programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after retransfer to normal.

5. Time delay on transfer to standby, programmable 0-9999 seconds, factory set at 3 seconds.

6. A maintained type load test switch shall be included to simulate a normal power failure, keypad initiated.

7. A time delay bypass on retransfer to normal shall be included. Keypad initiated.

8. Contact, rated 10 A at 30VDC, to close on failure of normal source to initiate engine starting.

9. A plant exerciser shall be provided with (10) 7 day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise the standby plant programmable in one minute increments. Also include a control switch for selection of either "no load" (switch will not transfer) or "load" (switch will transfer) during the exercise period. Keypad initiated.

10. Relay contacts which close when normal source fails wired to a terminal strip.

11. Rela□contacts which open when normal source fails wired to a terminal strip.
12. Two au□iliar□contacts rated 15 A at 120 VAC on main shaft, closed on normal and wired to a terminal strip.
13. Two au□iliar□contacts rated 15 A at 120 VAC on main shaft, closed on stand□□and wired to a terminal strip.

2.03 PAINTING

A. Painting shall conform with the re□uirements of Section 09900. Finish coat shall □e ANSI □□1.

B. Prior to final completion of the work, all metal surfaces of the e□uipment shall □e cleaned thoroughl□, and all scratches and a□rasions shall □e retouched with the same coating as used for factor□finishing coats.

PART 3 - E□ECUTION

3.01 INSTALLATION

A. Each automatic transfer switch shall □e installed as shown on the Drawings and in accordance with the manufacturer□s installation instructions.

B. The automatic transfer switch shall □e provided with ade□uate lifting means for installation of wall or floor mounted enclosures.

C. The Contractor shall tighten all assem□led □olted connections to the manufacturer□s tor□ue recommendations prior to energizing.

D. Install each switch to allow complete door swing re□uired for component removal. This is specificall□re□uired where a switch is set ne□t to a wall to the left of the switch enclosure.

3.02 RUBBER MATS

A. A three foot wide ru□□er mat shall □e furnished and installed on the floor and in front of each automatic transfer switch. The mat shall □e long enough to cover the full length of each enclosure. The mat shall □e 1/4 inch thick with □eveled edges, canvas □ack, solid t□pe with corrugations running the entire length of the mat. The mat shall □e guaranteed e□tra □ualit□, free from cracks, □low holes or other defects detrimental to their mechanical or electrical strength. The mat shall meet OSHA re□uirements and the re□uirements of ANSI/ASTM D-178 □□-7 for T□pe 2, Class 2 insulating matting.

END OF SECTION

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SECTION 1□500

LIGHTING

PART 1 - GENERAL

1.01 SUMMAR□

A. Section Includes:

1. Material and installation re□uirements for:

    a. Interior □uilding and e□terior □uilding mounted luminaires.

    □. E□terior and site luminaires.

    c. LEDs.

    d. Drivers.

    e. Light poles.

    f. Lighting control.

B. Related Specification Sections include □ut are not necessaril□ limited to:

1. Division 03 - Concrete.

2. Section 1□000 - Basic Electrical Re□uirements.

3. Section 1□123 – Low Voltage Wire and Ca□le.

4. Section 1□902 - Electric Controls and Rela□s.

1.02 □UALIT□ ASSURANCE

A. Referenced Standards:

1. American National Standards Institute □ANSI□:

    a. C78.377, Specification for the Chromaticit□ of Solid State Lighting Products.

2. Federal Communications Commission □FCC□:

    a. Code of Federal Regulations □CFR□, 47 CFR 18, Industrial, Scientific and Medical E□uipment.

3. Institute of Electrical and Electronics Engineers, Inc. □IEEE□:

    a. C□2.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

4. Illuminating Engineering Societ□ of North America □IESNA□:

a. LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products.

b. LM-80, Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules.

5. National Electrical Manufacturers Association (NEMA):

a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

b. 410, Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.

c. LE 4, Recessed Luminaires, Ceiling Compatibility.

6. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):

a. SSL 1, Electronic Drivers for LED Devices, Arrays or Systems.

7. National Fire Protection Association (NFPA):

a. 70, National Electrical Code (NEC).

b. 101, Life Safety Code.

8. Underwriters Laboratories, Inc. (UL):

a. 248-4, Low-Voltage Fuses - Part 4: Class CC Fuses.

b. 844, Standard for Luminaires for Use in Hazardous (Classified) Locations.

c. 924, Standard for Emergency Lighting and Power Equipment.

d. 1012, Power Units Other Than Class 2.

e. 1310, Standard for Class 2 Power Units.

f. 1598, Luminaires.

g. 8750, Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products.

9. United States Department of Energy (USDOE):

a. EPAct, the National Energy Policy Act.

1.03 DEFINITIONS

A. Useful Life for LED luminaire light sources:

1. The operating hours before reaching 70% of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions.

2. This is also known as 70% "Rated Lumen Maintenance Life" as defined in IESNA LM-80.

1.04 SUBMITTALS

A. Shop Drawings:

1. Product technical data:

a. Provide submittal data for all products specified in PART 2 of this Specification Section.

b. Identify luminaire by Luminaire Schedule designation.

c. Luminaire data sheet:

1) Name of manufacturer.

2) Complete order information (catalog number).

3) Description of construction and optics.

4) Total input wattage.

5) Luminous efficacy (lumens/Watt).

6) Photometric performance data including candlepower distribution and coefficient of utilization (CU) table.

7) Dimensional size.

8) Weight.

9) UL nameplate data for luminaires used in Class 1, Division 1 and 2 areas.

10) Effective Projected Areas (EPA) for pole mounted luminaires.

d. Solid state Luminaire additional data:

1) Voltage.

2) Initial and IES L70 lumens.

3) Luminous efficacy (lumens/Watt).

4) Correlated Color Temperature (CCT).

5) Color Rendering Index (CRI).

6) Total Harmonic Distortion (THD).

7) Lamp life.

8) Driver manufacturer and model number.

9) Driver life.

10) Driver type (0-10V, constant voltage, constant current).

11) Dimming range and control device compatibility.

12) Remote driver: Maximum wire length to luminaire.

13) Emergency battery driver:

a) Compatibility with lighting module.

b) Lumen output of lighting module in emergency operation.

c) Battery life.

d) Description of testing.

e) Ambient operating temperature.

14) Toxicity Characteristic Leaching Procedure (TCLP) compliance.

15) DesignLights Consortium (DLC) Listing.

16) Warranty information.

e. Pole data sheet:

1) Name of manufacturer.

2) Complete order information (catalog number).

3) Description of construction.

4) Length, shaft size and thickness.

5) Wind loading (available luminaire EPA per wind speed).

6) Anchor bolt template.

7) Bolt size and material.

f. See Specification Section 16000 for additional requirements.

2. Test Reports:

a. IESNA LM-79 Test Report for Solid-State Luminaire.

b. IESNA LM-80 Test Report Solid-State Light Source.

3. Certifications: Solid-state Luminaire Useful Life Certificate.

B. Contract Closeout Information:

1. Operation and Maintenance Data:

a. Submittal data for each component covered by warranty.

b. Warranty.

1.05 WARRANTY

A. Minimum of a five year Warranty from date of manufacture against failure for solid-state luminaire including LED arrays, LED drivers and integral control devices. The solid-state product is considered defective if more than 15% of the individual light emitting diodes fail to illuminate.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Luminaires: Per Luminaire Schedule or equal.

2. Solid State Light Sources:

a. Cree.

b. Bicato.

c. Luminaire manufacturer’s proprietary system.

3. LED Driver: Luminaire manufacturer's standard.

4. Emergency Ballasts:

a. Iota Engineering.

b. Philips Bodine.

5. Emergency transfer devices: Philips Bodine.

6. Poles: Luminaire manufacturer's standard.

2.02 GENERAL REQUIREMENTS

A. Luminaires complete with LED modules and drivers.

B. Rated for area classification as indicated on the Drawings.

1. In Class I, Division 1 and 2 areas, the temperature rating of the luminaires and LED combination shall not exceed the auto-ignition temperature of the atmosphere in which the Luminaire is used.

C. No live parts normally exposed to contact.

D. When intended for use in wet areas: Mark luminaire "Suitable for wet locations."

E. When intended for use in damp areas: Mark luminaire "Suitable for damp locations" or "Suitable for wet locations."

2.03 LUMINAIRES

A. Standards and Listings:

1. DesignLights Consortium (DLC).
2. UL 1598.
3. UL 844 for hazardous locations.
4. NEMA LE 4 for recessed locations.

B. Housings:

1. As indicated in the Luminaire Schedule and the following:
   a. Extruded aluminum housings, where scheduled, shall be at least 1/8 inches thick.
   b. Punch and form housings prior to finishing (post-paint).

C. Castings:

1. As indicated in the Luminaire Schedule and the following:
   a. Uniform quality, free from imperfections affecting strength and appearance.
   b. Exterior surfaces, if not receiving a finish coat, shall be smooth and match adjacent surfaces. At least one coat of clear methacrylate lacquer shall be applied unless a painted finish is specified.

D. Fasteners:

1. As indicated in the Luminaire Schedule and the following:
   a. Aluminum or steel luminaires: Zinc-Nickel plated, stainless steel, or equivalent.
   b. Stainless steel luminaires: Stainless steel.
   c. Bronze luminaires: Bronze or stainless steel.
   d. Non-metallic luminaires: Stainless steel.

E. Finishes:

1. As indicated in the Luminaire Schedule and the following:
   a. Painted surfaces:
      1) Manufacturer's standard metal pretreatment and baked or air-dried, light-stabilized enamel finish, acrylic, alkyd, epoxy, polyester, or polyurethane.
      2) White finishes shall have minimum 85% reflectance.
   b. Unpainted surfaces:

1□ Interior: Clear anodic coating, satin finish.

2□ Exterior: Clear anodic coating.

F. Lens/Louver Frames:

1. As indicated in the Luminaire Schedule and the following:

   a. Extruded aluminum with mitered corners.

   b. Hinging or other normal motion shall not cause lens or louver to drop out.

   c. No light leak between frame and housing.

G. Lenses:

1. As Indicated in the Luminaire Schedule and the Following:

   a. 100% virgin, UV stabilized acrylic.

   b. Held securely in place but must also be removable for cleaning and servicing.

   c. Luminaires with directional lenses shall include a lens orientation device to ensure that lens installation provides light distribution as designed.

   d. No light leaks between the lens and the luminaire.

H. Gaskets:

1. As Indicated in the Luminaire Schedule and the Following:

   a. Gaskets at face plates or frames of recessed luminaires which serve as ceiling trim and allow interior access.

   b. Moisture seal gaskets at exterior locations and in other designated wet areas.

   c. Secure frames to luminaire bodies with screws or other means, to result in tight installation, without light leaks.

I. Ventilation:

1. Ventilation openings of adequate size and quantity to permit operation of driver without affecting rated output or life expectancy. Include wire mesh screens.

J. Wiring:

1. Factory-wired to be compatible with the project electrical and controls systems.

K. Mounting Accessories:

1. Provide appropriate mounting accessories for each luminaire, compatible with various structural conditions encountered.

2. All luminaires with adjustable beam angles shall have a locking device to ensure that the beam distribution is not effected during servicing or cleaning.

3. Luminaire Suspension Material:

   a. Unfinished Spaces:

      1□ 1/2 inches minimum diameter swivel stem, unless otherwise noted.

      2□ Safet□chain on high □a□t□pe.

   □. Finished Spaces: Unless otherwise noted.

      1□ Manufactured ca□le or stem and outlet □o□canop□.

         a□ Contemporar□design with swivel self-aligning features.

         □□ Size canop□to cover outlet □o□, minimize size of canop□not associated with outlet □o□.

         c□ Finish to match luminaire.

      2□ Coordinate pendant location with ceiling tiles/ceiling grid.

         a□ Su□mit coordinated mounting accessories as part of Shop Drawing su□mission.

      3□ Luminaires mounted on suspended ceiling grids should □e provided with outlet □o□designed for grid mounting with direct cord entr□and supported □□outlet □o□.

2.04 SOLID-STATE LUMINAIRES - ADDITIONAL RE□UIREMENTS

A. Standards:

   1. IESNA LM-79, IESNA LM-80.

   2. NEMA SSL 1.

   3. UL 1012, 1310, and 8750.

   4. UL 844 for hazardous locations.

B. Solid state modules and driver to □e provided and warrantied □□luminaire manufacturer.

C. Solid-State Modules:

   1. Uniform color temperature of 4000K unless otherwise noted on the Luminaire schedule.

      a. Color temperature measurement shall have a ma□imum 3 SDCM on the MacAdam Ellipse for frosted lensed luminaires, and 2 SDCM for other luminaire t□pes □ANSI C78.377□.

   2. Minimum color rendering inde□□CRI□of 80 for indoor and 70 for outdoor applications.

3. LED module light output and efficacy: Measured in accordance with IESNA LM-79 standards.

4. LED useful life and lumen maintenance: Measured in accordance with IESNA LM-80 standards.

5. Driver and LED module: Minimum useful life of 50,000 hours (L70).

6. Individual LEDs connected such that a failure of one LED will not result in a light output loss of the entire luminaire.

D. Driver:

1. Compatible with solid-state modules and control devices specified.

2. Operate from 60 Hz input source of 120V through 277V with sustained variations of (±10% voltage and frequency).

3. Input current Total Harmonic Distortion (THD): Less than 20% when operated at nominal line voltage.

4. Power Factor: Greater than 0.90.

5. Avoid interference with infrared devices and eliminate visible flicker.

6. Comply with ANSI C62.41 Category A for Transient protection.

7. Comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 18, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

8. Dimmable drivers capable of continuous dimming over a range of 100% to 10% of rated lumen output, unless otherwise specified in Luminaire Schedule. Dimming controlled by a 0 - 10 VDC signal, unless otherwise specified in Luminaire Schedule.

9. Control device must be compatible with type of driver and coordinated prior to submission of Shop Drawings. List of compatible dimming controllers must include the range of perceived brightness. No visible flicker throughout the dimming range.

10. Remote-mounting:

    a. Provide maximum allowable distances for secondary wire runs to luminaires.

    b. Provide remote mounting hardware and enclosures as required.

11. Operating temperature range must be suitable for site temperature conditions within exterior and gasketed luminaires.

E. Emergency Battery Driver:

1. UL 924.

2. Confirm compatibility with LED modules utilized.

3. Consist of a high temperature, maintenance-free nickel cadmium □atter□, charger, and electronic circuitr□.

4. A solid state charging indicator light to monitor the charger and □atter□.

5. Single-pole test switch.

□. The following product famil□shall □e selected □ased on coordination with LED lamp t□pe:

    a. Philips Bodine “BSL23C”: can operate up to 4.5W at 410mA.

    □. Philips Bodine “BSL26C”: can operate up to 5.1W at 2□5mA.

    c. Philips Bodine “BSL722 inches: can operate up to 23W at 770mA.

    d. Philips Bodine “BSL23C”: can operate up to 23W at 770mA in operating conditions ranging from -20 degrees C □-4 degrees F□to □0 degrees C □140 degrees F□

    e. Alternate manufacturer: Iota.

F. Luminaire properl□heat sinked to assure LED □unction temperature ratings are not e□ceeded.

1. Provide am□ient operating temperature range for which product is warrantied.

2.05 E□IT SIGNS

A. Standards:

1. UL 924.

2. NFPA 101.

3. Local State or Cit□re□uirements.

B. E□it Signs:

1. Housing and finish: As indicated in the Luminaire Schedule.

2. LED illuminated with integral driver.

3. AC powered or AC and □atter□powered: As indicated in the Luminaire Schedule.

4. Batter□powered units:

    a. Batter□t□pe: As indicated in the Luminaire Schedule.

    □. Self-testing/self-diagnostic.

        1□ Electronic circuitr□automaticall□test emergenc□lighting for a minimum of 30 seconds ever□30 da□s and 90 minutes once a □ear.

    c. Consist of □atter□, charger, and electronic circuitr□.

d. Solid state charging indicator light to monitor the charger and battery.

e. Single-pole test switch.

f. A user selectable audible alarm. The alarm shall be engaged unless noted otherwise on the Drawings.

C. Emergency Circuit Transfer Device:

1. Transfer device permits emergency lights to be switched under normal conditions and automatically transfers to unswitched emergency circuit upon power interruption.

2. Multiple luminaire switching:

a. Up to 20A.

b. Mounting as indicated on the Drawings.

c. Acceptable product family:

1) Philips Bodine GTD20A or equal.

3. Individual luminaire switching:

a. Mount on top of luminaire or in ballast channel.

b. Acceptable product family:

1) Philips Bodine GTD or equal.

2.06 POLES

A. As Indicated in the Luminaire Schedule and the Following:

1. Designed for attached luminaire EPA with a 180 MPH maximum wind velocity at the base with a 1.3 wind gust factor.

2. Additional features:

a. Handhole near base of pole.

b. Grounding lug accessible at handhole.

c. Galvanized anchor bolts.

d. Anchor bolt covers.

e. Vibration dampener(s).

2.07 MAINTENANCE MATERIALS

A. Furnish a minimum of 10% of total of each type and amperage of fuses for fixtures indicated to be fused.

B. Spare parts are to be stored in a box clearly labeled as to its contents.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Coordinate Luminaire Types with Ceiling Construction:

1. Provide mounting hardware for the ceiling system in which the luminaire is to be installed.

B. Fasten luminaires supported by suspended ceiling systems to ceiling framing system with hold down clips.

C. Provide mounting brackets and/or structural mounting support for wall-mounted luminaires.

1. Do not support luminaire from conduit system.

2. When luminaire is supported from outlet boxes, install per NFPA 70.

3. Supports for luminaire mounted on exterior walls shall not be attached to exterior face of the wall.

D. Support surface mounted luminaires from the building structure and not from the ceiling suspension system.

1. Luminaires up to 4 feet wide and 4 feet long: A minimum of four supporting points, one at each corner.

2. Luminaires 8 feet long: A minimum of five support points, one at center of luminaire and one at each corner.

3. Luminaires smaller than 2 feet in length: A minimum of two supporting points.

E. Provide pendant luminaires with swivel hangers which will allow luminaire to swing in any direction but will not permit stem to rotate.

1. Provide hangers with enclosure rating (NEMA 1, 4, or 7) equal to enclosure requirements of area in which they are installed.

2. Swivel hangers for luminaires in mechanical equipment areas: Shock absorbing type.

3. Secure low and high bay luminaires with safety chain or safety aircraft cable to the building structure.

   a. Chain or cable to prevent luminaire from falling more than 3 inches before the luminaire is caught by the chain or cable.

F. Pendant Mounted, Open, Industrial Luminaire:

1. Not in continuous rows:

   a. Supported by conduit or by approved chains or cable:

   b. Hardwired to ceiling mounted junction box.

2. In continuous rows:
    a. Supported rigidl□ with conduit and fasten luminaire to each other or mount on continuous metal channel per Specification Section 1□000.
    □. Hardwired to ceiling mounted □unction □o□.
    c. Provide reflector alignment clips.

G. Provide access panels for recessed luminaires that re□uire access for maintenance when such access is not provided for in design of luminaire.
    1. Locate luminaires in accordance with reflected ceiling plans.

H. Locate luminaire in e□act center of ceiling tile unless otherwise indicated.
    1. Relocate incorrectl□ installed luminaire and replace damaged ceiling materials.

I. Mount luminaire at heights indicated in Specification Section 1□000 or per Luminaire Schedule or as indicated on the Drawings.

□. Install e□terior luminaires so that water cannot enter or accumulate in the wiring compartment.

K. Luminaires with Emergenc□ Batter□:
    1. Where luminaires with emergenc□ □atter□ are shown controlled via switching device, connect the emergenc□ □atter□ to corresponding unswitched circuit so emergenc□ □atter□ will not operate when normal power is availa□le and switching device turns lights off. Upon failure of normal power, luminaire will operate in emergenc□ mode regardless of switch position.
    2. Luminaire manufacturer to suppl□ the emergenc□ □atter□ with luminaire.

L. Ground luminaire.

3.02 POLE INSTALLATION

A. Drawings Indicate the Intended Location of Light Pole:
    1. Field conditions ma□ affect actual location.
    2. Coordinate location with all e□isting or new utilities and pavement.

B. Anchor Base Plated Poles:
    1. Mounted on cast-in-place foundations, as detailed on the Drawings.
        a. Concrete and reinforcing steel, in accordance with Division 03 Specification Sections.
    2. Protect pole finish during installation.
        a. Repair damage to pole finish with manufacturer approved repair kit.

C. Ground poles as indicated on the Drawings.

D. Conductors:

1. See Specification Section 16123 for required underground conductors.

2. Use interior building wire, as specified in Specification Section 16123, from pole base to luminaire, #12 AWG minimum.

E. Overcurrent and Short Circuit Protection:

1. Protect each phase with a UL Class CC fuse:

a. Size: Three times load current.

b. Standard: UL 248-4.

2. Fuseholder:

a. Watertight, in-line and break-a-way style.

b. Accept up to a 30 A, 600 V fuse.

c. Neutral conductor shall utilize a fuseholder with a solid copper rod.

d. Conductor terminal: Adequate size for the installed conductors.

3.03 LIGHTING CONTROL

A. See Specification Section 16902 for lighting control equipment.

B. Exterior and Interior fixtures controlled as detailed on the Drawings.

END OF SECTION

SECTION 16620

PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install a standby power engine generator set complete with base-mounted fuel storage tank, fuel transfer pumps, leak detection systems, piping, exhaust silencer, batteries, charger, enclosure, and devices for automatic and manual control.

B. It is the intent under this Contract to require an installation complete in every detail whether or not indicated on the Drawings or specified. Consequently, the Contractor is responsible for all details, devices, accessories and special construction necessary to properly install, adjust, test, and place in successful and continuous operation the engine-generator set.

C. Use materials which are new, unused, and as specified, or, if not specifically indicated, the best and most suitable of their kinds for the purpose intended, and for the design and expected conditions of service, subject to the approval of the Engineer.

D. Provide workmanship that is first class in every respect. Employ workers thoroughly experienced in such work. A neat and workmanlike appearance in the finished work shall be required.

E. All materials used must bear the inspection labels of the Underwriter's Laboratories, if the material is of a class inspected by the Laboratory.

F. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

G. The engine generator sets shall fully comply with all current Environmental Protection Agency (EPA) emission regulations including, but not limited to, the New Source Performance Standards (NSPS) for stationary and non-road generator sets. The engine generator set(s) must meet the EPA new source performance requirements required at the time the engine generator set(s) submittal is approved by the engineer. Engines manufactured previous to the submittal approval date that do not meet the current regulated emissions levels are not acceptable.

H. Reference Section 16000 - Basic Electrical Requirements, Section 16496, Automatic Transfer Switch, and Section 16490 – Overcurrent and Short Circuit Protective Devices.

1.02 CODES AND STANDARDS

A. The packaged engine-generator s□stem shall compl□ with the following Codes and Standards as a minimum:

1. NEMA MG1, Motors and Generators.
2. NEMA MG2, Safet□ Standard for Construction and Guide for Selection, Installation and Use of Motors and Generators.
3. ISO STD 8528, Reciprocating Internal Com□ustion Engines.
4. ISO STD 304□, Performance Standard for Reciprocating Internal Com□ustion Engines.
5. NFPA 30, Flamma□le and Com□usti□le Li□uids Code.

□. NFPA 37, Standard for Installation and use of Stationar□ Com□usti□le Engine and Gas Tur□ines.

7. NFPA 70, National Electrical Code
8. NFPA 70E, Standard for Electrical Safet□ in the Workplace
9. NFPA 110, Standard for Emergenc□ and Stand□□ Power S□stems.
10. UL 508, Industrial Control E□uipment.
11. EGSA, Electrical Generating S□stems Association.
12. UL 2200 – Stationar□ Engine Generator Assem□lies
13. ANSI C57, Dr□-T□pe Transformers.
14. UL 142, Steel A□oveground Tanks for Flamma□le and Com□usti□le Li□uids.
15. UL 123□ – Standard for Batter□ Chargers for Charging Engine Starter Batteries.

1□. Florida Building Code.

1.03 SUBMITTALS

A. In accordance with the procedures and re□uirements set forth in the General Conditions and Section 01300, Su□mittals, the Contractor shall o□tain from the e□uipment manufacturer and su□mit the following:

1. Shop Drawings
2. Spare Parts List
3. Reports of Certified Shop and Field Tests
4. Operation and Maintenance Manuals
5. Manufacturer□s Field Start-up Report

[illegible]. Manufacturer's Representative's Installation Certification

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for <u>each engine-generator set</u> shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CDE) letter. If the shop drawings are submitted without this CDE letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CDE letter shall also address deviations, and exceptions taken to each Drawing related to this specification section.

2. Manufacturers printed specification sheets showing critical engine and generator set specifications including the following:

   a. Dimensions, and weights

   b. Guaranteed fuel consumption at 25%, 50%, 75% and 100% of full rated load

   c. Engine bhp available

   d. Brake Mean Effective Pressure (BMEP)

   e. Engine jacket water heat rejection

   f. Exhaust flow rate and temperature at 100% of rated load

   g. Ventilation and combustion air requirements

   h. Exhaust backpressure limitation

   i. Liquid refill capacities

   j. Voltage regulation characteristics

   k. Guaranteed noise levels

3. Alternator technical electrical data, including, but not limited to:
    a. Alternator efficiency at 50%, 75%, and 100% load
    b. Telephone Interference Factor (TIF)
    c. Harmonic waveform distortion
    d. Type of winding insulation and generator temperature rise
    e. Per unit subtransient impedance X'' and X/R ratios for positive, negative, and zero sequences
    f. Transient reactance (Xd')
    g. Synchronous reactance (Xd)
    h. Sub transient time constant (Td'')
    i. Transient time constant (Td)
    j. DC time constant (Tdc)
    k. Decrement curve
4. Manufacturer's printed warranty statement of the engine and generator set showing single source responsibility by the engine manufacturer.
5. Generator control panel equipment and features. Include a written explanation of the auto start/stop logic and operation.
6. Engine-generator set and accessory product data sheets including, but not limited to, the following:
    a. Alternator strip heater
    b. Radiator
    c. Seismically rated vibration isolators
    d. Flexible exhaust coupling
    e. Exhaust silencer
    f. Batteries
    g. Battery charger
    h. Engine manufacturers shutdown contactors
    i. Jacket coolant heater
    j. Fuel cooler
    k. Fuel tank(s) and pump(s)

l. Fuel level and leak detection devices

m. Output circuit breaker and trip unit

n. Conduit

o. Wire and Cable

p. Wiring Devices

q. Lighting

r. Fuel polishing system (if applicable)

7. Normal operating ranges for systems temperature, pressure and speed.

8. Manufacturer's part number for the engine and generator operation guide, parts book, service manual, warranty policy, and installation guide.

9. Location of other similar units showing compliance with the experience requirements specified herein.

10. Phone numbers of twenty-four (24) hour products support contacts and locations.

11. Drawing showing right hand, left hand, and top views of proposed assembly, battery rack, isolators, exhaust silencer, conduit stub up locations, and flexible fittings; wiring schematics, interconnection diagrams (point to point), and written description of engine generator controls and alarm circuits.

12. Control panel layout drawings and wiring diagrams.

13. Drawings and specifications for base-mounted fuel storage tank with accessories.

14. EPA Certificate of Conformity for Exhaust Emissions

15. Detailed drawings showing plan, front, and side views as well as appropriate section views of the weatherproof, engine-generator enclosure. Include product data sheets for all appurtenances (e.g. exhaust fan, thermostat, lighting, switches, receptacles, combination power unit, etc.) to be furnished and installed in the enclosure. Drawings shall be of sufficient detail to assure proper installation by the Contractor.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 REPORTS OF CERTIFIED SHOP AND FIELD TESTS

A. Submit two (2) certified copies of all test reports. This includes all shop tests and field tests. Certified shop test reports for prototype engine-generator sets are unacceptable. The manufacturer's serial number for the actual engine-generator set furnished for this project shall appear on all test reports.

1.06 OPERATION AND MAINTENANCE MANUALS

A. Two (2) preliminary copies of Operation and Maintenance Manuals, prepared specifically for this Project, shall be furnished for each item of equipment furnished under this Contract. The preliminary manuals shall be provided to the Engineer not more than 10 days after the equipment arrives on the project site.

B. The preliminary manuals shall be reviewed by the Engineer prior to the Contractor submitting final copies for distribution to the City. Following review of the preliminary copies of the Operation and Maintenance Manuals, one (1) copy will be returned to the Contractor with required revisions noted, or the acceptance of the Engineer noted.

C. Manuals shall contain complete information in connection with assembly, operation, lubrication, adjustment, wiring diagrams and schematics, maintenance, and repair, including detailed parts lists with drawings or photographs identifying the parts. Manuals shall contain all information submitted as part of the shop drawing review process.

D. Manuals furnished shall be assembled and bound in separate volumes, by major equipment items or trades, and properly indexed to facilitate locating any required information. In addition, manuals should be labeled in the front cover with the project, name, equipment description, and manufacturer contract information.

E. Engineer and the City shall be the sole judge of the acceptability and completeness of the manuals and may reject any submittal for insufficient information included, incorrect references and/or the manner in which the material is assembled.

F. Following the Engineer's review of the preliminary manuals, the Contractor shall submit five (5) paper copies and two (2) electronic copies of the final Operation and Maintenance Manuals to the City. The manuals shall reflect the required revisions noted during the Engineer's review of the preliminary documents, as well as any changes made during installation. Failure of the final manuals to reflect the required revisions noted by the Engineer as well as changes made during installation will result in the manuals being returned to the Contractor. Acceptable final Operation and Maintenance Manuals shall be provided not more than one (1) month after receipt of the Engineer's comments.

1.07 SPARE PARTS

A. Routine maintenance and adjustments shall be performed without the use of special tools or instruments. All spare parts as recommended by the equipment manufacturer shall be furnished to the City by the Contractor.

   1. In addition to the manufacturer recommended spare parts, the Contractor shall furnish the following spare parts <u>for each engine-generator set</u>:

No. Required	Description
1	Set of Fuel Oil Particulate Filters
1	Set of Air Filters
1	Set of Lube Oil Filters
1	Set of Fuel Oil/Water Separator Filters

No. Required	Description
1	Set of Coolant Filters

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the City.

D. Spare parts list, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

F. The dealer shall have sufficient parts inventory to maintain over-the-counter availability of at least 90% of any required part and 100% availability within 48 hours.

1.08 IDENTIFICATION

A. Each engine-generator set shall be identified with the identification name/number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on the generator main circuit breaker or output termination box enclosure.

1.09 WARRANTY TERMS

A. The manufacturer's and Dealer's warranty shall in no event be for a period of less than five (5) years, from date of delivery of equipment to the project site and shall include repair labor, travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, coolant, and other service items made unusable by the defect) used during the course of repair. Submittals received without written warranties as specified shall be rejected in their entirety.

B. Provided warranty shall cover all equipment included in the scope of supply. This warranty shall include, but is not limited to, the following:

1. Engine-generator set and respective auxiliary equipment
2. All controls for the engine-generator set
3. Generator enclosure and fuel tank (where applicable)

C. Batteries shall be provided with two (2) year full replacement guarantee, and a pro-rated replacement schedule thereafter.

1.10 OIL SAMPLING KIT

A. The generator set supplier shall provide an oil sampling analysis kit which operating personnel shall utilize for scheduled oil sampling. All equipment needed to take oil samples shall be provided in a kit and shall include the following:

1. 1 Sample extraction gun
2. 10 Bottles
3. 10 Postage-paid mailers
4. 1 Written instructions

B. An additional oil sampling kit shall be made available to the City to continue the sampling when the above specified kit has been depleted. All kits in addition to that specified above shall be at an additional cost to the City, if the City desires to continue the sampling service.

1.11 CONSTRUCTION SEQUENCING

A. The Contractor shall reference Section 01520, Construction Constraints, of these Specifications.

1.12 PREVENTIVE MAINTENANCE AGREEMENT

A. The engine/generator set supplier shall provide, as an adder to the base price, a preventive maintenance agreement using qualified factory trained service personnel, for a period of 2-year minimum. Provide all recommended fluids, dealer labor, travel labor and travel mileage to complete the suggested preventive maintenance as defined in the manufacturer's Operation and Maintenance Manual and as listed below. All parts shall be new and provided by the generator manufacturer. The maintenance agreement shall include the following as a minimum:

1. Check oil level, check oil pressure safety shutdown switches, complete an oil sample analysis, check oil pressure and gauges, and inspect the system for leaks. Change oil and oil filter if required.
2. Check coolant level, inspect/replace cooling system hoses, check high/low temperature alarms and shutdowns, inspect radiator, inspect fan and fan belts (tighten or replace as required). Flush coolant system and replace coolant if required.
3. Inspect the fuel system including fuel pumps and tank(s), check fuel pressure, inspect fuel filters and replace if required, and check for water in fuel storage tank.
4. Check the battery and battery charging system including a voltage test, check and clean battery terminals, check and inspect engine starting system.
5. Inspect and test the generator, check bearing grease and add grease if required, check terminations, and complete a generator winding insulation resistance (i.e. megger test).

6. Check engine control system including overspeed alarms and shutdowns, overcrank alarm, engine starter, circuit breaker and fuses, and test and adjust engine governor.
7. Check and the engine air intake and exhaust systems for leaks and damage. Check air filter and replace if required.
8. Test automatic transfer switch. Check all indicating lights and replace as required.
9. Inspect all components of the generator enclosure including, but not limited to, lights, louvers, fans, doors, etc.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Consideration will be given only to the equipment of those manufacturers who have furnished comparable size diesel engine-generator sets for at least two similar installations that have been in regular successful operation for not less than five (5) years.

C. The engine-generator set basis of design is Cummins. Other acceptable manufacturers are Caterpillar, MTU Onsite Energy, or Kohler using MTU engines. No substitutions shall be permitted. The engine-generator set manufacturer and/or dealer shall be responsible for the entire engine-generator package including the engine-generator set with all accessories and equipment specified herein and all other devices required for a complete and operable system.

2.02 GENERAL DESCRIPTION

A. The engine-generator set shall be rated as specified herein and as indicated on the Drawings. It shall have the capability to operate at its standby rating for the duration of any power outage with all accessories including engine running devices, silencer, radiator, cooling fans, fuel system, and all appurtenances complete as it would be installed in the field. The Contractor shall note and take appropriate action regarding the intended operation of the engine-generator sets while connected to motor driven loads controlled by reduced voltage solid state starters (RVSS).

2.03 ENGINE

A. The engine shall be diesel, 4 cycle, radiator cooled, and shall be turbocharged having an operating speed of 1800 RPM. Engine shall operate on ASTM D-975 Grade No. 2D S15 ultra-low sulfur diesel fuel. Engines requiring any other fuel type are not acceptable.

B. The engine will not be acceptable if the design is a conversion of a naturally aspirated engine to which a turbo-blower has been attached unless the engine is certified by the manufacturer as having been analyzed and redesigned with ample provisions for increased stresses and bearing or heat loads due to increased pressures and rate of heat liberation.

C. Brake Horsepower (BHP), and Engine-Generator efficiency shall conform with ASME, IEEE and NEMA standards that electrical energy delivered by the machine is within the minimum certified guaranteed fuel oil consumption rate and evidence that these parameters have been met shall be furnished.

D. Only engine manufacturers' standard ratings shall be acceptable. No dealer special ratings will be acceptable.

E. The specified standby kW rating shall be for continuous electrical service during interruption of the normal utility source, per NEMA standards.

F. Engine speeds shall be governed by an electronic isochronous governor that will sense generator speed and provide accurate load transient correction capability at less than 0.5 percent regulation, from no load to full load generator output.

2.04 ALTERNATOR

A. The alternator shall conform with NEMA and IEEE standards and be rated as indicated on the Drawings. The alternator shall have a UL 2200 listing. The alternator shall be brushless, salient pole, 2/3 pole pitch and synchronous for operation at 480VAC, wye connected, as indicated on the Drawings. The generator shall be capable of delivering an instantaneous voltage dip of no more than 20% with site load.

B. Laminations and windings shall be designed for minimum reactance, low voltage waveform distortion and maximum efficiency.

C. The main stator coils shall be random wound. Insulation shall be minimum Class F, 105 degrees rise according to NEMA standards. The insulation system shall be made of epoxies and polyesters which are inorganic compounds and shall prevent fungus growth.

D. The rotor shall be dynamically balanced and include amortisseur windings to minimize voltage deviations and heating effects under unbalanced load conditions.

E. Radio interference suppression (both directions) shall be provided in accordance with NEMA and IEEE Standards.

F. The alternator shall have a brushless, permanent magnet generator (PMG) excitation support system to provide input to the automatic voltage regulator to enable the alternator to support 300% of rated current for 10 seconds to allow fault clearing during a 3-phase fault.

G. Waveform deviation shall not exceed 5% from true sine wave. The transient response from no load to full load in one step of the engine-generator set shall not exceed a voltage dip of 35%, a frequency dip of 20%, and shall recover to complete steady state performance within 12 seconds for both voltage and frequency. The transient response from full load to no load in one step shall not exceed a voltage overshoot of

13% and shall recover to steady state performance within 4 seconds. Transient performance shall be in accordance with ISO 8528.

H. The Telephone Influence Factor (TIF) shall be less than 50.

I. The voltage regulator shall be an adjustable, solid-state, three-phase RMS sensing, volts/hertz type. Voltage regulation shall be a minimum of +/-0.25% from no load to continuous rating. The voltage regulator shall provide +/-10% voltage adjustment. The voltage regulator shall be located within the engine control panel.

J. An alternator mounted strip heater shall be furnished and installed as part of the system. The strip heater shall be energized to prevent condensation when the engine generator set is not running.

2.05 CONTROLS

A. Engine-generator monitoring and controls shall be mounted in a single NEMA 1 (gasketed) dust-tight enclosure. A suitable accessible terminal strip having all wires properly identified shall be furnished within the enclosure. The control panel shall be mounted at a height of 4'-8" measured from the center of the panel to the equipment pad or enclosure floor.

B. The control panel shall accept a dry contact input for engine starting from remote locations. The starting and stopping of the engine-generator set shall be initiated through the control panel only. When the engine starts, starting control shall automatically disconnect cranking controls. Three (3) cranking cycles of 15 seconds "ON", 15 seconds "OFF" shall be provided. The starting controls shall prevent re-cranking for a definite time after source voltage has been reduced to a low value, or the four (4) cranking cycles have been reached without a successful start. The automatic engine starting controls shall use industrial rated control type elements throughout, and controls shall have the capability to operate at 50% battery voltage.

C. Speed sensing shall be provided to protect against accidental starter engagement with a moving flywheel. Battery charging alternation output voltage is not acceptable for this purpose.

D. A generator/exciter field circuit breaker with shunt trip device shall be furnished and installed as part of the engine generator set. Shunt trip shall be activated upon engine-generator fault conditions.

E. A main line circuit breaker as specified herein and sized as indicated on the Drawings shall be installed as a load circuit interrupting and protection device in a NEMA 1 (gasketed) dust-tight enclosure. See specification section 1□490 for Overcurrent and Short Circuit Protective Devices.

F. Engine-generator monitoring and control shall be provided using a microprocessor based control panel complete with an LCD display. The devices necessary for automatic starting shall be on the engine and in the engine control panel The following hardware (minimum) shall be provided on the front of the control panel, the use of the LCD display and keypad to accomplish the same function is <u>not acceptable</u>:

1. Engine control mode switch (Run-Off-Auto)

2. Large, red emergency stop pushbutton
3. Generator voltage adjust potentiometer
4. Generator frequency adjust potentiometer

G. The following parameters (minimum) shall be shown on the LCD display or otherwise be indicated at the control panel:

1. Engine oil pressure
2. Coolant temperature
3. Generator output voltage
4. Generator output current
5. Generator elapsed run time
6. Generator output frequency
7. Engine run
8. Engine fail
9. Low coolant temperature
10. Pre-high engine temperature
11. Pre-low fuel level
12. Engine speed (RPM)

H. The following events (minimum) shall cause an immediate shutdown of the engine-generator set if it operating or prevent starting if it is not operating. The specific event that causes the shutdown/prevents starting shall be shown on the LCD display or otherwise be indicated at the control panel. A reset shall be required to clear the fault and allow the unit to operate:

1. Engine coolant high temperature
2. Engine low oil pressure
3. Engine overspeed
4. Engine overcrank
5. Engine tried to start but failed
6. Low coolant level

I. The generator control panel shall have Form C dry contacts rated 5A (minimum) at 120VAC/24VDC for the following signals:

1. Engine coolant high temperature

2. Engine low oil pressure
3. Pre-low fuel level
4. Low fuel level
5. Engine overspeed
□. Engine overcrank
7. Engine tried to start □ut failed
8. Low coolant level
9. Engine fail
10. Engine run

□. The normall□ closed □NC□contacts for all of the a□ove signals □e□cept engine run and Pre-low fuel level□shall □e wired in series to provide a common "Generator S□stem Failure" alarm for remote indication. Other contacts shall also □e wired as a part of this alarm as specified elsewhere herein.

2.0□ ENGINE ACCESSORIES

A. Furnish and install the engine with all accessor□e□uipment and appurtenances which are re□uired for proper operation, including the following:

1. Heav□dut□dr□t□pe air filter with restriction indicator
2. Heav□dut□lu□ricating oil filter, □□pass t□pe, with replacea□le a□sor□ent-t□pe elements
3. Lu□ricating oil cooler, water cooled
4. Heav□dut□fuel oil filter, spin-on, with non-replacea□le a□sor□ent-t□pe elements
5. Fuel oil fuel/water separator
□. Heav□dut□crankcase vapor coalescer
7. Radiator mounted fuel cooler to cool recirculated fuel □efore it is re-deposited into the fuel tank as recommended □□the manufacturer.

2.07 MOUNTING

A. Couple the engine and generator together through a fle□i□le, non-□acklash t□pe, all metal coupling which overcomes all normal misalignment stresses and transmits full engine tor□ue with ample safet□factor. Also provide fle□i□le connections for piping connections.

2.08 COOLING SYSTEM

A. Provide a radiator manufactured of a non-corrosive material mounted on the engine. The radiator core shall be coated with a corrosion resistant coating. Corrosion resistant coating shall be a corrosion resistant baked phenolic coating or similar.

B. Connect the radiator to the engine internal cooling system with flexible piping. Furnish appropriately sized coolant expansion tank for the cooling system.

C. The engine shall be cooled through a radiator sized to continuously maintain safe operation at full load and at 105°F outside ambient air with 50% ethylene glycol coolant. A blower type fan and low noise fan drive and controls shall be furnished. The fan and all rotating members and drive belts shall be guarded and meet OSHA standards. Proof of 105°F ambient temperature capability shall be required.

D. Coolant

1. After the cooling system is flushed and cleaned, provide an initial fill of coolant consisting of 50% ethylene glycol. An anti-corrosion treatment shall be added during the initial fill.

2. The coolant shall meet the requirements of the generator manufacturer including corrosion inhibitors provided in the coolant to protect the engine cooling system.

E. The engine shall be equipped with coolant heaters. Heaters shall be in accordance with the following:

1. Unit mounted thermal circulation type coolant heater with coolant recirculation pump shall be furnished to maintain engine jacket coolant temperature as recommended by manufacturer in a 3 phase, ambient temperature of minus 20°F. The heater shall be 208 VAC, 60 hertz, 1-phase, thermostatically controlled.

2. The heater shall be of sufficient capacity to keep the coolant at a suitable temperature for trouble-free starting.

3. Each heater shall be provided with a suitable contactor to automatically disconnect the heater when the engine is started.

2.09 ENGINE STARTING AND CHARGING SYSTEM

A. Engine starting batteries shall be sealed, lead-acid type, rated 12 volts, wired for 12V or 24V DC starting batteries shall have adequate capacity for rolling the engine for five (5), ten (10) second cycles without starting, and then operating the control devices in the local generator controls for two (2) hours. The batteries shall be mounted on a suitable non-corrosive rack. Batteries shall have battery cables with lugs and shall be provided with lugs for connection to the battery charger.

B. Battery charger shall be a U.L. 123[illegible] listed, automatic, solid-state battery charger, 10 A (min.) current limited, ±2% voltage regulation, ±10% line voltage variation, automatic float equalizing system, DC voltmeter, and DC ammeter. Provide a Form C unpowered (dry) contact to indicate a low battery alarm condition.

C. In addition, the engine shall □e provided with an engine □atter□charging alternator that automaticall□changes the starting □atteries during engine operation.

2.10 E□HAUST SILENCER

A. Furnish and install an e□haust silencer. Silencers shall □e of critical t□pe and sized to produce a high degree of silencing. Reference the sound attenuation re□uirements specified herein.

B. Connect the silencer to the engine e□haust manifold with a high corrosion and temperature resistant stainless steel fle□i□le convoluted e□haust pipe. Use flange-t□pe connections. Provide a taper-cut tail pipe complete with rain cap to e□haust the gases to the atmosphere.

C. The silencer □if installed inside□, e□haust piping, and e□pansion fittings, including collector □o□, shall □e completel□covered with a remova□le insulation □lanket in order to protect operating personnel and to reduce noise. Insulation shall □e of composite fi□erglass and stainless steel construction capa□le of withstanding 1200□F continuousl□. The insulation □lankets shall □e tailored and custom fa□ricated to fit the contours of the manifolds. Average weight of the insulating □lanket shall □e 1.5 psf. Insulation shall conform to MIL-1-1□411D, T□pe II and shall □e custom fa□ricated to fit the contours of the components.

D. The silencer s□stem shall □e designed, furnished, and installed to prevent moisture and condensation from corroding the silencer. All e□terior components of the e□haust s□stem shall □e of 31□ stainless steel.

E. Silencer shall □e mounted within the generator enclosure dependent on generator size and manufacturers standards. Silencers mounted within the generator enclosure shall □e painted steel and insulated using a calcium silicate material covered □□a □rushed aluminum skin.

2.11 WIRING

A. Furnish and install internal wiring in the engine-generator set. All internal wiring □etween the generator and engine-generator control panel, the on-□oard power source and all accessories shall □e provided.

2.12 AUTOMATIC TRANSFER SWITCH

A. Furnish and install an automatic transfer switch as indicated on the Drawings and specified in Section 1□49□, Automatic Transfer Switch. The switch and its operation shall □e considered to □e part of the stand□□generator s□stem.

2.13 BASE MOUNTED FUEL TANK

A. The generator set shall □e supplied with a U.L.-142 listed □ase mounted fuel tank of sufficient capacit□to operate the engine-generator set at full load for a minimum of 24 hours. The tank, painted in a color as selected □□the Cit□, shall □e fa□ricated from steel with a rupture □asin and leak detector s□stem. The alarm and indicator for the leak detection shall □e mounted ad□acent to the generator control panel and a contact for remote indication of a fuel leak condition shall be provided. This contact shall be wired as part of a common "Generator System Failure" alarm.

B. A level device shall also be furnished and installed to provide a local (generator control panel) and remote indication of low fuel tank level. The low fuel tank level shall activate a set of dry contacts for remote alarm indication. The low fuel level alarm shall activate when only [illegible] hours of fuel for full load operation remains in the fuel tank. The remote low fuel tank level alarm shall be wired separate from the "Generator System Failure" alarm.

C. The tank shall be supplied with all necessary fuel supply, return, vent, and fill fittings and a fuel level gauge. The lockable fill port and level gauge shall be easily accessible from inside the enclosure. Provide a valve that automatically closes the fuel fill inlet when the tank level reaches 95% of its capacity. The vent line shall be piped to the outside and be equipped with a fill whistle.

D. The underside of the tank shall not be in contact with the mounting surface (concrete pad).

E. Fuel tank shall be equipped with necessary hardware and penetrations to interface with the fuel polishing system (if applicable).

2.14 WEATHERPROOF ENGINE - GENERATOR ENCLOSURE

A. Furnish and install an outdoor, weather-protective housing constructed to meet the HVHZ Large Missile Impact Requirement of Section 1[illegible]2[illegible] of the Florida Building Code. The housing shall be rated for 180mph wind loading. The housing shall be furnished complete with a full sub-base floor resulting in complete enclosure. The enclosure shall be factory-assembled to the engine-generator set base and radiator cowling. Lifting eyes shall be provided. Housing shall provide ample airflow for generator set operation. The housing shall be constructed of 12 gauge (minimum) aluminum or 14 gauge (minimum) galvanized steel, reinforced to be vibration free in the operating mode. The housing shall have hinged side-access doors and if needed, a rear control panel access door. Each door shall have at least two latch-bearing points. All doors shall be lockable. All steel sheet metal shall be primed for corrosion protection and finish painted in a color as selected by the City. Roof shall be peaked to allow drainage of rain water. Unit shall have sufficient guards to prevent entrance by small animals. Batteries shall fit inside enclosure and alongside the engine (batteries under the generator are not acceptable). Unit shall have engine coolant and oil drains piped to outside the unit to facilitate maintenance. Each drain line shall have a valve located near the fluid source.

B. “Skin-tight” housing shall be provided. No walk-around access is required within the enclosure; however, adequate working clearance shall be provided as required by the NEC. Alternatively, access doors may be provided so that when opened, adequate working clearance is achieved in front of electrical equipment.

C. Enclosure shall be sound attenuated to provide sound level as specified herein.

D. All hardware (nuts, bolts, screws, washers, etc.) that is installed on the exterior of the generator enclosure shall be stainless steel. Galvanized steel hardware is not acceptable.

E. Coordinate access requirements with elevated platform, stairs and rails provider. Reference Division 03 and Division 05 specifications.

F. LED lighting shall be provided in sufficient quantity. Compact fluorescent lighting fixtures are not acceptable. Interior lighting shall be controlled by 3-way light switches located at each door. Reference Section 16141.

G. Convenience receptacles shall be furnished at each door within the enclosure. Receptacles shall be 125V, 20A, two-pole, three wire grounded type. Reference Section 16141.

H. Conduit and wire shall be in accordance with Sections 16111 and 16123, respectively.

I. Enclosure shall include an air intake hood and air discharge hood with gravity dampers. Design shall eliminate water intrusion to the interior of the enclosure when the generator is operating at full load (maximum airflow) during rain events.

J. Enclosure shall be provided with a 120/208V, 3 Phase load center factory wired to feed all generator auxiliary loads.

2.15 SOUND ATTENUATION

A. Extreme care shall be exercised in providing equipment for and setting the engine-generator in place to guard against excessive noise transmission and vibrations. Fasten to the underside of the skids seismically-rated spring type isolators.

B. The engine-generator enclosure shall be designed, furnished, and installed to reduce source noise to 68 dB(A) as measured at seven (7) meters from the enclosure.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The standby generator system shall be furnished and installed as indicated on the Drawings and as recommended by the equipment manufacturer.

B. The initial filling of the fuel storage tank shall be provided by the Contractor. Fuel tank shall be filled to its full capacity. At the conclusion of all field testing, the Contractor shall fill the fuel storage tank back to its full capacity. Fuel shall be ultra-low sulfur diesel Grade No. 2D S15 in accordance with ASTM D-975. Fuel shall be new and free from contaminants and water.

3.02 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified generator manufacturer's factory-trained technical representative who shall adequately supervise the installation and of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the City.

B. The manufacturer’s technical representative shall perform all startup and field testing of the generator assembly as specified herein.

C. The Contractor shall provide training for the City’s personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct City’s personnel in operation and maintenance of <u>all equipment provided under this Section</u>. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after the generator has been installed and tested. Training shall be conducted at times coordinated with the City and shall occur during the same week as the training specified in Section 1□49□ – Automatic Transfer Switch.

D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of two (2) working days during installation of the engine-generator set.
2. One (1) trip of one (1) working day to perform startup of the engine-generator set.
3. One (1) trip of two (2) working days to perform the field testing of the engine-generator set.
4. One (1) trip of one (1) working day to perform training as specified herein.

E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests
   a. None required.
2. Certified Shop Tests
   a. Fully test the engine-generator set with all accessories in the manufacturer's plant before shipment. Tests shall be conducted through the use of balanced, three-phase, dry-type, resistive/reactive load banks at rated power factor.
   b. Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure.
   c. The manufacturer shall conduct a shop test run of at least six (6) consecutive hours for the set under the following conditions of load, in the following order:

      1) 2 hours - full load

      2) 2 hour - 3/4 load

      3) 2 hour - 1/2 load

d. Fuel, lubricants, and other fluids as required for the shop tests shall be furnished by the manufacturer.

3. Field Tests

a. Field tests shall be performed by the generator manufacturer's technical representative. The Contractor shall obtain from the manufacturer and submit a detailed field test plan and procedures documenting the intended field test program.

b. In the presence of the Engineer and City, the representative shall inspect, adjust, and test the entire system after installation and leave in good working order. Field tests specific to each generator shall be conducted after the entire engine-generator system is installed including, but not limited to, the following: diesel fuel tanks including leak detection, exhaust silencer, radiators, enclosures, batteries, and all other equipment included in the complete system.

c. Field test the generator enclosure to ensure the enclosure performs as specified herein. The generator enclosure field tests shall include water tests to confirm the enclosure does not leak and that the air intake louvers eliminate water intrusion to the interior of the generator enclosure when the generator is operating at its full load capacity (maximum airflow). A garden hose shall be used to simulate falling rain for this test. Water supply and garden hose will be provided by the City for this test.

d. Field test, as far as practicable, all control, shutdown, and alarm circuits. Document the successful completion of these tests as witnessed by the City and the Engineer.

e. Generator load tests shall be conducted through the use of balanced, three-phase, dry-type, resistive load banks per NFPA 110 section 7.13.4. Conduct a continuous run test using the load bank without shutdown for the engine-generator set and in the presence of the City and Engineer under load conditions that are in accordance with NFPA 110 section 7.13.4.

f. Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure every 15 minutes during the continuous run test. If any failures, malfunctions, and/or shutdowns occur during this test, the problems shall be fixed and the test shall be restarted.

g. After the completion of the switchgear/transfer controls startup (see Section 1□428) and the load tests listed above, the generator and switchgear automatic transfer controls shall be tested as an overall system in the presence of the Engineer and City. Utility service outages shall be **simulated** to allow automatic controls to perform the transfers, transfers shall not be manually initiated. As a minimum, the generator and switchgear automatic transfer tests shall be performed as follows:

1) Three (3) open transition transfers from the utility service to the generator and then back to the utility service under the then current plant operating load.

h. It is the intent that these tests take place utilizing plant loads. If the system cannot be fully loaded as required by the plant loads, the manufacturer shall connect a resistive load bank to feed through lugs in Distribution Board ‘MDP’ as needed to test the system under the loads described above. If any failures, malfunctions, and/or shutdowns occur during any of the transfer tests listed above, the problems shall be fixed and the test shall be restarted. Each test shall not be considered complete until the generator/switchgear system has performed the required number of transfers consecutively without any failures or malfunctions. During the transfer testing above, the loads shall remain on the utility or generator source for at least five (5) minutes in between transfers.

i. The Contractor shall collect a sample of engine oil from each engine for analysis after the start-up and testing has been completed. The sampling method shall be of the atomic absorption spectrophotometry method and be accurate to within a fraction of one part per million for the following elements:

1) Iron

2) Chromium

3) Copper

4) Aluminum

5) Silicon

6) Lead

j. The sample shall also be tested for the presence of water, fuel dilution, and coolant.

k. The oil samples shall be analyzed at an independent laboratory that is not a part of the engine supplier's facility. Immediate notification of critical results shall be provided to the City when the analysis shows any critical reading.

l. All fuel, lubricants, and other fluids required to complete all field tests shall be paid for by the Contractor. Upon completion of tests, all fuel, lubricants, and other fluid levels shall be returned to full at contractor’s expense.

3.04 PAINTING

A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

END OF SECTION

SECTION 1□902

ELECTRIC CONTROLS AND RELA□S

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactor□operation all electric controls and rela□s as specified herein and indicated on the Drawings.

B. Electrical control and rela□s□stems shall □e assem□led using NEMA rated components. Components designed and □uilt to International Electrotechnical Commission □IEC□standards <u>are not</u> recognized. E□uipment designed, manufactured and la□eled in compliance with IEC standards is not accepta□le.

C. Reference Section 1□000, Basic Electrical Re□uirements and Section 1□195, Electrical Identification.

1.02 CODES AND STANDARDS

A. Products specified herein shall □e in conformance with or listed to the following standards as applica□le:

1. NEMA 250 – Enclosures for Electrical E□uipment
2. UL 508A – Standard for Industrial Control Panels
3. UL-1203 – Standard for E□plosion-proof and Dust-ignition-proof Electrical E□uipment for use in Hazardous □Classified□Locations.
4. ANSI/ISA 12.12.01-2013 – Nonincendive Electrical E□uipment for use in Class I and II, Division II Hazardous □Classified□locations.

1.03 SUBMITTALS

A. In accordance with the procedures and re□uirements set forth in the General Conditions and Section 01300, Su□mittals, the Contractor shall o□tain from the e□uipment manufacturer and su□mit the following:

1. Shop Drawings
2. Spare Parts List

B. Each su□mittal shall □e identified □□the applica□le specification section.

1.04 SHOP DRAWINGS

A. Each su□mittal shall □e complete in all respects, incorporating all information and data listed herein and all additional information re□uired for evaluation of the proposed e□uipment□s compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 SPARE PARTS

A. All spare parts as recommended by the equipment manufacturer shall be furnished to the City by the Contractor. In addition to the manufacturer recommended spare parts, the following spare parts shall be provided for the local control stations:

1. One (1) contact block of each type furnished on the project

2. One (1) indicating light lens of each color furnished on the project

3. One (1) LED lamp of each color furnished on the project

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the City.

D. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same part number.

PART 2 - PRODUCTS

2.01 CONTROL COMPONENTS

A. Manufacturers

1. Unless noted otherwise, control components shall be manufactured by Eaton, The Square D Company, General Electric, Allen-Bradley, Siemens Energy and Automation, or Engineer approved equal.

2. Photocells and time clocks shall be manufactured by Grasslin by Intermatic, Tork by NSi Industries, Intermatic, or Paragon Auto Control.

B. Pilot Devices

1. General

   a. All pilot devices shall be provided with a legend plate. Legend plates shall have a white background and black lettering and indicate the function of the respective pilot device. The text shown on the Drawings or indicated in the specifications shall be used as the basis for legend plate engraving (i.e. HAND-OFF-AUTO, RUN, EMERGENCY STOP, etc.)

   b. All pilot devices shall be selected and properly installed to maintain the NEMA 250 rating of the enclosure in which they are installed. All pilot devices shall be UL 508 Listed.

   c. All pilot devices shall be 30.5mm in diameter, unless otherwise indicated. 22mm devices are not acceptable.

   d. Pilot devices for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

   e. In Class 1 Division 2 hazardous locations, pilot devices shall be the hermetically-sealed type, constructed in accordance with ANSI/ISA 12.12.01.

2. Pushbuttons

   a. Pushbuttons shall be non-illuminated, black in color, and have momentary style operation unless otherwise indicated on the Drawings.

   b. Pushbuttons shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each pushbutton. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

   c. Pushbuttons shall be provided with a full guard around the perimeter of the button. Where a lockout style pushbutton is specified or indicated on the Drawings, provide a padlockable guard.

3. Selector Switches

   a. Selector switches shall be non-illuminated, black in color, and have the number of maintained positions as indicated on the Drawings and as required. Handles shall be the extended type that provide a greater surface area for operation.

   b. Selector switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each selector switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

   c. Where indicated in the Drawings or Specifications, provide spring return positions.

d. Selector switches shall be provided with an indexing component that fits into the keyed portion of the cutout for the device and prevents the switch from spinning when operated.

4. Indicating Lights

a. Indicating lights shall LED type, with the proper voltage rating to suit the application, and push-to-test feature.

b. Indicating light lens colors shall be as required in equipment specifications and/or as indicated on the Drawings. If lens colors are not indicated, the following colors shall be used:

1) Red - "Run", "On", “Open”

2) Green - "Off", “Closed”

3) Amber - "Alarm", "Fail"

4) White - “Control Power On”

5. Emergency Stop and Tagline Switches

a. Emergency stop switches shall be non-illuminated, red in color, with a minimum 35mm diameter mushroom head. Once activated, switch shall maintain its position and require a manual pull to release/reset.

b. Tagline switches shall have a plunger that activates upon tension from the associated safety cable. Once activated, switch shall maintain its position and require a manual release/reset.

c. Emergency stop and tagline switches shall have the quantity of normally closed and/or normally open contacts as indicated on the Drawings and as required. In addition to the required contacts, one (1) spare normally open and one (1) spare normally closed contact shall be installed at each switch. Contacts shall be rated for 5A at 250VAC/DC (minimum), but no less than required for the application.

C. Relays and Timers

1. General

a. Relays and timers shall be furnished with an integral pilot light for positive indication of coil energization.

b. Relays and timers shall have tubular pin style terminals with matching 11-pin DIN rail mount socket. Spade or blade style terminals are not acceptable.

c. Relays and timers for all electrical equipment under this Contract shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

2. Control and Pilot Relays

   a. Miniature or “ice-cube” type relays are not acceptable.

   b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.

   c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have 3-pole, double-throw (3PDT) contact arrangement.

3. Time Delay Relays

   a. Timers delay relays shall utilize electronic timing technology. Mechanical timing devices are not acceptable.

   b. Relays shall have coil voltage as required to suit the application and/or as indicated on the Drawings.

   c. Relays shall be provided with contacts rated for 10A (resistive), minimum, at 120/240 VAC and 28 VDC. Relays shall have double-pole double-throw (DPDT) contact arrangement.

   d. Time delay ranges shall be as indicated on the Drawings and/or as required to suit the application. Timing range shall be adjustable from the front of the relay. On delay and off delay timer configurations shall be provided as indicated on the Drawings and/or as required to suit the application.

4. Elapsed Time Meters

   a. Elapsed time meters shall be non-resettable type with no less than a 4 digit display. Coil voltage shall be as required to suit the application and/or as indicated on the Drawings.

D. Control Terminal Blocks

1. Control terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or subpanel. Terminals shall be tubular screw type with pressure plate that will accommodate wire size range of #22 - #8 AWG.

2. Control terminal blocks shall be single tier with a minimum rating of 600 volts and 20A. Separate terminal strips shall be provided for each type of control used (i.e. 120VAC vs. 24VDC). Quantity of terminals shall be provided as required to suit the application. In addition, there shall be a sufficient quantity of terminals for the termination of all spare conductors.

3. Terminals shall be marked with a permanent, continuous marking strip, with each terminal numbered. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal.

E. Photocells and Time Clocks

1. Photocells:
   a. Weatherproof enclosure.
   □. Ad□usta□le turn-on range, initiall□ set at 1.0 foot-candles.
      1□ Turn-off level appro□imatel□ three times turn-on.
   c. Provide time dela□ device to eliminate nuisance switching.
   d. Voltage, amperage and/or wattage ratings as re□uired for the application.
2. General Re□uirements for Time Clocks:
   a. Separate manual on-off operation without distur□ing automatic settings.
   □. Enclosure:
      1□ NEMA 1 for indoor locations.
   c. Voltage, amperage and/or wattage ratings as re□uired for the application.
3. Electronic:
   a. 3□5 da□ programma□le using solid state technolog□ with □lock programming.
   □. Minimum of 72 hour carr□over power utilizing rechargea□le □atter□ or capacitor.
   c. Minimum of 48 events per week, 1□ individual holida□ overrides, da□light savings or standard time selecta□le, automatic leap □ear correction.
4. Astronomical Clocks:
   a. Ad□usta□le for the installed latitude.
      1□ Settings for astro on/astro off, astro on/time off or time on/astro off.
   □. 3□5 da□ programma□le using solid state technolog□ with □lock programming.
   c. Minimum of 72 hour carr□over power utilizing rechargea□le □atter□ or capacitor.
   d. Minimum of 48 events per week, 1□ individual holida□ overrides da□light savings or standard time selecta□le, automatic leap □ear correction.

PART 3 - E□ECUTION

3.01 INSTALLATION

A. Local control stations shall □e provided in the enclosure t□pe and material of construction re□uired for the area in which it is installed. Reference the re□uirements in Part 2 herein, and the area designations indicated on the Drawings.

B. All control components shall □e mounted in a manner that will permit servicing, ad□ustment, testing, and removal without disconnecting, moving, or removing an□ other component. Components mounted on the inside of panels shall □e mounted on remova□le plates and not directl□ to the enclosure. Mounting shall □e rigid and sta□le unless shock mounting is re□uired otherwise □□ the manufacturer to protect e□uipment from vi□ration. Component□s mounting shall □e oriented in accordance with the component manufacturer□s and industries□standard practices.

C. Pilot devices shall □e properl□ □onded to the e□uipment enclosure door where the□ are installed. If proper □onding cannot □e achieved through the locknuts that affi□ the device in place, a green colored □onding screw shall □e provided on the pilot device. The □onding screw shall □e □onded to the e□uipment enclosure through the use of an insulated green □onding conductor.

D. Local control station covers shall □e □onded to the local control station enclosure through the use of an insulated green □onding conductor.

E. Wiring to devices at each local control station shall □e provided with enough slack to permit the local control station cover to □e removed and pulled at least □ inches awa□ from the enclosure.

F. Terminal strips, rela□s, timers, and similar devices shall not □e installed on the rear of the panel/ca□inet doors. Terminal strips, rela□s, timers, and similar devices shall not □e installed on the side walls of panel/ca□inet interiors without written permission from the Engineer.

END OF SECTION

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SECTION 17000

CONTROL AND INFORMATION SYSTEM SCOPE AND GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SCOPE

A. The Contractor shall provide, through the services of an instrumentation and control system subcontractor, all components, system installation services, as well as all required and specified ancillary services in connection with the Instrumentation, Control and Information System. The System includes all materials, labor, tools, fees, charges and documentation required to furnish, install, test and place in operation a complete and operable instrumentation, control and information system as shown and/or specified. The system shall include all measuring elements, signal converters, transmitters, local control panels, digital hardware and software, operator workstations, remote telemetry units, signal and data transmission systems, interconnecting wiring and such accessories as shown, specified, and/or required to provide the functions indicated.

B. The scope of the work to be performed under this Division includes but is not limited to the following:

1. The Contractor shall retain overall responsibility for the instrumentation and control system as specified herein.

2. Furnish and install process instrumentation and associated taps and supports as scheduled or shown on the Drawings, unless otherwise noted or supplied by equipment vendors.

3. Furnish and install local control panels, field panels and associated cabinets and panels as shown on the Drawings and as specified in Division 17.

4. Furnish and install digital control system hardware and software as specified in Division 17.

5. Final termination and testing of all instrumentation and control system signal wiring and power supply wiring at equipment furnished under Division 17.

6. Furnish, install and terminate all special cables (instruments, printers, telemetry, etc.). Furnish and terminate control system communication network cables.

7. Furnish and install surge protection devices for all digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division, including connections to grounding system(s) provided under Division 16.

8. Coordinate grounding requirements with the electrical subcontractor for all digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division. Terminate grounding system cables at all equipment provided under this Division.

9. Provide system testing, calibration, training and startup services as specified herein and as required to make all systems fully operational.

C. It is the intent of the Contract Documents to construct a complete and working installation. Items of equipment or materials that may reasonably be assumed as necessary to accomplish this end shall be supplied whether or not they are specifically stated herein.

1.02 RELATED ITEMS

A. Field mounted switches, torque switches, limit switches, gauges, valve and gate operator position transmitters, sump pump controls and other instrumentation and controls furnished with mechanical or electrical equipment not listed in the instrument schedule shall be furnished, installed, tested and calibrated as specified under other Divisions.

B. Additional and related work performed under Division 16 includes the following:

1. Instrument A.C. power source and disconnect switch for process instrumentation, A.C. grounding systems, and A.C. power supplies for all equipment, control panels and accessories furnished under Division 17.
2. Conduit and raceways for all instrumentation and control system signal wiring, grounding systems, special cables and communication network cables.
3. Instrumentation and control system signal wiring.
4. Install control system communication network cables.
5. Furnish and install grounding systems for all digital equipment, local control panels, remote telemetry units, and instrumentation provided under Division 17. Grounding systems shall be complete to the equipment provided under Division 17, ready for termination by the instrumentation subcontractor.
6. Termination of all instrumentation and control system signal wiring at all equipment furnished under other divisions of the Specifications.
7. Final wiring and termination to A.C. grounding systems and to A.C. power sources (e.g. panelboards, motor control centers, and other sources of electrical power).

1.03 GENERAL INFORMATION AND DESCRIPTION

A. Where manufacturers are named for a particular item of equipment, it is intended as a guide to acceptable quality and performance and does not exempt such equipment from the requirements of these Specifications or Drawings.

B. In order to centralize responsibility, it is required that all equipment (including field instrumentation and control system hardware and software) offered under this Division shall be furnished and installed by the instrumentation subcontractor, or under the supervision of the instrumentation subcontractor, who shall assume complete responsibility for proper operation of the instrumentation and control system equipment, including that of coordinating all signals, and furnishing all appurtenant equipment.

C. The Contractor shall retain total responsibility for the proper detailed design, fabrication, inspection, test, delivery, assembly, installation, activation, checkout, adjustment and operation of the entire instrumentation and control system as well as equipment and controls furnished under other Divisions of the Specifications. The Contractor shall be responsible for the delivery of all detailed drawings, manuals and other documentation required for the complete coordination, installation, activation and operation of mechanical equipment, equipment control panels, local control panels, field instrumentation, control systems and related equipment and/or systems and shall provide for the services of a qualified installation engineer to supervise all activities required to place the completed facility in stable operation under full digital control.

D. The instrumentation and control system shall be capable of simultaneously implementing all real-time control and information system functions, and servicing all operator service requests as specified, without degrading the data handling and processing capability of any system component.

E. Control system inputs and outputs are listed in the Input/Output Schedule. This information, together with the functional control descriptions, process and instrumentation diagrams, and electrical control schematics, describes the real-time monitoring and control functions to be performed. In addition, the system shall provide various man/machine interface and data reporting functions as specified in the software sections of this Specification.

F. The mechanical, process, and electrical drawings indicate the approximate locations of field instruments, control panels, systems and equipment as well as field-mounted equipment provided by others. The instrumentation subcontractor shall examine the mechanical, process and electrical drawings to determine actual size and locations of process connections and wiring requirements for instrumentation and controls furnished under this Contract. The instrumentation subcontractor shall inspect all equipment, panels, instrumentation, controls and appurtenances either existing or furnished under other Divisions of the Specifications to determine all requirements to interface same with the control and information system. The Contractor shall coordinate the completion of any required modifications with the associated supplier of the item furnished.

G. The instrumentation subcontractor shall review and approve the size and routing of all instrumentation and control cable and conduit systems furnished by the electrical subcontractor for suitability for use with the associated cable system.

H. The Contractor shall coordinate the efforts of each supplier to aid in interfacing all systems. This effort shall include, but shall not be limited to, the distribution of approved shop drawings to the electrical subcontractor and to the instrumentation subcontractor furnishing the equipment under this Division.

I. The Contractor shall be responsible for providing a signal transmission system free from electrical interference that would be detrimental to the proper functioning of the instrumentation and control system equipment.

J. The City shall have the right of access to the subcontractor's facility and the facilities of his equipment suppliers to inspect materials and parts; witness inspections, tests and work in progress; and examine applicable design documents, records and certifications during any stage of design, fabrication and tests. The instrumentation subcontractor and his equipment suppliers shall furnish office space, supplies and services required for these surveillance activities.

K. The terms "Instrumentation", "Instrumentation and Control System", and "Instrumentation, Control and Information System" shall hereinafter be defined as all equipment, labor, services and documents necessary to meet the intent of the Specifications.

1.04 INSTRUMENTATION AND CONTROL SYSTEM SUBCONTRACTORS

A. Instrumentation and control system subcontractors shall be regularly engaged in the detailed design, fabrication, installation, and startup of instrumentation, controls and telemetry for stormwater or wastewater collection and conveyance systems. Instrumentation and control system subcontractors shall have a minimum of five years of such experience, and shall have completed a minimum of three projects of similar type and size as that specified herein. Where specific manufacturers and/or models of major hardware or software products (PLC, HMI software, LAN, etc.) are specified to be used on this project, the instrumentation and control system subcontractor shall have completed at least one project using that specified hardware or software. As used herein, the term “completed” shall mean that a project has been brought to final completion and final payment has been made. Any instrumentation and control system subcontractor that has been subject to litigation or the assessment of liquidated damages for nonperformance on any project within the last five calendar years shall not be acceptable.

1.05 DEFINITIONS

A. Solid State: Wherever the term solid state is used to describe circuitry or components in the Specifications, it is intended that the circuitry or components shall be of the type that convey electrons by means of solid materials such as crystals or that work on magnetic principles such as ferrite cores. Vacuum tubes, gas tubes, slide wires, mechanical relays, stepping motors or other devices will not be considered as satisfying the requirements for solid state components of circuitry.

B. Bit or Data Bit: Whenever the terms bit or data bit are used in the Specification, it is intended that one bit shall be equivalent to one binary digit of information. In specifying data transmission rate, the bit rate or data bit rate shall be the number of binary digits transmitted per second and shall not necessarily be equal to either the maximum pulse rate or average pulse rate.

C. Integrated Circuit: Integrated circuit shall mean the physical realization of a number of circuit elements inseparably associated on or within a continuous body to perform the function of a circuit.

D. Mean Time Between Failures (MTBF): The MTBF shall be calculated by taking the number of system operating hours logged during an arbitrary period of not less than six months and dividing by the number of failures experienced during this period plus one.

E. Mean Time to Repair (MTTR): The MTTR shall be calculated by taking the total system down time for repair over an arbitrary period of not less than six months coinciding with that used for calculation of MTBF and dividing by the number of failures causing down time during the period.

F. Availability: The availability of a non-redundant device or system shall be related to its MTBF and MTTR by the following formula:

$$A = 100 \times (MTBF/(MTBF + MTTR))\ \text{Percent}$$

The availability of a device or system provided with an automatically switched backup device or system shall be determined by the following formula:

$$A = A2 = 1 - ((1 - A1) \times (1 - A1))$$

where:

A1	=	availability of non-redundant device or system
A2	=	availability of device or system provided with an automatically switched backup device or system

G. Abbreviations: Specification abbreviations include the following:

A	-	Availability
ADC	-	Analog to Digital Converter
AI	-	Analog Input
AO	-	Analog Output
AVAIL	-	Available
BCD	-	Binary Coded Decimal
CSMA/CD	-	Carrier Sense Multiple Access/Collision Detect
CPU	-	Central Processing Unit
CRC	-	Cyclic Redundancy Check
CRT	-	Cathode Ray Tube
CS	-	Control Strategy
DAC	-	Digital to Analog Converter
DBMS	-	Data Base Management System
DI	-	Discrete Input
DMA	-	Direct Memory Access
DO	-	Discrete Output
DPDT	-	Double Pole, Double Throw
DVE	-	Digital to Video Electronics
EPROM	-	Erasable, Programmable Read Only Memory
FDM	-	Frequency Division Multiplexing
FSK	-	Frequency Shift Keyed
HMI	-	Human Machine Interface (Software)
I/O	-	Input/Output
LAN	-	Local Area Network
LDFW	-	Lead-Follow
MCC	-	Motor Control Center
MTBF	-	Mean Time Between Failures
MTTR	-	Mean Time To Repair
OS	-	Operating System
PAC	-	Programmable Automation Controller
PCB	-	Printed Circuit Board
PID	-	Proportional Integral and Derivative Control

PLC	-	Programma□le Logic Controller
PROM	-	Programma□le Read Onl□Memor□
RAM	-	Random Access Memor□
RD□	-	Read□
RMSS	-	Root Mean S□uare Summation
RNG	-	Running
ROM	-	Read Onl□Memor□
RTU	-	Remote Telemetr□Unit
SPDT	-	Single Pole, Dou□le Throw
ST/SP	-	Start/Stop
TDM	-	Time Division Multiple□ing
UPS	-	Uninterrupti□le Power Suppl□

H. To minimize the num□er of characters in words used in te□tual descriptions on graphic displa□s, printouts and nameplates, a□□reviations ma□ □e used su□□ect to the Engineer□s approval. If a specified a□□reviation does not e□ist for a particular word, an a□□reviation ma□ □e generated using the principles of masking and or vowel deletion. Masking involves retaining the first and last letters in a word and deleting one or more characters □usuall□ vowels□from the interior of the word.

1.0□ ENVIRONMENTAL CONDITIONS

A. Instrumentation e□uipment and enclosures shall □e suita□le for am□ient conditions specified. All s□stem elements shall operate properl□in the presence of telephone lines, power lines, and electrical e□uipment.

B. Inside control rooms and climate-controlled electrical rooms, the temperature will normall□ □e 20 to 25 degrees C□relative humidit□40 to 80 percent without condensation and the air will □e essentiall□free of corrosive contaminants and moisture. Appropriate air filtering shall □e provided to meet environmental conditions □i.e., for dust□.

C. Other indoor areas ma□not □e air conditioned/heated□temperatures ma□range □etween 0 and 40 degrees C with relative humidit□ □etween 40 and 95 percent.

D. Field e□uipment including instrumentation and panels ma□ □e su□□ected to wind, rain, lightning, and corrosives in the environment, with am□ient temperatures from -20 to 40 degrees C and relative humidit□from 10 to 100 percent. All supports, □rackets, interconnecting hardware, and fasteners shall □e aluminum, t□pe 31□ stainless steel, or metal allo□as otherwise suita□le for chemical resistance within chemical feed/storage areas shown on the installation detail drawings.

PART 2 - PRODUCTS

2.01 NAMEPLATES

A. All items of e□uipment listed in the instrument schedule, control panels, and all items of digital hardware shall □e identified with nameplates. Each nameplate shall □e located so that it is reada□le from the normal o□servation position and is clearl□associated with the device or devices it identifies. Nameplates shall □e positioned so that removal of the device for maintenance and repair shall not distur□ the nameplate. Nameplates shall include the e□uipment identification num□er and description. A□□reviations of the description shall □e su□□ect to the Engineer□s approval.

B. Nameplates shall □e made of 1/1□-inch thick machine engraved laminated phenolic plastic having white num□ers and letters not less than 3/1□-inch high on a □lack □ackground.

C. Nameplates shall □e attached to metal e□uipment □□ stainless steel screws and to other surfaces □□ an epo□□-□ased adhesive that is resistant to oil and moisture. In cases where the la□el cannot □e attached □□ the a□ove methods, it shall □e drilled and attached to the associated device □□ means of stainless steel wire.

PART 3 - E□ECUTION

3.01 SCHEDULE OF PA□MENT

A. Pa□ment to the Contractor for Control and Information S□stem materials, e□uipment, and la□or shall □e in accordance with the General and Supplementar□ Conditions. The schedule of values su□mitted as re□uired □□ the General and Supplementar□ Conditions shall reflect a □reakdown of the work re□uired for completion of the Control and Information S□stem. The □reakdown shall include sufficient detail to permit the Engineer to administer pa□ment for the Control and Information S□stem as outlined □elow.

B. The following pa□ment schedule defines pro□ect milestones that will □e used for esta□lishing ma□imum partial pa□ment amounts for the Control and Information S□stem. Pa□ment for field instruments, field wiring, fi□er optic network ca□le and similar items will □e made in addition to the pa□ment for the scopes of services incorporated into the schedule □elow.

Task Completed	**Maximum Cumulative % Request for Payment**
Mo□ilization	3□
Preliminar□ Design Review	5□
Approved Su□mittals	20□
Hardware Purchase □e□cludes field instruments□	40□
Factor□ Acceptance Test	□0□
Loop Checkout	70□
Control S□stem Start-up and Test	80□
Plant Start-up	90□
Final S□stem Acceptance Test	95□
Final Acceptance	100□

C. Re□uests for pa□ment for materials and e□uipment that are not installed on site, □ut are re□uired for s□stem construction and the factor□ acceptance test □e.g., digital hardware□, or are properl□ stored as descri□ed in the General and Supplementar□

Conditions and herein, shall be accompanied by invoices from the original supplier to the instrumentation subcontractor substantiating the cost of the materials or equipment.

D. Any balance remaining within the schedule of values for field instruments and other materials installed on the site, or for other materials for which payment is made by invoice, will be considered due upon completion of the Final Acceptance test.

3.02 CLEANING

A. The Contractor shall thoroughly clean all soiled surfaces of installed equipment and materials.

B. Upon completion of the instrumentation and control work, the Contractor shall remove all surplus materials, rubbish, and debris that has accumulated during the construction work. The entire area shall be left neat, clean, and acceptable to the City.

3.03 FINAL ACCEPTANCE

A. Final acceptance of the Instrumentation, Control and Information System will be determined complete by the Engineer, and shall be based upon the following:

1. Receipt of acceptable start up completion and availability reports and other documentation as required by the Contract Documents.
2. Completion of the Availability Demonstration.
3. Completion of all specified control system training requirements.
4. Completion of all punch-list items that are significant in the opinion of the Engineer.

B. Final acceptance of the System shall mark the beginning of the extended warranty period.

END OF SECTION

SECTION 17015

PRELIMINARY DESIGN REVIEW

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall conduct a preliminary design review meeting for City personnel and the Engineer to ensure design compliance with all hardware and software requirements in the Contract Documents. Other supplemental design review meetings may be held as required by the Engineer or the City to resolve specific problems, to provide positive assurance to the City that the design conforms to contractual requirements, or to allow for concurrent planning activities by the City that are dependent upon the as-built system configuration/operation.

B. The Preliminary Design Review shall, at the discretion of the City, be conducted at the City's facility, the Contractor's facility, or at a location suggested by the City.

C. The Preliminary Design Review shall be conducted no later than □0 days after notice to proceed.

1.02 PRELIMINARY DESIGN REVIEW

A. The Preliminary Design Review (PDR) shall be a formal meeting to review the overall system design with emphasis being placed upon the arrangement and interactive operation of all items of digital equipment.

B. While the Preliminary Design Review is a meeting rather than a submittal, to the greatest extent possible all data to be presented at the PDR shall be furnished to the City two (2) weeks prior to the meeting date. Data made available by the Contractor shall include, but not be limited to the following:

1. Overall system block diagram(s), and preliminary digital hardware placement, preliminary console and equipment panel arrangements and layouts.

2. A brief functional description of the block diagram(s) shall be provided. The functional description shall describe the overall system operation, interaction between system elements, fail-over procedures and system/operator interactions.

3. A listing of the manufacturer's name and model number for each item of hardware shown in the block diagram(s), all analog instruments and auxiliary equipment such as power supplies.

4. The following software information:

   a. Brief overall description of software design and organization.

   b. List and description of all system software.

   c. List and description of all process control system software.

5. Brief description of the intended plan for implementing system development, assembly, checkout, hardware/software performance verification, installation, activation and factory test activities.

6. Identification of critical engineering activities and long lead-time procurement items.

7. Preliminary construction schedule, including submittal dates.

8. A copy of the proposed System Maintenance Contract.

9. Resumes listing qualifications of process control system engineering and technical personnel (including field installation personnel) expected to be assigned to the project, together with an estimate of the percentage of time such personnel are expected to devote to the project.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 17030

CONTROL AND INFORMATION SYSTEM SUBMITTALS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall submit for review complete Shop Drawings for all equipment in accordance with the General Conditions and Division 1 of the Specifications. All submittal material shall be complete, legible, and reproducible, and shall apply specifically to this project.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Submittals

B. Section 17000 – Control and Information System Scope and General Requirements

1.03 DIGITAL HARDWARE SUBMITTALS

A. Submit system block diagram(s) showing:

1. All equipment to be provided.
2. All interconnecting cable.
3. Equipment names, manufacturer, and model numbers.
4. Equipment locations.

B. Submit information for all digital equipment including, but not limited to, the following:

1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.
2. Catalog cuts, including complete part number breakdown information.
3. Complete technical, material and environmental specifications.
4. Assembly drawings.
5. Mounting requirements.
6. Color samples.
7. Nameplates.
8. Environmental requirements during storage and operation.

1.04 SOFTWARE SUBMITTALS

A. Software submittals shall include the following as a minimum:

1. Bill of materials with software names, vendors, and complete listings of included software modules.

2. Standard manufacturer's literature describing the products.

3. Description of function of software in Control and Information System.

4. Limitations or constraints of software.

5. Minimum system (processor and memory) requirements.

6. Operation and maintenance requirements.

B. Submit information on the following software:

1. Third-party software, including:

   a. Operating system.

   b. Operator workstation (SCADA or HMI) software, including all add-in software provided to perform specific functions (alarm dialers, schedulers, backup creation software, etc.).

   c. Office-type products, such as spreadsheets, word processors, etc.

   d. Database management software.

   e. Communication software, including all applicable local and wide area network software.

   f. Programmable controller programming software (where applicable).

2. Software configuration, including:

   a. Graphic display organization.

   b. Database configuration for operator workstations and database management system.

   c. Trends.

   d. System security.

   e. Formats for all reports, including all required calculations.

   f. Intercommunications between software products required to implement system functions.

   g. Equipment backup configuration and requirements.

C. Control Strategies

1. Provide control strategy documentation that includes control strategy diagrams (block oriented logic and ladder logic diagrams, as appropriate) to describe the control of all processes. The written description shall follow the format of the

functional control descriptions contained herein. The control strategy submittals shall contain the following as a minimum:

a. An overall description of the program structure and how it will meet the specified control requirements.

b. A listing of the program.

c. Extensive comments in the listings to describe program steps.

d. Equation and ladder program derivations for all specified control routines.

e. Resource (processor and memory) requirements.

f. A listing of inputs and outputs to the control strategy.

D. Application Software

1. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.

2. Application software includes all custom routines developed specifically for this project, or pre-written routines used for accomplishing specified functions for this project. This shall include any add-in custom software.

E. Graphic Displays

1. Submit all graphic displays required to perform the control and operator interface functions specified herein.

2. Submit the complete set of graphic displays for review by the City and the Engineer at least 60 days prior to commencement of factory testing.

3. Where a large number of graphic displays are required, submit an initial set of example displays for review before the complete set of displays is submitted. This initial set shall include examples of all basic graphic display design features and parameters, and is intended to allow the Contractor to obtain preliminary approval of these features and parameters prior to beginning main graphic display production.

4. The Contractor shall allow for one major cycle of revisions to the displays prior to factory testing and one minor cycle of revisions following factory test. A cycle of revisions shall be defined as all revisions necessary to complete a single set of changes marked by the Engineer and the City. Additional corrections shall be performed during start-up as required to accommodate changes required by actual field conditions, at no additional cost to the City.

5. Two of the required submittals in each revision cycle shall be full color prints of the entire set of displays. Additional sets may be in black-and-white or gray-scale.

6. Displays shall be printouts of actual process graphics implemented in the system.

1.05 CONTROL PANEL SUBMITTALS

A. Submittals shall be provided for all control panels, and shall include:

1. Exterior panel drawings with front and side views, to scale.
2. Interior layout drawings showing the locations and sizes of all equipment and wiring mounted within the cabinet, to scale.
3. Panel area reserved for cable access and conduit entry.
4. Location plans showing each panel in its assigned location.

B. Submit information for all exterior and interior panel mounted equipment including, but not limited to, the following:

1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.
2. Catalog cuts, including complete part number breakdown information.
3. Complete technical, material and environmental specifications.
4. Assembly drawings.
5. Mounting requirements.
6. Color samples.
7. Nameplates.
8. Environmental requirements during storage and operation.

C. Submit panel wiring diagrams showing power, signal, and control wiring, including surge protection, relays, courtesy receptacles, lighting, wire size and color coding, etc.

1.06 INSTRUMENT SUBMITTALS

A. Submit information on all field instruments, including but not limited to the following:

1. Product (item) name and tag number used herein and on the Contract Drawings.
2. Catalog cuts, including complete part number breakdown information.
3. Manufacturer's complete model number.
4. Location of the device.
5. Input - output characteristics.
6. Range, size, and graduations.
7. Physical size with dimensions, NEMA enclosure classification and mounting details.
8. Materials of construction of all enclosures, wetted parts and major components.

9. Instrument or control device sizing calculations where applicable.

10. Certified calibration data on all flow metering devices.

11. Environmental requirements during storage and operation.

12. Associated surge protection devices.

1.07 WIRING AND LOOP DIAGRAMS

A. Submit interconnection wiring and loop diagrams for all panels and signals in the Control and Information System.

B. Electrical interconnection diagrams shall show all terminations of equipment, including terminations to equipment and controls furnished under other Divisions, complete with equipment and cable designations. Where applicable, interconnection wiring diagrams shall be organized by input/output card. Interconnecting diagrams shall be prepared in a neat and legible manner on 11 x 17-inch reproducible prints.

C. Loop drawings shall conform to the latest version of ISA Standards and Recommended Practices for Instrumentation and Control. Loop Drawings shall conform to ISA S5.4, Figures 1-3, Minimum Required Items.

D. Loop drawings shall not be required as a separate document provided that the interconnecting wiring diagrams required in Paragraph B., above, contain all information required by ISA 5.4.

1.08 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall deliver equipment operation and maintenance manuals in compliance with Section 01300 - Submittals. Operation and maintenance (O&M) manuals shall consist of two basic parts:

   1. Manufacturer standard O&M manuals for all equipment and software furnished under this Division.

   2. Custom O&M information describing the specific configuration of equipment and software, and the operation and maintenance requirements for this particular project.

B. The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All modifications to manufacturer standard equipment and/or components shall be clearly identified and shown on the drawings and schematics. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

C. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operation and maintenance personnel unfamiliar with such equipment. The maintenance instructions shall include troubleshooting data and full preventive maintenance schedules. The instructions shall be bound in locking 3-D-ring binders with bindings no larger than 3.5 inches. The manuals shall include 15% spare space for the addition of future material. The instructions shall include drawings reduced or folded and shall provide the following as a minimum.

1. A comprehensive index.
2. A functional description of the entire system, with references to drawings and instructions.
3. A <u>complete</u> "as-built" set of <u>all</u> approved shop drawings, which shall reflect all work required to achieve final system acceptance.
4. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data.
5. Full specifications on each item.
6. Detailed service, maintenance, and operation instructions for each item supplied.
7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
8. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier.
9. References to manufacturers' standard literature where applicable.
10. Warning notes shall be located throughout the manual where such notes are required to prevent accidents or inadvertent misuse of equipment.

D. The operating instructions shall clearly describe the step-by-step procedures that must be followed to implement all phases of all operating modes. The instructions shall be in terms understandable and usable by operating personnel and maintenance crews and shall be useful in the training of such personnel.

E. The maintenance instructions shall describe the detailed preventive and corrective procedures required, including environmental requirements during equipment storage and system operation, to keep the System in good operating condition. All hardware maintenance documentation shall make reference to appropriate diagnostics, where applicable, and all necessary wiring diagrams, component drawings and PCB schematic drawings shall be included.

F. The hardware maintenance documentation shall include, as a minimum, the following information:

1. Operation Information - This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.
2. Preventive-Maintenance Instructions - These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the System.

3. Corrective-Maintenance Instructions - These instructions shall include guides for locating malfunctions down to the card-replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction.

4. Parts Information - This information shall include the identification of each replaceable or field-repairable component. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross-references between equipment numbers and manufacturer's part numbers shall be provided.

G. Software documentation shall conform to a standard format and shall include, but not be limited to, the following:

1. A program abstract that includes:

   a. Program Name - The symbolic alphanumeric program name.

   b. Program Title - English text identification.

   c. Program Synopsis - A brief text shall be provided that specifies the need for the program, states when it shall be used and functionally describes all inputs, outputs and functions performed. This descriptive text shall be written in a language that is understandable by nonsoftware oriented readers.

2. A program description that shall include, but not be limited to, the following:

   a. Applicable Documents - List all documents (standard manufacturer's literature, other program descriptions, etc.) by section, if practical, that apply to the program. One complete copy of all applicable reference material shall be provided.

   b. Input-Output - Identify each input and output parameter, variable, and software element used by the program. State the purpose of all inputs, outputs, and variables.

   c. Processing - This section shall contain a description of the overall structure and function of the program. Describe the program run stream and present a detailed description of how the program operates. Describe the timing and sequencing of operations of the program relative to other programs. Describe all interactions with other programs. Processing logic that is not readily described without considerable background information shall be handled as a special topic with references to an appendix or to control strategy document that details the necessary information. Reference shall also be made to an appendix or control strategy document for equation and program algorithm derivations.

   d. System Configuration - Describe in detail the system configuration or status required for program implementation, if appropriate.

   e. Limitations and Constraints - Summarize all known or anticipated limitations of the program, if appropriate.

f. Storage - Define program storage requirements in terms of disk or RAM memory allocation.

g. Verification - Describe, as a minimum, a test that can be used by the operator to assure proper program operation. Define the required system configuration, input requirements and criteria for successful test completion.

h. Diagnostics - Describe all program diagnostics, where applicable. Descriptions shall list each error statement, indicate clearly what it means, and specify what appropriate actions should be taken.

i. Malfunction Procedures - Specify procedures to follow for recovering from a malfunction due to either operator error or other sources.

1.09 FINAL SYSTEM DOCUMENTATION

A. All documentation shall be delivered to the City prior to final system acceptance in accordance with the Contract Documents. As a minimum, final documentation shall contain all information originally part of the control system submittals.

B. If any documentation or other technical information submitted is considered proprietary, such information shall be designated. Documentation or technical information which is designated as being proprietary will be used only for the construction, operation, or maintenance of the System and, to the extent permitted by law, will not be published or otherwise disclosed.

C. Provide a complete set of detailed electrical interconnection diagrams required to define the complete instrumentation and control system. All diagrams shall be 11 x 17-inch original reproducible prints. All diagrams shall be corrected so as to describe final "as-built" hardware configurations and to reflect the system configuration and control methodology adopted to achieve final system acceptance.

D. Provide system software documentation for the operation and maintenance of all system software programs provided as a part of the digital system. All system software documentation shall be amended as required to delineate all modifications and to accurately reflect the final as-built software configurations.

E. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.

F. Provide control strategy documentation which shall include control strategy block oriented or ladder logic diagrams to describe the control of all processes. Control strategy documentation shall reflect the system configuration and control methodology adopted to achieve final system acceptance. Control strategy documentation shall conform to the submittal requirements listed hereinabove.

G. O&M documentation shall be amended with all final, adjusted values for all setpoints and other operating parameters for City reference.

H. The City recognizes the fact that not all possible problems related to real-time events, software interlocks, and hardware maintenance and utilization can be discovered during the Acceptance Tests. Therefore, the instrumentation subcontractor through the

Contractor shall investigate, diagnose, repair, update, and distribute all pertaining documentation of the deficiencies that become evident during the warranty period. All such documentation shall be submitted in writing to the City within 30 days of identifying and solving the problem.

1.10 PROGRAMS AND SOURCE LISTINGS

A. Provide one copy of all standard, of-the-shelf system and application software (exclusive of firmware resident software) on original media furnished by the software manufacturer.

B. Provide one copy of source listings on optical media for all custom software written specifically for this facility, all database files configured for this facility, and all control strategies. All source listings shall include a program abstract, program linkage and input/output data. Comments describing the program flow shall be frequently interspersed throughout each listing.

1.11 SUBMITTAL/DOCUMENTATION FORMAT

A. All drawing-type submittals and documentation shall be rendered and submitted in the latest version of AutoCAD.

B. All textual-type submittals and documentation shall be rendered and submitted in the latest version of Microsoft Word or in Searchable Adobe Portable Document Format (.pdf).

1.12 ELECTRONIC O&M MANUALS

A. Subject to acceptance by the City and Engineer, the O&M information may be submitted in part or in whole in an electronic format on optical media.

B. Electronic O&M manuals shall contain information in standard formats (Searchable Adobe PDF, Word, AutoCAD, HTML, etc.) and shall be easily accessible through the use of standard, “off-the-shelf” software such as an Internet browser.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 17040

CONTROL AND INFORMATION SYSTEM TRAINING REQUIREMENTS

<u>PART 1 - GENERAL</u>

1.01 THE REQUIREMENT

A. To familiarize the City's personnel with the process control system and field instrumentation, training shall be provided as detailed hereunder.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

1.03 SUBMITTALS

A. A minimum of □0 days prior to beginning training, submit a detailed training plan describing the following:

1. A listing of all courses to be conducted.
2. Course content.
3. Applicability of each course to management, operations, maintenance, laboratory, etc., personnel.
4. Course schedules.
5. Qualifications and experience of individual(s) providing training.

B. A minimum of 14 days prior to beginning each training course, submit documentation for use by the City's personnel during training. The training documentation shall be specific to the particular course, and shall include the following:

1. A listing of all subjects to be covered.
2. Course schedule.
3. Documentation/lesson plans covering all subjects to be covered during the course instruction. Information shall be in a "how to" format, with sufficient background documentation and references to manufacturer literature to provide a thorough and clear understanding of the materials to be covered.

1.04 GENERAL REQUIREMENTS

A. All costs of providing the training courses shall be borne by the Contractor.

B. As used herein, the term "day" shall mean an eight-hour day, and the term "week" shall mean a five-day, 40-hour week.

C. Training courses, especially those for operator training, may be required to be scheduled during non-standard business hours (i.e., not between the hours of 8:00 am and 5:00 pm) to accommodate the working schedule of the City's personnel. No additional compensation will be awarded to the Contractor for training at non-standard hours.

D. All training courses shall complement the experience and skill levels of the City's personnel.

E. Training courses shall be structured in order of increasing capability or security levels. The purpose of this requirement is to allow personnel with lesser training requirements or security password levels to drop out of the training at certain times while the training continues for personnel with greater requirements or higher security levels.

F. All training courses shall include lecture as well as "hands on" experience for each of the attending personnel. The Contractor shall provide sufficient equipment for this to be accomplished. For example, training in which the instructor uses the computer and the City's personnel passively observe as the instructor demonstrates system functions <u>shall not be acceptable</u>.

G. Unless otherwise specified, all training courses shall be conducted in the City's facilities.

H. All training shall be completed prior to system acceptance.

I. Standard manufacturer training courses are acceptable pending approval by the Engineer and City.

1.05 OPERATOR TRAINING

A. One four-hour session for up to ten persons shall be conducted to provide instruction in the use of the Control and Information System to monitor and control the pump station.

B. Operator training shall include familiarization training covering the Control and Information System. Operators shall be instructed in the names, locations, functions, and basic operation of all items of digital equipment and associated software.

C. Operator training shall cover process and equipment operation both individually and collectively as an operating system. Normal as well as abnormal operating conditions shall be covered, including the response to failure occurrences and system alarms. All operator/system interactions shall be described.

D. Operators shall be trained to instruct other operators and shall be provided with all course materials.

1.06 MAINTENANCE TRAINING

A. A 2-hour course shall be conducted for at least six persons prior to the start-up of digital equipment at the City's pump station. Instruction shall be provided in the following:

1. Operating all digital equipment, including system start-up and shutdown procedures.

2. The use of hardware diagnostic routines, test equipment and test procedures as required to enable the City's personnel to detect and isolate system faults to the

circuit board or module level and to implement repairs by replacing failed circuit boards or modules.

3. Calibration and routine maintenance procedures for all analog and digital equipment.

B. Step by step written procedures shall be provided for all preventive maintenance tasks and for identifying hardware faults to the circuit board or module level for all items of digital equipment.

C. All digital equipment preventive and corrective maintenance training activities shall be limited to the use of commercially available off-the-shelf test equipment and to the use of diagnostic routines and hardware items which are the same as those to be provided as part of the system.

1.07 INSTRUMENT TRAINING

A. A 2-hour course shall be provided no more than 30 days prior to system start-up to instruct a minimum of five persons each in the calibration and preventive maintenance of the field instruments provided under this Contract.

B. Instrumentation subcontractor shall perform a live demonstration of the radar level instrument configuration using the manufacturer’s Bluetooth smartphone or tablet app for the City during the instrument training session.

<u>PART 2 - PRODUCTS (NOT USED)</u>

<u>PART 3 - EXECUTION (NOT USED)</u>

END OF SECTION

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SECTION 17050

TOOLS, SUPPLIES AND SPARE PARTS - GENERAL

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall provide tools, supplies, and spare parts as specified herein for the operation and maintenance of the Control and Information System.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Submittals

B. Section 17000 – Control and Information System Scope and General Requirements

PART 2 - PRODUCTS

2.01 TOOLS

A. Provide special tools, other than those normally found in an electronic technician's tool box, required to test, diagnose, calibrate, install, wire, connect, disconnect, assemble and disassemble any digital equipment, instrument, panel, rack, cabinet or console mounted equipment for service and maintenance. This shall include, but not be limited to, the following: connector pin insertion and removal tools, wire crimping tools, special wrenches, special instrument calibrators, indicator lamp insertion and removal tools, etc.

B. Provide tools and test equipment together with items such as instruction manuals, carrying/storage cases, unit battery charger where applicable, special tools, calibration fixtures, cord extenders, patch cords and test leads, which are not specified but are necessary for checking field operation of equipment supplied under this Division.

2.02 SUPPLIES

A. The Contractor shall provide supplies as specifically required in other Sections of Division 17.

2.03 SPARE PARTS

A. Provide spare parts for items of control and instrumentation equipment as recommended by the manufacturer and in accordance with the Contract Documents.

B. Furnish all spares in moisture-proof boxes designed to provide ample protection for their contents. Label all boxes to clearly identify contents and purpose.

C. The Contractor shall replace all spare parts consumed during installation, testing, start-up, the system availability demonstration, and the guarantee period.

D. Refer to individual digital hardware and instrument sections for additional requirements specific to those devices.

PART 3 - E□ECUTION

□NOT USED□

END OF SECTION

SECTION 170□0

SIGNAL COORDINATION RE□UIREMENTS

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall conform to the signal coordination re□uirements specified herein.

B. The Contractor shall □e responsi□le for coordinating signal t□pes and transmission re□uirements □etween the various parties providing e□uipment under this Contract. This shall include, □ut not □e limited to, distri□ution of appropriate shop drawings among the e□uipment suppliers, the electrical su□contractor and the instrumentation su□contractor.

C. Analog signals shall □e signals for transmitting process varia□les, etc. from instruments and to and from panels, e□uipment PLC□s and Control S□stem PLC□s.

D. Discrete signals shall consist of contact closures or powered signals for transmitting status/alarm information and control commands □etween starters, panels, e□uipment PLC□s, the Control S□stem, etc.

1.02 ANALOG SIGNAL TRANSMISSION

A. Signal transmission □etween electric or electronic instruments, controllers, and all e□uipment and control devices shall □e individuall□ isolated, linear 4-20 milliamperes and shall operate at 24 volts D.C.

B. Signal output from all transmitters and controllers shall □e current regulated and shall not □e affected □□ changes in load resistance within the unit□s rating.

C. All ca□le shields shall □e grounded <u>at one end onl□</u>, at the control panel, with terminals □onded to the panel ground □us.

D. Analog signal isolation and/or conversion shall □e provided where necessar□ to interface with instrumentation, e□uipment controls, panels, and appurtenances.

E. Non-standard transmission s□stems such as pulse duration, pulse rate, and voltage regulated shall not □e permitted e□cept where specificall□ noted in the Contract Documents. Where transmitters with nonstandard outputs do occur, their outputs shall □e converted to an isolated, linear, 4-20 milliampere signal.

F. The Contractor shall provide 24 V power supplies for analog signals and instruments where applica□le and as re□uired inside panels, controls, etc.

G. Where two-wire instruments transmit directl□ to the Control and Information S□stem, the instrumentation su□contractor shall provide power supplies at the PLC-e□uipped control panels for those instruments.

H. Where four-wire instruments with on-□oard loop power supplies transmit directl□ to the Control and Information S□stem, the instrumentation su□contractor shall provide necessar□ signal isolators or shall otherwise isolate the input from the Control and Information S□stem loop power suppl□. Similar provisions shall □e made when a third element such as a recorder, indicator, or single loop controller with integral loop power suppl□ is included in the loop.

1.03 DISCRETE INPUTS

A. All discrete inputs to e□uipment and Control and Information S□stem PLC□s, from field devices, starters, panels, etc., shall □e unpowered □dr□□ contacts in the field device or e□uipment, powered from the PLC□s, unless specified otherwise.

B. Sensing power □wetting voltage□ supplied □□ the PLC shall □e 24 VDC.

1.04 DISCRETE OUTPUTS

A. All discrete outputs from local control panels and Control and Information S□stem PLC□s to field devices, starters, panels, etc., shall □e 24 VDC powered □sourced□ from PLC□s.

B. PLC powered discrete outputs shall energize 24 VDC pilot rela□ coils in the field devices, starters, panels, etc. which in turn open or close contacts in the associated control circuit. The 24 VDC rela□ coil, contacts, and associated control circuitr□ shall □e furnished integral with the field device, starter, panel, etc. □□ the supplier and contractor furnishing the field device, starter, or panel.

C. Where re□uired or specified herein, discrete outputs from e□uipment and Control and Information S□stem PLC□s to field devices, starters, panels, motor operated valves, etc., shall □e dr□ contact or rela□ outputs.

D. Outputs to solenoid valves shall □e 120 VAC, powered from the PLC or control panel unless specified or shown otherwise.

1.05 OTHER DISCRETE SIGNALS

A. Discrete signals □etween starters, panels, etc. where no 24 VDC power suppl□ is availa□le ma□ □e 120 VAC, as long as such contacts are clearl□ identified in the starter, panel, etc. as □eing powered from a different power suppl□ than other starter/panel components.

B. Where applica□le, warning signs shall □e affi□ed inside the starter, panel, etc. stating that the panel is energized from multiple sources.

C. Output contacts in the starter, panel, etc., that are powered from other locations shall □e provided with special tags and/or color-coding. Disconnecting terminal strips shall □e provided for such contacts.

D. The a□ove re□uirements shall appl□ to all starters and panels, regardless of supplier.

PART 2 - PRODUCTS

2.01 PILOT RELA□S

A. Pilot rela□s shall □e supplied with the following:

1. 24 VDC or 120 VAC coils, as re□uired.
2. At a minimum, DPDT contacts rated at 5 A, 120 VAC or 28 VDC.
3. Sockets for 24 VDC and 120 VAC rela□s shall □e of different configurations.
4. Clips for attachment to sockets.
5. Indicator lights that glow when the rela□coil is powered.

B. Pilot rela□s shall □e as manufactured □□S□uare D, Allen Bradle□, Potter □ Brumfield, or e□ual.

PART 3 - E□ECUTION □NOT USED□

END OF SECTION

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SECTION 17070

CONTROL AND INFORMATION SYSTEM TESTING - GENERAL

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall test the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17071 – Factory Acceptance Test

C. Section 17072 – Field Testing

D. Section 17073 – Final Acceptance Test

1.03 SUBMITTALS

A. For each of the specified tests, submit a test plan to the Engineer at least one month in advance of commencement of the tests. The test plan shall contain the following at a minimum:

1. A schedule of all testing to be conducted.
2. A brief description of the testing to be performed
3. Test objectives.
4. Testing criteria per the Specifications.
5. Check lists and procedures for performing each of the specified tests.
6. Sample test result documentation.
7. Requirements for other parties.

1.04 GENERAL REQUIREMENTS

A. All system start-up and test activities shall follow detailed test procedures, check lists, etc., previously approved by the Engineer. The Engineer shall be notified at least 21 days in advance of any system tests and reserves the right to have his and/or the City's representatives in attendance.

B. The Contractor shall provide the services of experienced factory trained technicians, tools and equipment to field calibrate, test, inspect, and adjust all equipment in accordance with manufacturer's specifications and instructions.

C. The Contractor (or designee) shall maintain master log books for <u>each</u> phase of installation, startup and testing activities specified herein. Each log book shall include signal, loop or control strategy tag number, equipment identification, description and space for sign-off dates, Contractor signature and Engineer signature. Example test documentation specific to each phase of testing shall be approved prior to initiation of that testing, as specified hereinabove.

D. All test data shall be recorded on test forms, previously approved by the Engineer. When each test has been successfully completed, a certified copy of all test results shall be furnished to the Engineer together with a clear and unequivocal statement that all specified test requirements have been met and that the system is operating in accordance with the Contract Documents.

E. The Engineer will review test documentation in accordance with the Contract Documents and will give written notice of the acceptability of the tests within 10 days of receipt of the test results.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 17071

FACTORY ACCEPTANCE TEST

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall perform a Factory Acceptance Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17070 – Control and Information System Testing, General

C. Section 17072 – Field Testing

D. Section 17073 – Final Acceptance Test

1.03 FACTORY ACCEPTANCE TEST

A. The Control and Information System equipment shall not be shipped until the Contractor receives notice of acceptability of the factory tests.

B. Each item of equipment shall be fully factory inspected, calibrated and tested for function, operation and continuity of circuits. Exceptions shall be approved in writing by the Engineer.

C. Each subsystem shall be fully factory tested for function and operation.

D. System performance shall be tested using a fully integrated system, including all software and hardware. To achieve this, the entire control system, including all peripheral devices and all interconnecting cables (field instruments are not included in this requirement), shall be assembled on the factory test floor and the complete operational program loaded and simulated inputs applied.

E. All hardware and software required to perform the specified testing shall be furnished by the Contractor at no additional cost to the City.

F. The instrumentation subcontractor shall perform a 100-hour full system test, during which the entire system shall operate continuously without failure in accordance with the requirements of the Contract Documents. If a system component fails during the test, the 100-hour test period shall be restarted after its operation is restored.

G. The factory testing shall demonstrate all aspects of system sizing and timing including:

1. Monitoring and control scan times at the PLC level.

2. Response times at the operator workstation level.

H. The overall system as well as individual component hardware shall be tested under conditions of power failure to ensure proper response as specified herein.

I. Operator Workstation Operation - This demonstration shall provide proof of system operation on an individual subsystem basis first, and then in the expected operating environment. Both normal and abnormal operating modes shall be demonstrated. Operator workstation testing shall include the following:

1. Demonstrate proper operation, under both normal and abnormal conditions of the operator workstation application software (SCADA, remote alarm dial-up, etc.). This shall include demonstration of system on-line diagnostics, fail-over features, reconfiguration operations, system initialization and restart, software fault tolerance, error detection and recovery, communications, and all additional features necessary to assure the successful operation of the system.

2. Demonstrate the standard features of the system. This shall include proof of operation of the process control database generator, the display generator, data storage and retrieval functions, data acquisition and control, trending functions, and reporting functions.

3. Demonstrate the configuration of the system to verify conformance with the Contract Documents. This shall include graphic displays and vectoring, operator interface functions, trending, reports, alarm management, security system configuration, etc.

4. The system shall be operated with data input/output with the PLC's and associated panels to prove operation of all workstation functions.

5. The testing in Items 2 and 3 above may be performed concurrently (i.e., the standard and configured features of the system may be demonstrated simultaneously).

J. PLC Operation - All functions comparable to those demonstrated for the operator workstations shall be demonstrated on the PLC's. This shall include the following:

1. On-line and off-line diagnostics.

2. For redundant units, fail-over operation and reconfiguration.

3. System initialization and restart.

4. Network communications, including fieldbus communications where required.

5. Non-volatility of memory.

6. Operation of all control logic shall be demonstrated as described herein.

K. Process I/O Simulation - Process input/output simulation for PLC's shall be performed with a manual simulation control panel, a separate programmable logic controller, network-based simulation software, analog signal generators, and/or jumpering of discrete signals between outputs and associated inputs, or some combination of these. Alternate process I/O systems such as plug-in circuit cards or I/O test modules may be utilized subject to approval by the Engineer to provide the specified simulation functions. The simulation system shall provide analog and discrete I/O hardware devices in sufficient quantity to allow complete and thorough testing of the control strategies and functions of the system. The process I/O simulation system shall be used in several ways as follows:

1. To provide a means of communications checkout from the operator workstations through the various levels of software in the PLC's and to the process, i.e., the simulation panel. Likewise, a discrete or analog input shall be initiated from the simulation panel and the result monitored at the workstations.
2. Alarm response to discrete status changes or analog value limits shall be verified. Database entries or attributes such as engineering units and conversion equations shall be verified by varying analog inputs.
3. To provide data for use at all levels of the control system at the time of system integration.

L. Control Strategy Testing - Provision shall be made to test all control strategies to prove the integrity of each strategy and the process control language in which it is implemented. For each control strategy, all functions shall be tested individually (where possible) and collectively to verify that the control strategy performs as described herein and as required for overall functionality within the control system.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

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SECTION 17072

FIELD TESTING

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall perform field testing on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17070 – Control and Information System Testing, General

C. Section 17071 – Factory Acceptance Test

D. Section 17073 – Final Acceptance Test

1.03 GENERAL REQUIREMENTS

A. Control system start-up and testing shall be performed to ensure that all plant processes shall be systematically and safely placed under digital control in the following order:

1. Primary elements such as transmitters and switch devices shall be calibrated and tested as specified in Sections 17□00, 17700, and 17800.
2. Each final control element shall be individually tested as specified hereinafter.
3. Each control loop shall be tested as specified hereinafter.
4. Each control strategy shall be tested under automatic digital control as specified hereinafter.
5. The entire control system shall be tested for overall monitoring, control, communication, and information management functions, and demonstrated for system availability as specified hereinafter.

B. System start-up and test activities shall include the use of water, if necessary, to establish service conditions that simulate, to the greatest extent possible, normal operating conditions in terms of applied process loads, operating ranges and environmental conditions.

C. Each phase of testing shall be fully and successfully completed and all associated documentation submitted and approved prior to the next phase being started. Specific exceptions are allowed if written approval has been obtained in advance from the Engineer.

1.04 CONTRACTOR'S RESPONSIBILITIES

A. The Contractor shall ensure that all mechanical equipment, equipment control panels, local control panels, field instrumentation, control system equipment and related equipment and/or systems are tested for proper installation, adjusted and calibrated on a loop-by-loop basis prior to control system startup to verify that each is ready to function as specified. Each test shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

B. The Contractor shall be responsible for coordination of meetings with all affected trades. A meeting shall be held each morning to review the day's test schedule with all affected trades. Similarly, a meeting shall be held each evening to review the day's test results and to review or revise the next day's test schedule as appropriate.

C. The Contractor shall ensure that the electrical subcontractor conforms to the start-up, test and sign-off procedures specified herein to assure proper function and coordination of all motor control center control and interlock circuitry and the transmission of all discrete and/or analog signals between equipment furnished by the electrical subcontractor and the control system specified herein.

D. The Contractor shall ensure that the HVAC subcontractor conforms to the start-up, test and sign-off procedures specified herein to assure proper function of all HVAC system control and interlock circuitry and the transmission of all discrete and/or analog signals between HVAC equipment and controls and the control system specified herein.

1.05 FINAL CONTROL ELEMENT TESTING

A. The proper control of all final control elements shall be verified by tests conducted in accordance with the requirements specified herein.

B. All modulating final control elements shall be tested for appropriate speed or position response by applying power and input demand signals, and observing the equipment for proper direction and level of reaction. Each final control element shall be tested at 0, 25, 50, 75, and 100 percent of signal input level and the results checked against specified accuracy tolerances. Final control elements, such as VFD's, that require turndown limits shall be initially set during this test.

C. All non-modulating final control elements shall be tested for appropriate position response by applying and simulating control signals, and observing the equipment for proper reaction.

1.06 LOOP CHECKOUT

A. Prior to control system startup and testing, each monitoring and control loop shall be tested on an individual basis from the primary element to the final element, including the operator workstation or loop controller level, for continuity and for proper operation and calibration.

B. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses. Simulated input data signals may be used subject to prior written approval by the Engineer. All modes of control shall be exercised and checked for proper operation.

C. The accuracy of all DAC's shall be verified by manually entering engineering unit data values at the operator workstation and then reading and recording the resulting analog output data.

D. The accuracy of all ADC's shall be verified using field inputs or by manually applying input signals at the final controller, and then reading and recording the resulting analog input data at the operator workstation.

E. Each loop tested shall be witnessed, dated and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

1.07 CONTROL SYSTEM STARTUP AND TESTING

A. Control system startup and testing shall be performed to demonstrate complete compliance with all specified functional and operational requirements. Testing activities shall include the simulation of both normal and abnormal operating conditions.

B. All digital hardware shall be fully inspected and tested for function, operation and continuity of circuits. All diagnostic programs shall be run to verify the proper operation of all digital equipment.

C. Final control elements and ancillary equipment shall be tested under start-up and steady-state operating conditions to verify that proper and stable control is achieved using local area control panels, motor control center circuits, and local field mounted control circuits. All hardwired control circuit interlocks and alarms shall be operational. The control to final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits.

D. Signals from transducers, sensors, and transmitters shall be utilized to verify control responses for final control elements. Simulated input data signals may be used subject to prior written approval by the Engineer.

E. Each control strategy shall be tested to verify the proper operation of all required functions. The control system start-up and test activities shall include procedures for tuning all control loops incorporating PID control modules, and for adjusting and testing all control loops as required to verify specified performance.

F. The control system start-up and test activities shall include running tests to prove that the Instrumentation, Control and Information System is capable of continuously, safely and reliably regulating processes, as required by the Contract, under service conditions that simulate, to the greatest extent possible, normal plant operating ranges and environmental conditions.

G. A witnessed functional acceptance test shall be performed to demonstrate satisfactory performance of individual monitoring and control loops and control strategies. At least one test shall be performed to verify that the control and instrumentation system is capable of simultaneously implementing all specified operations.

H. Each loop and control strategy test shall be witnessed and signed off by both the Contractor (or designee) and the Engineer upon satisfactory completion.

1.08 FACILITY STARTUP COORDINATION

A. Facility start-up shall comply with requirements specified in the Contract Documents and those requirements specified herein. Facility start-up shall commence after all previously described start-up and test activities have been successfully completed and shall demonstrate that the Instrumentation, Control and Information System can meet all Contract requirements with equipment operating over full operating ranges under actual operating conditions.

B. The control system start-up period shall be coordinated with process startup activities and shall be extended as required until all plant processes are fully operational and to satisfy the Engineer that all control system Contract requirements have been fulfilled in accordance with the Contract Documents.

C. The instrumentation subcontractor's personnel shall be resident at the facility to provide both full time (eight hours/day, five days/week) and 24 hours on call (seven days/week) support of operating and maintenance activities for the duration of the start-up period.

D. At least one qualified control systems technician shall be provided for control system startup and test activities (at least two when loop checkout is being performed).

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

SECTION 17073

FINAL ACCEPTANCE TEST

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall perform the Final Acceptance Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17070 – Control and Information System Testing, General

C. Section 17071 – Factory Acceptance Test

D. Section 17072 – Field Testing

1.03 AVAILABILITY DEMONSTRATION AND FINAL SYSTEM ACCEPTANCE

A. Upon completion of all control system startup activities and prior to final system acceptance, the Contractor shall demonstrate that the availability of the entire control system, including operation under conditions of digital equipment fail-over, initiated either automatically or manually, shall be not less than 99.8 percent during a 30-day availability test period. The City shall be given two (2) weeks notice of the starting date of the 30-day availability test.

B. For purposes of determining availability figures, downtime of each system or portions of each system resulting from the causes specified hereunder will not be considered system failures.

1. Downtime of any network-connected device that is automatically backed-up upon failure shall not be considered a system failure provided that the downtime of the failed component does not exceed 24 hours.

2. Downtime of a PLC that is not automatically backed-up shall be considered a system failure if the downtime of the failed controller exceeds one (1) hour.

3. Downtime of a portion of the system resulting from failure of any field sensor shall not be considered a system failure provided that the system operates as specified under this condition.

4. Downtime of the following devices shall not be considered a system failure provided the failed device is repaired within the specified time:

   a. Hard disc (one day)

   b. Workstations (one day)

   c. Communication interfaces (eight hours)

d. Printer (three days)

e. Process control system networks (eight hours)

f. Off-line (optical, etc.) storage units (one day)

g. UPS unit (one day)

5. Total shutdown of a single PLC resulting from a software fault shall be considered a system failure.

6. An erroneous command to the process that can be specifically related to a software fault shall be considered as one (1) hour of downtime.

7. The inoperability of any subsystem resulting from a software fault shall be considered a system failure.

8. The failure of the same component more than one time during the 30-day test shall be considered a system failure.

C. If the system fails the 30-day availability test, the 30-day test period shall be restarted after the failed component or software is repaired/replaced and full operation is restored. The system shall be demonstrated for the full 30-day period following the restart.

D. The Contractor shall submit an availability demonstration report that shall state that all system availability requirements have been met.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

SECTION 17080

QUALITY ASSURANCE

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. It is the intent of these Specifications and Drawings to secure high quality in all materials, equipment and workmanship in order to facilitate operations and maintenance of the facility. The Contractor shall provide equipment and services to meet this intent.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. All work shall be installed in accordance with the National Electric Code, National Electric Safety Code, OSHA, State, local and other applicable codes.

1.03 QUALITY ASSURANCE - GENERAL

A. All equipment and materials shall be new and the products of reputable recognized suppliers having adequate experience in the manufacture of these particular items.

B. For uniformity, only one manufacturer will be accepted for each type of product.

C. All equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for all stresses that may occur during fabrication, transportation, and erection as well as during continuous or intermittent operation. They shall be adequately stayed, braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.

D. All components and devices installed shall be standard items of industrial grade, unless otherwise noted, which shall be of sturdy and durable construction and be suitable for long, trouble-free service.

E. Electronic components shall be de-rated to assure dependability and long-term stability.

F. Printed circuit boards in field mounted equipment shall be suitable for the specified environmental conditions.

G. Alignment and adjustments shall be non-critical, stable with temperature changes or aging and accomplished with premium grade potentiometers.

H. Components of specially selected values shall not be inserted into standard electronic assemblies in order to meet the performance requirements of this specification.

1.04 OPTIONAL EQUIPMENT

A. Optional or substituted equipment or both requiring changes in details or dimensions required to maintain all structural, mechanical, electrical, control, operating, maintenance or design features incorporated in these Specifications and Drawings shall be made at no additional cost to the City. In the event that the changes are necessary, calculations and drawings showing the proposed revisions shall be submitted for approval. The Contractor shall coordinate all changes with other affected trades and contracts and pay all additional charges incurred.

1.05 GUARANTEE

A. The instrumentation subcontractor through the Contractor shall install, maintain and guarantee the Instrumentation, Control and Information System as specified under the General Conditions and Division 1 of the Specifications. Maintenance personnel provided by the instrumentation subcontractor shall instruct the City's personnel in the operation, adjustment, calibration and repair of the equipment being serviced. All preventive and corrective activities shall be documented with service reports, which shall identify the equipment being serviced, state the condition of the equipment, describe all work performed and list materials used. A copy of all service reports shall be delivered to the City on the day the work is performed.

B. The instrumentation subcontractor shall provide the services of factory-trained service technician(s) at least twice during the guarantee period, for the purpose of performing preventive hardware maintenance.

C. Corrective hardware and software maintenance during the guarantee period shall be performed in accordance with the requirements of Division 1 and, in addition, shall meet the following requirements:

1. Corrective hardware maintenance shall be performed by factory-trained service technician(s) specifically trained to service the digital equipment provided. Technicians possessing suitable training and experience shall be provided to perform corrective maintenance on all other equipment. The hardware service technician(s) shall be available on-site within 24 working hours after notification by the City.

2. Corrective software maintenance shall be performed for software provided by the instrumentation subcontractor and incorporated into the system prior to the completion of system commissioning. Software service programmer(s) shall be available for consultation within four business hours and, if required, on-site within 1[illegible] business hours after notification by the City. Corrective software maintenance shall include the supply, installation and startup of all application software upgrades released during the guarantee period.

3. Corrective hardware and software maintenance performed during the guarantee period shall be performed at no cost to the City.

4. As used herein, the term "working hours" shall be defined as those of the treatment facility (seven days per week, 24 hours per day). The term "business hours" shall be defined as the hours between 8:00 a.m. and 5:00 p.m., local time, Monday through Friday, excluding holidays.

5. The guarantee period shall commence upon final acceptance of the completed treatment facility in accordance with the provisions of the Contract Documents.

D. The instrumentation subcontractor shall submit to the City a proposed maintenance agreement incorporating the following features:

1. Extension of preventive hardware maintenance services as described above for a period of up to five years from the expiration of the warranty period.

2. Provisions for corrective hardware and/or software maintenance work on a will-call basis for a period of up to five years from the expiration of the warranty period. Corrective maintenance work shall be performed by properly trained personnel as described above.

E. The proposed agreement shall include provisions for payment based upon an annual fee for preventive maintenance and cost plus expenses for corrective maintenance work. The portion dealing with corrective maintenance shall be written to include corrective maintenance caused by actions of the City during the warranty period and shall contain clauses for re-negotiation of contract prices based upon changes in recognized economic indicators published by the United States Department of Commerce.

1.06 SHIPPING HANDLING AND STORAGE

A. In addition to shipping, handling and storage requirements specified elsewhere in the Contract Documents, air conditioning/heating shall be provided for storage of all field instrumentation, panels, digital equipment and ancillary devices to maintain temperatures between 20 and 25 degrees C and relative humidity 40 to 60 percent without condensation. The air shall be filtered and free of corrosive contaminants and moisture.

1.07 FABRICATION

A. Fabrication of all equipment shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.

B. The Engineer may inspect the fabricated equipment at the factory before shipment to job site. The Contractor shall provide the Engineer with sufficient prior notice so that an inspection can be arranged at the factory. Inspection of the equipment at the factory by the Engineer will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.

C. Equipment approval at the factory only allows the equipment to be shipped to the project site. The Contractor shall provide for the proper storage, installation and satisfactory start-up and operation of the equipment to the satisfaction of the equipment manufacturer, the instrumentation subcontractor, and the Engineer.

1.08 INSTALLATION

A. All instrumentation and control system installation work, whether new construction or modifications to existing equipment/panels/structures, shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.

B. The instrumentation subcontractor shall assign a competent representative who shall provide full time coordination and supervision of all on-site instrumentation and control system construction work from commencement of construction through completion and final acceptance.

C. All labor shall be performed by qualified craftsmen in accordance with the standards of workmanship in their profession and shall have had a minimum of three years of documented experience on similar projects.

D. All equipment and materials shall fit properly in their installations. Any required work to correct improperly fit installations shall be performed at no additional expense to the City.

E. All work shall be performed in a neat and workmanlike manner. All hardware and instrumentation shall be installed in accordance with requirements specified herein, in accordance with industry best practices, in accordance with manufacturers' recommendations, and in a manner suitable for ease of operation, inspection, and maintenance. All wiring shall be neatly bundled, run in wireway, and terminated. All spare wiring shall be neatly coiled and clearly labeled at both ends for future use by the City. Any work not meeting these requirements shall be corrected at no expense to the City.

F. Sufficient common-mode and differential-mode noise rejection shall be provided to insure operation of the plant process control system to meet all specification requirements. General practice shall include:

   1. Maintaining crossings between noisy wires and signal wires at right angles.
   2. Maintaining separation between noisy wires and signal wires as wide as practical.
   3. Grounding all signals, shields and power supplies at the process control unit or local control panel.
   4. Providing passive filters on signals with time constant compatible with scan intervals and overvoltage protection.
   5. Eliminating cable splices. All splices in instrumentation and control system signal and network cables shall be approved in advance by the Engineer.
   6. Providing a floating output for transmitters that have their own power sources.

G. DC and AC power grounding shall be performed in accordance with the digital hardware manufacturer's recommendations as well as all applicable code requirements.

H. The case of each field instrument and control panel shall be grounded in compliance with the National Electric Code.

I. Power wires shall be separated from parallel-running signal wires by the following minimum spacing:

CIRCUIT VOLTAGE (VAC)	MINIMUM SPACING (IN.)
120	12
240	18
480	18
2000 and above	24

J. The Contractor shall provide all required cutting, drilling, inserts, supports, bolts, and anchors, and shall securely attach all equipment and materials to their supports. Embedded supports for equipment furnished under this Division shall be provided and installed as shown specified herein and shown on the Drawings.

K. Following acceptance of the factory tests by the Engineer, and in accordance with the construction schedule, the Contractor shall commence installation of the digital control system hardware. Digital system equipment items shall not be installed, however, until all architectural, mechanical, HVAC and electrical work has been completed in the equipment rooms, MCC's, control rooms and all structural and/or mechanical work has been completed within 50 feet of equipment locations.

L. Upon completion of the above construction work, the Contractor shall request an inspection of the above-named areas. The Engineer will issue a written approval to proceed with delivery and installation only after being satisfied that all work described above has been properly performed. Digital equipment shall remain at the factory site or storage prior to approval for delivery to the project site. Partial shipments may be required to meet construction schedule requirements.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

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SECTION 17100

CONTROL AND INFORMATION SYSTEM HARDWARE, GENERAL

PART 1 - GENERAL

1.01 THE REQUIREMENT

The process control system is physically and functionally distributed between PLC equipped control panels, motor control panels, field panels, operator workstations and appurtenances.

A. Although manual control facilities shall be provided adjacent to each final control element or in local control panels, such facilities are for testing, maintenance and local monitoring purposes only and shall not be regarded as backup to the PLC-based control system.

B. PLCs may be categorized as either “process PLCs” that are provided by the instrumentation subcontractor or “equipment control PLCs” provided by equipment manufacturers for the operation of their equipment (Blowers, centrifuges, chemical systems, filters, etc.). Unless otherwise specified, all PLCs provided under this Contract shall conform to the requirements specified in this Division.

C. Major plant control system digital equipment items are described in the Specifications and shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17120 – Programmable Logic Controllers

1.03 DIGITAL HARDWARE CONFIGURATIONS

A. The digital hardware configuration shown on the Control System Architecture Drawing depicts overall system configuration requirements. System design shall be based upon this concept and shall provide an overall digital system availability of 99.8 percent under the conditions specified in Section 17073. Unless otherwise specified, designs that vary from this concept will be rejected.

B. All discrete and analog data acquisition, pre-processing, storage and process control functions shall be performed at the PLC level. Run time and flow accumulations shall be performed at the PLC level. Except for minimal calculations related to report-specific functions such as minimum, maximum, average, etc., operator workstations shall not be used to perform calculation for the process control system. Operator workstations shall be fully independent devices, individually connected to the plant control system networks.

C. No other exceptions will be considered.

PART 2 - PRODUCTS

2.01 GENERAL SYSTEM HARDWARE REQUIREMENTS

A. Unless otherwise specified, all hardware shall be rated for industrial use, resistant to shock, vibration, electromagnetic interference, static discharge, and suitable for the environmental conditions described elsewhere in this Division. Commercial or office grade equipment shall not be accepted.

B. Unless otherwise specified, modular construction shall be employed to simplify maintenance and to provide for future hardware expansion. Plug-in, modular PCB's or modules shall be employed for easy removal to permit exposure of circuit wiring, components and test points. Extender boards shall be provided if necessary to permit PCB's to be completely exposed for testing purposes.

C. Keying schemes shall be used to prevent PCB misplacement.

D. The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature.

2.02 DIGITAL SYSTEM FAILURE DETECTION AND FAIL-OVER REQUIREMENTS

A. No degradation in control system performance shall occur when the system is operating in a partial failure or an equipment fail-over mode. Likewise, no degradation of system performance shall occur while a backed up system component is undergoing preventive or corrective maintenance.

B. All devices connected to the plant control system network shall be self-checking and shall report their operational status to the operator workstations as either "normal" or "failed". A graphic display based on the system architecture drawing shall be furnished with the control and information system showing this information along with current communication status of each device.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17000, Part 3.

END OF SECTION

SECTION 17120

PROGRAMMABLE LOGIC CONTROLLERS

<u>PART 1 - GENERAL</u>

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation all programma□le logic controllers, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 170□0 – Signal Coordination Re□uirements

C. Section 17100 – Control and Information S□stem Hardware - General

D. Section 17125 – Operator Interface Units

E. Section 17170 – Mo□ile Workstation Computer □Laptop PC□

F. Section 17190 – Uninterrupti□le Power S□stems

G. Section 17500 – Enclosures, General

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall □e provided as specified in Section 17050 - Tools, Supplies, and Spare Parts. In addition, the following specific spare parts items shall □e provided:

1. One of each t□pe and size of module for PLC e□uipment furnished under this Contract.

2. One of each t□pe and size of PLC and e□uipment power suppl□furnished under this Contract.

<u>PART 2 - PRODUCTS</u>

2.01 PROGRAMMABLE LOGIC CONTROLLERS - GENERAL

A. The instrumentation su□contractor shall furnish programma□le controllers □PLC□s□as specified herein and as shown on the Drawings. PLC□s shall □e provided complete with □ackplane, power suppl□, I/O cards, special function cards, instructions, memor□, input/output capacit□, and appurtenances to provide all features and functions as descri□ed herein. No su□stitutions will □e permitted.

B. All components of the PLC s□stem shall □e of the same manufacturer□who shall have full□tested units similar to those □eing furnished in an industrial environment with associated electrical noise. The PLC system shall have been tested to meet the requirements of NEMA Standard ICS 2-230 (Arc Test) and IEEE C37.90.1 (SWC). The processing unit shall perform the operations functionally described herein based on the program stored in memory and the status of the inputs and outputs.

C. Programmable controllers shall be designed to operate in an industrial environment. The PLC shall operate in an ambient temperature range of 0-60°C and a relative humidity of 5-95 percent, non-condensing. The PLC shall operate on supply voltages of 90-132 VAC at 47-63 Hz or 24 VDC if provided with a battery backup system. An integral fuse shall be provided on the power supply for short circuit protection and shall be front panel accessible. Integral overcurrent and undervoltage protection shall be provided on the power supply.

D. Where applicable, the minimum PLC backplane size shall be 7 slots, not including power supply slots.

E. System configuration shall be as shown on the Control System Architecture Drawing. PLC types shall be designated on the System Block Diagram Drawing and correspond to the specifications herein. Only a single type of processor shall be supplied for all PLCs of a designated type. **Memory and processor shall be adequate for all control functions specified.** PLCs shall be as manufactured or equal to the following:

   1. Allen-Bradley CompactLogix with 5380 processor Catalog Number 5069-L306ER with 5000 series I/O modules as manufactured by Rockwell Automation, no substitution or exceptions.

2.02 PROCESSORS

A. The processor and its associated memory shall be enclosed in a modular enclosure. A multiple-position selector switch or equivalent shall be used to select processor operating mode. LED-type indicating lights shall be provided to indicate processor, memory, and battery status. Errors in memory shall be recognized and shall activate the memory error indicating lights. The PLC processor shall monitor the internal operation of the PLC for failure and provide an alarm output. Nonvolatile memory in the form of a manufacturer supplied industrial CompactFlash card or equivalent technology shall be required to maintain the entire current program and firmware of the controller in the event of power loss. The program shall be updated onto the flash memory each time a program change such as an online edit or tag value is changed. When nonvolatile memory (flash memory) is not available for certain controller models as offered by the PLC manufacturer, lithium batteries shall be used to maintain process RAM memory for at least one year in the event of power loss. The lithium battery unit shall be an externally mounted battery assembly with the highest available capacity. The PLC shall send an alarm to the plant control system if battery level is low.

B. The instruction set for the PLC shall conform to the requirements of IEC 61131-3. Each PLC shall have the capability to run all five of the standard IEC 61131-3 languages simultaneously. These five languages shall be:

   1. Ladder Diagram

   2. Structured Text

3. Instruction List
4. Function Block Diagram
5. Sequential Function Chart

C. Additional co-processors or modules may be necessary and shall be furnished as required to meet the functions specified herein and in Section 17950 – Functional Control Descriptions.

D. PLC processors shall be provided with substantial user program, data and logic memory to allow for future expansion of the overall system. The total memory used on each processor shall be less than 60% of available memory at project completion.

2.03 COMMUNICATIONS

A. PLC communications shall be as shown on the Control System Architecture Drawing.

B. In addition to a communications port for the control system network, communication ports shall be provided for any other devices required (i.e., operator interface unit) plus an additional communication port for connection to a notebook computer.

C. The PLC shall be able to support various types of fieldbus communication systems for data links to field instruments (where specified) in addition to connected equipment such as power monitors, VFDs, motor protection monitors, etc. As a minimum, Profibus DP, Foundation Fieldbus, Modbus RTU Master and Slave, TCP/IP Ethernet shall be supported. The Contractor shall coordinate the efforts of the necessary parties (instrumentation subcontractor and equipment suppliers) to accomplish the required device and data table addressing between each PLC and the associated connected equipment.

D. Additional communication modules or protocol gateways may be required to support specific communication protocols required under this Contract, and shall be supplied at no extra cost to the City.

2.04 INPUT/OUTPUT SUBSYSTEMS

A. Input/output hardware shall be plug-in modules in associated I/O backplane/chassis or DIN-rail mounting assemblies. Each unit shall handle the required number of process inputs and outputs plus a minimum of 10 percent active pre-wired spares for each I/O type furnished, plus a minimum of 20 percent spare I/O module space for the addition of future circuit cards or modules.

B. Discrete inputs shall be 24 VDC or 120 VAC signals (integral to the PLC) from dry field contacts. Discrete outputs shall be 24 VDC or 120 VAC outputs sourced from the PLC, or dry relay contacts (2A minimum) as required. Refer to Section 17060 – Signal Coordination Requirements for further details of discrete signal type and voltage requirements. The PLC shall provide momentary and latched outputs as required to interface with motor controls and external devices. Interposing relays shall be provided where required to interface with field equipment. Interposing relays shall be as specified in Section 17550. Electrical isolation shall be provided where required.

Ma□imum densit□ for discrete I/O modules shall □e 32 per input module and 1□ per output module.

C. Analog input circuits shall □e isolated, minimum 1□-□it resolution t□pe. Analog input hardware shall □e provided as re□uired for all t□pes of analog inputs □eing transmitted to the PLC. In general, analog input modules shall □e capa□le of receiving 4-20 mA signals. Where re□uired, RTD input modules shall have a minimum resolution of 0.15□C and □e capa□le of accepting signals from 100-ohm Platinum RTD's. Analog outputs shall □e coordinated with the receivers □ut shall generall□ □e isolated 24 VDC 4-20 mA outputs powered from the PLC. Each input/output circuit shall have optical isolation to protect the e□uipment against high voltage transients. Optical isolation shall □e rated at not less than 1500 V RMS. Lightning/surge protection shall □e provided as specified in Section 175□0 - Surge Protection Devices. Ma□imum densit□ for analog I/O modules shall □e 8 per module.

D. Input/output modules shall □e configured for ease of wiring and maintenance. The modules shall □e connected to wiring arms that can □e disconnected to permit removal of a module without distur□ing field wiring. Covers shall □e provided to prevent operator personnel from inadvertentl□ touching the terminals. The process interface modules shall □e provided with screw-t□pe terminal □locks with □arriers □etween ad□acent terminals for connection of field inputs. Terminals shall □e suita□le for accepting up to and including No. 14 AWG wire. All DC output circuits to the field shall include fuses, either integral or at the terminal strip. Output failure mode shall □e selecta□le so that upon station or communication s□stem failure all outputs shall □e placed either in the non-conducting mode, or remain as were prior to failure. Light-emitting diodes shall □e provided for status indication for each input and output point.

E. E□ternal power supplies shall □e provided with the PLC as re□uired to meet specified installed I/O power re□uirements plus spares. Power supplies shall □e modular units, shall □e full□ redundant and shall alarm the PLC upon failure. Power supplies shall have a line regulation of 0.05□ and meet the environmental and power re□uirements specified herein for the PLC.

2.05 REMOTE I/O SUBS□STEMS

A. Remote I/O shall □e provided as designated on the Control S□stem Architecture Drawing. Remote I/O shall □e either PLC □ackplane t□pe I/O or field modules as manufactured □□ the PLC manufacturer. Field modules shall meet the re□uirements of Su□section 2.04, Input/Output Su□s□stems. Remote I/O processor or communication modules shall □e modular and individuall□ replacea□le.

B. Remote I/O shall communicate with the PLC using the PLC manufacturer's standard protocol or an open standard network such as DeviceNet, Ethernet IP, ProfiNet, Foundation Field□us, Mod□us TCP/IP, or e□ual.

2.0□ INPUT/OUTPUT CIRCUIT ARRANGEMENT

A. Signal and control circuitr□ to individual input/output □oards shall □e arranged such that □oard failure shall not disa□le more than one half of the control loops within an□ group of controlled e□uipment □e.g., one pump out of a group of three pumps, two pumps out of four, etc.□. Where possi□le, individual control loops and e□uipment shall □e assigned to individual boards such that failure of the board will disable only one loop or piece of equipment.

2.07 PROGRAMMING SOFTWARE

A. The PLC programming and configuration software shall be the manufacturer's latest, full-featured version, Windows-based, and shall be fully compliant with IEC 61131-3 standards. The software package shall consist of all programming, configuration, and documentation software needed to place the control and information system in satisfactory operation. The software shall allow on-line and off-line program development and documentation. PLC programming software shall include documentation on optical media.

B. A minimum of one copy of the PLC programming software shall be purchased by the instrumentation subcontractor and registered to the City.

C. All configuration and programming software necessary shall be provided on the computer specified in Section 17170 – Portable Notebook Computers for connection to the PLC processor via a communications port. All necessary hardware required to allow the notebook computer to perform PLC configuration and programming shall be provided.

<u>PART 3 - EXECUTION</u>

3.01 REQUIREMENTS

A. PLC programming shall be furnished to perform all functions described in Section 17950 – Functional Control Descriptions, including global functions. In addition, PLCs shall be programmed to provide additional functions described in other sections of this Division.

B. PLC programming shall make use of the various IEC languages as appropriate to the specific task and shall be performed in a modular style making extensive use of program blocks (subroutines) and program variables to be passed to the program blocks for specific equipment. It is the intent of this requirement to allow for enhanced readability and ease of modification of the program code through the elimination of multiple instances of repeated code for the same function in a “hard-coded” style.

C. Extensive comments shall be placed in the program code to describe the functions of all elements of the program code. PLC code that does not contain comments shall be rejected.

D. Refer to Section 17000, Part 3 for additional requirements.

3.02 REQUIREMENTS FOR MANUFACTURER-SUPPLIED PLCS

A. PLCs that are supplied for equipment local control panels by individual equipment manufacturers or suppliers shall, where so indicated on the Control System Architecture Drawing, be integrated into the plant control system. The manufacturer-supplied PLC shall be furnished, installed and programmed by the manufacturer. The PLC shall continuously monitor and control the associated system and at the same time shall provide all the required alarms, indications of system parameters, equipment status, etc. to the main control system at the plant.

B. Each equipment manufacturer shall provide all monitoring and control data to be transferred between the PLC and the plant control system in contiguous blocks of PLC registers to facilitate block read and write commands for efficient scanning by the control system SCADA servers. These contiguous registers shall be arranged in a single data transfer area, which shall be divided into eight distinct areas with an emphasis on flexibility and future expansion. The distinct areas shall be arranged by data type (analog or discrete), transfer direction (server to PLC or PLC to server), and, where applicable, implementation schedule (current or future). Where required, peer-to-peer communication between PLCs shall likewise be accomplished using separate blocks of contiguous registers. Where individual equipment PLCs are not required to be connected to the plant control system via the data highway network, they shall provide the individual hardwired signals as specified in the Contract Documents. Data and commands for connection to the control system are described in the Drawings, the Input/Output Schedule, the individual equipment specification sections, and in Section 17950 – Functional Control Descriptions.

C. The operator interface for control of each individual system shall be performed by local operator interface units as specified in Section 17125 or individual pilot devices on the equipment local control panel, as specified in the associated equipment specification section. Additional operator interface functions shall be provided through the plant control system as specified in the respective equipment specifications and in Section 17950.

D. Where operator interface and control functions are required to be provided through the plant control system, the individual system supplier shall be responsible for coordination with the instrumentation subcontractor to provide a complete and working equipment control system. The individual equipment supplier shall also be responsible for limiting the access of the plant control system to the equipment PLC code so as to prevent malfunctions of the equipment and any failure to continuously perform its intended functions. The equipment supplier shall be responsible for ensuring that no actions by the plant control system can damage or otherwise adversely affect the operation of the associated equipment or the safety of personnel working on or near that equipment. The equipment supplier shall also provide direction in the configuration of the SCADA software’s security system by the instrumentation subcontractor to limit access to the control functions of the equipment control system to authorized personnel only. The equipment supplier shall coordinate testing of the completed system with the instrumentation subcontractor, which shall conform to the requirements of Section 17072 – Field Testing.

E. The Contractor, equipment supplier and instrumentation subcontractor shall coordinate testing and startup of the equipment provided by the equipment supplier with the plant control system, including but not limited to the following tasks:

1. Provide assistance with control system testing of inputs, outputs, and control strategies as needed.

2. Provide support or interface work necessary to perform physical checkout and field testing to the final field devices. The schedule may require the instrumentation

subcontractor and equipment manufacturer personnel to perform loop checks simultaneously, as directed by the Engineer.

3. Coordinate and assist as needed to maintain I/O connectivity throughout the system.

4. Ensure personnel safety while equipment is exercised via the plant control system.

5. Ensure that process, instrumentation, and control equipment are not damaged while equipment is exercised via the plant control system.

6. Provide temporary modifications to field devices and their terminations, if needed.

7. Providing labor and supervision, which may include, but is not limited to, the following: electricians, instrument technicians, manufacturer's representatives, and individual(s) knowledgeable about process startup and operation.

8. Operation of process equipment for verification of each plant control system input and output.

END OF SECTION

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SECTION 17125

OPERATOR INTERFACE UNITS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all operator interface units, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17120 – Programmable Logic Controllers

PART 2 - PRODUCTS

2.01 OPERATOR INTERFACE UNIT

A. An Operator Interface Unit (OIU) shall be provided to view and change PLC monitoring and control parameters and to display alarm messages using a graphical user interface. The OIU shall provide the following features as a minimum:

1. Minimum of 12.1-inch diagonal display
2. 24-bit color TFT LCD display of 1024 x 768 pixels
3. 4- Wire Resistive film touch screen interface
4. Minimum of 4 GB Flash Memory
5. Minimum of 1GB MB RAM application memory
6. 1.0 GHz CPU

7. Battery-backed real-time clock
8. 1 USB 2.0, and PCI interfaces
9. Two RJ-45 Ethernet communication interface, 10/100 Mb auto selecting
10. RS-232 and RS-485 serial ports
11. EB Pro Software (Latest Version Available)
12. Operating Voltage: 120 VAC or 24 VDC (internal or via independent power supply)

13. Enclosure Rating: NEMA 12/4□ to match the associated PLC ca□inet rating

14. Environment: 0-55°C, 5-95□ relative humidit□, non-condensing

B. The operator interface unit shall □e Maple S□stems cMT2128□.

PART 3 - E□ECUTION

3.01 RE□UIREMENTS

A. The OIU shall □e configured to displa□ all PLC I/O, setpoints, and parameters. All e□uipment failures shall □e alarmed. PLC I/O values and operator-entered setpoints shall □e displa□ed with associated units and service descriptions. Menus shall □e provided to navigate □etween screens of different e□uipment items. Displa□s shall □e arranged in a hierarchical structure with displa□s for specific e□uipment items grouped together. Additional functionalit□ shall □e as specified elsewhere in this Division.

B. All necessar□ configuration and programming software shall □e provided on optical media and turned over to the Cit□.

C. Unless otherwise noted, each OIU shall □e mounted □etween 48 and □0 inches a□ove the floor or work platform.

D. Refer to Section 17000 for additional re□uirements.

END OF SECTION

SECTION 17135

CELLULAR COMMUNICATION S□STEM

<u>PART 1 - GENERAL</u>

1.01 RE□UIREMENTS

A. Contractor shall furnish, test, install and place in satisfactor□operation the cellular communication s□stem, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

B. The cellular communication s□stem shall utilize 4G LTE cellular Ethernet. The Contractor shall construct the s□stem in accordance with all applica□le FCC rules. In addition, the Contractor shall prepare and su□mit an□other re□uired documentation as re□uired.

1.02 RELATED WORK SPECIFED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements.

B. Section 17500 – Enclosures General

C. Section 175□0 – Surge Protection Devices.

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. The following tools shall □e provided:

1. One set of coa□ial ca□le preparation tools re□uired for installing coa□ial ground clamps and all t□pes of coa□ial ca□le connectors supplied under this Contract. Tools shall □e specificall□designed for the size and t□pe of ca□les supplied under this Contract.

2. Cellular router remote management software as descri□ed herein.

B. The following spare parts shall □e provided:

1. One □1□spare 4G LTE router of the make and model furnished under this Contract.

2. One □1□spare 4G LTE antenna of the make and model furnished under this Contract.

3. Two □2□of each t□pe of coa□ial ca□le connector furnished under this Contract.

1.04 SUBMITTALS

A. In addition to su□mittals re□uired under Section 17030 – Control and Information S□stem su□mittals, su□mit antenna installation details for antenna installations re□uired under this Contract. The details should include scaled drawings of the antenna, antenna mounting hardware and support structures, coa□ial ca□les, connectors, ground clamps, fasteners, and lightning surge protectors. An e□uipment list shall □e included identif□ing each component. Su□mit product literature for each component.

1.05 TELEMETR□ S□STEM E□UIPMENT LOCATIONS

A. Cellular router shall □e mounted on a DIN rail in the stormwater pump station LCP □local control panel□. Refer to the Drawings for the LCP and cellular antenna locations.

PART 2 - PRODUCTS

2.01 GENERAL

A. The Contractor shall provide a multicarrier 4G LTE cellular communications s□stem.

B. All communications equipment shall be installed in accordance with the manufacturer’s recommendations, FCC rules and regulations, and details on the Contract Drawings.

C. All cellular communications e□uipment power and signal lines that e□tend or are located outside of an enclosed structure shall □e protected from lightning and voltage surges in accordance with the re□uirements of Section 175□0 – Surge Protection Devices.

2.02 OMNI-DIRECTIONAL CELLULAR ANTENNAS AND APPURTENANCES

A. Omni-directional antenna for the remote station cellular routers shall □e of two t□pes. For remote sites with received signal strength □RSSI□greater than 20 dB a□ove the threshold □i.e., fade margin□, a low profile omni-directional antenna shall □e deplo□ed. To improve communication relia□ilit□at remote sites with lower signal strength, a higher gain omni-directional antenna shall □e deplo□ed.

B. Low profile omni-directional cellular antennas shall □e AirLink Panel LPWA □□Sierra Wireless□no su□stitutions.

C. Omni-directional cellular antenna shall meet the following re□uirements.

1. Rotation pattern: omni-directional.
2. Fre□uenc□Range: □98-3800 MHz.
3. Peak Gain: □98-9□0 MHz 2 dBi and 1710-3800 MHz 5 dBi.
4. Bandwidth VSWR: less than 2.5:1.
5. Impedance: 50 ohms.
□. Ma□imum input power rating: 30 watts.
7. RF Connector: SMA.
8. Ca□le t□pe CS29.

D. Cellular antennas shall □e supplied as a complete kit including mounting hardware, coa□ial antenna ca□le, surge suppressor, weatherproofing kits, and other appurtenances re□uired for a relia□le installation. Refer to Instrumentation Detail Drawings for additional installation re□uirements.

2.03 CELLULAR ETHERNET GATEWAY

A. Cellular routers shall utilize both 4G Cat 12. LTA-A Pro (600//150 Mbps), HSPA+, CBRS, FirstNet cellular radio to transmit and received Ethernet/IP PLC communications data. The routers shall be completely compatible with the control and information system's hardware and communication protocols. Cellular router shall have dual SIM card and multi-carrier support for link redundancy.

B. Cellular routers shall have the following operation and performance specifications:

1. Environmental

   a. Temperature Range: -30°C to +70°C

   b. Humidity: 95% at [illegible]0°C (non-condensing

2. Standards and Certifications:

   a. Safety: UL 60950-1

   b. EMI: FCC Part 15B Class A or B.

   c. Radio: FCC Rules Part 22H, FCC Part 24E

3. General Router Requirements

   a. Protocol Support: The router shall support the following network protocols.

      1) HTTP, HTTPS, FTP, SFTP, SSL, SMTP, Device Cloud SNMP, SNMP (v1/v2c/v3) SSH, Telnet, and CLI for web management.

      2) Remote management via Digi Remote Manager, SMS management, protocol analyzer, ability to capture PCAP for use with Wireshark.

      3) DynDNS, Dynamic DNS client compatible with BIND9/No-IP/DynDNS.

      4) DHCP.

      5) DNS client compatible with BIND9/No-IP/DynDNS.

      6) QoS via TOS/DSCP/WRED.

      7) Ethernet, serial I/O and Modbus bridging for connecting diverse field assets.

   b. Routing/Failover: The router shall support the following routing and failover features:

      1) IP pass-through.

      2) NAT, NAPT with IP Port Forwarding.

      3) Ethernet Bridging.

      4) GRE.

      5) Multicast Routing.

6) Routing Protocols: PPP, PPPoE, RIP (v1,v2) OSPF, SRI , BGP, iGMP routing (multicast).

7) RSTP (Rapid Spanning Tree Protocol).

8) IP Failover: VRRP, VRRP+TM.

c. Security: The router shall support the following security features:

1) IP filtering.

2) Stateful inspection firewall with scripting address and port translation.

3) VPN: IPSec with IKEv1, IKEv2, NAT Traversal.

4) SSL, SSLv2, SSLv3, FIPS 197, Open VPN client and server, PPTP, L2TP.

5) VPN Tunnels: 5. Cryptology: SHA-1, MD5, RSA.

6) Encryption: DES,3DES and AES up to 256-bit (CBC mode for IPsec).

7) Authentication: RADIUS, TACACS+, SCEP for X.509.

8) Certificates

9) Content Filtering (via 3rd party)

10) MAC Address Filtering: VLAN support.

d. Hardware Interfaces: The router shall support the following interfaces:

1) 2 x RJ45 10/100 Ethernet, 1 x RJ45 RS-232/RS-485 serial and 1 x USB 2.0.

2) Antenna connectors: SMA

e. Cellular Modem (WWAN)

1) The cellular model shall be equipped with two SIM card slots capable of supporting two different cellular service providers. The modem shall be capable of automatically switching between providers to ensure optimal cellular signal quality.

2) The cellular model shall be capable of supporting at least two of the following 4G LTE carriers through a Machine-to-Machine (M2M) data plan:

a) Verizon

b) AT&T

c) T-Mobile

3) Input Power: The cellular router shall be capable of operation on 24V DC power.

4) Remote Configurations: The user shall have the ability to configure any cellular radio over-the-air from the SCADA network.

5. PLC Programming: The radio shall provide the user the capability to program any remote site PLC over-the-air from any computer in the SCADA network.

6. Active Ports: The radio shall have, as a minimum, two active ports that can sequentially manage the transfer of Ethernet and serial data messages: 1 serial and 1 Ethernet. In addition, router shall have 1 USB 2.0 port.

f. Product Requirements:

1. Cellular routers shall be AirLink RV-50, by Sierra Wireless, no substitutions.

2.04 TRANSMISSION CABLE AND MISCELLANEOUS REQUIREMENTS

A. Provide all cables and connectors to connect the radio to the antenna. Provide flexible jumper cables with appropriate connectors within panels to connect the radio to the surge suppressor. Attenuation including connectors from the radio to the surge suppressor shall not exceed 0.25 dB.

B. Provide weatherproof connections that are suitable for direct environmental exposure. Weatherproof connections shall include heat shrink tubing that provides a waterproof and corrosion resistant seal. The heat shrink tubing shall be polyolefin lined with thermoplastic adhesive as manufactured by 3M, or equal. Heat shrink tubing shall be provided for all RF transmission cable connections located outside of panels or air-conditioned rooms.

C. Utilize appropriate bulkhead RF transmission cable surge suppression devised at cable entrances, Polyphaser or equivalent.

PART 3 - EXECUTION

3.01 CELLULAR ROUTER TESTING

A. Prior to the LCP Factory Acceptance Test, the instrumentation and controls subcontractor shall request one activated SIM card from the City and coordinate with the City to establish a reliable communications link with the City SCADA system. During the test, the instrumentation and controls subcontractor shall demonstrate internet to M2M (Machine to machine) cellular internet connectivity with the City SCADA system.

B. After the cellular routers have been installed, the Contractor shall test the following items and make all necessary adjustments to maximum performance of the communication links:

1. Signal strength

2. Cellular protocol mode (LTE 4G)

3. Standing wave ratio (SWR)

4. Radio temperature

5. Software revision

6. Hardware revision

C. The Contractor shall test the integrity of the antenna cable after installation to ensure that the insertion losses do not exceed 2.0 dBs.

D. The Contractor shall submit all test results of the above-described tests for approval by the Engineer. The Contractor shall provide a copy of the approved test results in the final O&M Manuals.

3.02 WARRANTY

A. Cellular routers shall be furnished with a minimum 5-year manufacturer’s warranty (3-year standard plus a 2-year extension). The warranty shall cover hardware and software provided by the manufacturer.

B. The warranty period shall begin upon Final Acceptance as described in Part 3 of Section 17000.

- END OF SECTION -

SECTION 17185

NETWORKS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all copper ethernet control system and process information local area networks complete with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17120 – Programmable Logic Controllers

D. Section 17510 – Cabinets and Panels

1.03 REFERENCED STANDARDS

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. 802.3, Information Technology – Local and Metropolitan Area Networks – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.

   a. 802.3u: IEEE Standards for Local and Metropolitan Area Networks: Supplement to Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100 Mb/s Operation, Type 100BASE-T.

   b. 802.3x: IEEE Standards for Local and Metropolitan Area Networks: Specification for 802.3 Full Duplex Operation.

B. National Institute of Standards and Technologies (NIST):

1. 800-82, Guide to Industrial Control Systems (ICS) Security.

1.04 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 17050 - Tools and Supplies

PART 2 - PRODUCTS

2.01 ETHERNET NETWORKS - GENERAL

A. The network topology shall be as shown on the Drawings, consisting of twisted pair copper to accomplish the data transmission requirements specified herein. Each equipment device connected to the network shall be equipped with its own network interface units.

B. Bi-directional communications between the network and network connected equipment shall be provided with network interface units. The network interface units shall be common to all equipment and shall include all required modems, communications processors and memories to provide a transparent interface between network(s) and the connected devices.

C. Each individual PLC shall be connected to the network via a dedicated port on its CPU module or a separate network interface module, and, where required, a fiber optic transceiver.

D. The network system shall meet the following requirements:

1. The minimum data transmission speed shall be 10/100 Mbps.

2. The network shall allow for a minimum of 64 nodes, with the maximum distance between nodes being 10,000 feet when using the above communication rate.

3. The network-connected devices shall equally share access to the data highway network. Devices shall be normally passive (listen) with respect to the network.

4. A separate data highway controller, "traffic director", or other network connected device used to maintain traffic control between devices is not acceptable.

5. A multi-layered peer-to-peer communications protocol shall be employed. Protocol shall be CSMA/CD ("Ethernet"). Repeaters (with associated UPS systems) shall be provided where necessary to meet data highway distance requirements or signal attenuation requirements whether or not they are specifically shown on the System Architecture Diagram Drawing IG-GN-02.

6. Data highway systems employing master/slave, or similar communications protocols shall be rejected.

7. An error detection check shall be made on each data word that is transmitted on the network, consisting of a cyclic redundancy check or a Bose-Chaudhuri (BCH) check. If an error is detected, the data word shall be rejected by the receiver and retransmitted by the sender. The receiving station shall positively acknowledge to the transmitter that all messages have been received. The receiving station shall respond with either a busy indication, with valid data, with a read command or by echoing the latest data word of a write message. The cyclic error detection code used shall be equal to or better than the performance on the CRC-CCITT code.

8. Data communications protocol shall be firmware resident.

2.02 ETHERNET SWITCHES

A. Layer 2 – Panel Mounted Ethernet Switches:

1. Manufacturers:

   a. Allen Bradley 5700 Series, Model 1783-BMS10CGA, or equivalent by Phoenix Contact, Hirschmann, Moxa, or Engineer approved Equal.

2. Design and fabrication:

   a. Support Ethernet 10/100/1000 Mbps.

   b. Eight (8) 10/100 Mbps twisted pair ports (RJ45), and two (2) 100/1000 combo ports (SFP slots) for multimode fiber optic cable (for future use by City). Provide additional ports as required for communication with devices as depicted in the Contract Documents. 10 port minimum.

      1) Unless otherwise noted, provide at least two spare 10/100 MBit/s port (twisted pair) at each Ethernet switch.

   c. Support SNMP v3 and Web-based management.

   d. Rapid Spanning Tree Protocol.

   e. IGMP (Internet Group Management Protocol) support for IP multicast filtering to enable switches to automatically route messages only to appropriate ports.

   f. Check all received data for validity.

      1) Discard invalid and defective frames or fragments.

   g. Monitor connected TP/TX line segments for short-circuit or interrupt using regular link pulses in accordance with IEEE 802.3.

   h. Monitor attached fiber optic lines for open circuit conditions in accordance with IEEE 802.3.

   i. As applicable, meet requirements of IEEE 802.3.

   j. 24 VDC power input.

   k. Provide dual redundant power supplies.

   l. Provide LED status lights to indicate:

      1) Power: Supply voltage present.

      2) Fault.

      3) Port status.

   m. Environmental rating:

      1) Operating temperature: 32 DEGF to 122 DEGF.

2□ Humidit□: 95□ relative humidit□, non-condensing.

3. DIN Rail mounted.

4. Configuration:

   a. All managed switch unused ports shall □e administrativel□ disa□led. Stick□ MAC or similar port configuration shall □e utilized to □ind ports to MAC address of connected device per NIST 800-82.

   □. Change default usernames and passwords.

5. Update firmware of managed ethernet switches to Supplier’s current version at the time of Su□stantial Completion.

2.03 SHIELDED TWISTED PAIR □STP□ ETHERNET CABLES FOR INSIDE CONDUIT

A. Twisted pair patch ca□ling for Ethernet connections shall □e 4-pair, 24 AWG solid Categor□ □ □CAT□□ shielded twisted pair □STP□ ca□le with 100□ foil shield, professionall□ installed R□-45 connectors, and strain relief □oots.

2.04 TWISTED PAIR PATCH CABLES FOR INSIDE CABINETS/PANELS

A. Patch ca□les shall □e CAT□, 24 AWG stranded and color coded for each connected device. Patch ca□les shall □e factor□ assem□led with connector and PVC snag free □oot. Black Bo□ EVNSL□A, or e□ual.

<u>PART 3 - E□ECUTION</u>

3.01 RE□UIREMENTS

A. Refer to Section 17000 for further information.

END OF SECTION

SECTION 17190

UNINTERRUPTIBLE POWER SYSTEMS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all uninterruptible power systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

B. One UPS shall be provided for each programmable logic controller (PLC) and its appurtenant equipment provided under this Contract. However, courtesy receptacles in PLC and RTU cabinets shall not be powered by the UPS.

C. UPS's shall be mounted in or near enclosures containing digital hardware, unless otherwise specified or shown on the Drawings, as follows:

1. UPS's for control panels containing PLCs shall be mounted either within the cabinet or in an adjacent cabinet of suitable environmental rating.
2. Where the UPS is mounted within a dedicated enclosure, that enclosure shall be properly sized for heat dissipation and all other applicable requirements as specified in Section 17500 and its subordinate Sections.
3. Where the UPS is mounted within the PLC or RTU cabinet, it shall not interfere with access to other equipment or wiring within the panel (i.e., it shall not be necessary to move or remove the UPS to remove or service other panel-mounted equipment). For floor-mounted PLC cabinets with bottom wiring access (including those cabinets with legs), the UPS shall be placed on a dedicated shelf within the cabinet.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17120 – Programmable Logic Controllers

1.03 SUBMITTALS

A. The Contractor shall submit UPS sizing calculations for all UPS's furnished under this Contract in accordance with Section 17030 - Control and Information System Submittals.

PART 2 - EQUIPMENT

2.01 UNINTERRUPTIBLE POWER SYSTEMS

A. Each UPS shall consist of a freestanding UPS module and battery modules as required to meet backup run time requirements.

B. UPS's shall be true double conversion on-line type. Each UPS shall be sized to match the maximum power requirements of the associated digital equipment, control panel power supplies and accessories. Under normal operation, the AC power shall be converted to DC. The DC power from the battery charger shall supply an inverter and maintain the battery module at full charge. The AC output from the inverter shall be fed to the associated digital equipment power supply unit and/or other equipment power supplies as appropriate. Upon loss of the AC supply, the inverter shall continue to supply normal power to the device, drawing DC from the batteries.

C. An automatic bypass switch shall be provided. The transfer switch shall be of the solid state, make-before-break type and shall automatically transfer load from the inverter to the AC line in the event of an inverter malfunction. The total transfer time shall be 5 milliseconds or less. The transfer switch shall be provided with a manual override.

D. A manually operated maintenance bypass switch shall be provided for each UPS installation to allow hardware to be powered while the UPS is removed for maintenance. The bypass switch shall be the make-before-break type to ensure continuous power to the associated PLC.

E. Loss of AC power shall be monitored on the line side of the UPS and reported via normally closed (fail safe) unpowered contacts to the associated PLC/RTU.

F. Each UPS shall meet the following requirements:

1. Input voltage shall be 117 VAC, single phase, 60 Hz.

2. Voltage regulation shall be +/-5 percent for line and load changes.

3. The output frequency shall be phase-locked to the input AC line on AC operation and shall be 60 hertz +/-0.5 percent when on battery operation.

4. The batteries shall be of the sealed, lead acid or lead calcium gelled electrolyte type, or VRLA absorbed glass mat (AGM) type. The battery modules shall have a minimum full load backup time of 30 minutes for PLC-based control panels, and 45 minutes for remote telemetry units.

5. A status monitoring and control panel shall be provided and shall include the following:

   a. Status indicating lights for both normal and abnormal conditions.

   b. Individual alarm contacts that shall close upon loss of the AC line, low battery level or operation of the static transfer switch. Contacts shall be wired to the closest discrete input subsystem. Alternatively, an RS-232 or USB port shall provide UPS status to an operator workstation. All required interface software and hardware shall be provided.

c. Circuit breaker for the AC input.

6. Sound absorbing enclosure.

7. EMI/RF noise filtering.

8. Surge protection shall be provided on the AC input circuit, which shall have a UL TVSS clamping voltage rating of 400 V with a □5 ns response time.

G. UPS systems shall be Model 9SX as manufactured by Eaton, equivalent by APC, or Engineer approved equal.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17000, Part 3 of the Specifications.

END OF SECTION

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SECTION 17500

ENCLOSURES, GENERAL

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the control enclosures, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

B. Control enclosures shall be assembled, wired, and tested in the instrumentation subcontractor's own facilities, unless specified otherwise. All components and all necessary accessories such as power supplies, conditioning equipment, mounting hardware, signal input and output terminal blocks, and plug strips that may be required to complete the system shall be provided.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17510 – Cabinets and Panels

D. Section 17520 – Field Panels

E. Section 17550 – Panel Instruments and Accessories

F. Section 175□0 – Surge Protection Devices

G. Section 17□00 – Unpowered Instruments, General

H. Section 17700 – Powered Instruments, General

I. Section 17910 – Instrument Schedule

J. Section 17950 – Functional Control Descriptions

K. Refer to Division 1□ for additional requirements for cable, circuit breakers, disconnect switches, etc.

1.03 GENERAL INFORMATION AND DESCRIPTION

A. The cabinet itself and all interior and exterior equipment shall be identified with nameplates. The equipment shall be mounted such that service can occur without removal of other equipment. Face mounted equipment shall be flush or semi-flush mounted with flat black escutcheons. All equipment shall be accessible such that adjustments can be made while the equipment is in service and operating. All enclosures shall fit within the allocated space as shown on the Drawings.

B. Either manufacturer-standard or custom cabinetry may be furnished subject to the requirements of the Contract Documents and favorable review by the City.

C. Due consideration shall be given to installation requirements for enclosures in new and existing structures. The Contractor shall examine plans and/or field inspect new and existing structures as required to determine installation requirements, and shall coordinate the installation of all enclosures with the City and all affected contractors. The Contractor shall be responsible for all costs associated with installation of enclosures, including repair of damage to structures (incidental, accidental or unavoidable).

1.04 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 17050 - Tools, Supplies and Spare Parts. In addition, the spare parts items shall be provided as specified in the individual cabinet and panel specification sections (175xx).

PART 2 - PRODUCTS

2.01 TERMINAL BLOCKS

A. Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the cabinet subpanel. Terminals shall be of the screw down pressure plate type as manufactured by Phoenix Contact, Weidmuller, Wieland, Square D, or equal.

B. Power terminal blocks for both 120 VAC and 24 VDC power shall be single tier with a minimum rating of 600 volts, 30 amps.

C. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20 amps.

PART 3 - EXECUTION

3.01 FABRICATION

A. Enclosures shall provide mounting for power supplies, control equipment, input/output subsystems, panel-mounted equipment and appurtenances. Ample space shall be provided between equipment to facilitate servicing and cooling.

B. Enclosures shall be sized to adequately dissipate heat generated by equipment mounted inside the panel. If required, one or more of the following shall be provided to facilitate cooling:

1. Louvered openings near the bottom and top (NEMA 12 cabinets only).

2. Thermostatically controlled, low noise internal air blowers (initial setpoint 75°F) to circulate air within the enclosure, maintaining a uniform internal temperature.

3. Thermostatically controlled, low-noise cooling fans to circulate outside air into the enclosure, exhausting through louvers near the top of the cabinet (NEMA 12 cabinets only). Air velocities through the enclosure shall be minimized to assure quiet operation.

4. All openings in cabinets and panels shall be fitted with dust filters.

C. Enclosures shall be constructed so that no screws or bolt heads are visible when viewed from the front. Punch cutouts for instruments and other devices shall be cut, punched, or drilled and smoothly finished with rounded edges.

D. The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature. This thermostat shall be independent and separate from the thermostat used to control the temperature in the enclosure described above. Enclosure interior temperature alarm shall be displayed on the HMI.

E. Intrusion alarm switches shall be provided on all enclosures containing digital hardware and shall generate an alarm to the nearest PLC when any enclosure door is opened.

F. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for field incoming conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system will be acceptable.

G. Wiring within cabinets, panels, and consoles shall be installed neatly and shall comply with accepted standard instrumentation and electrical practices. Power, control and signal wiring shall comply with Division 1□ of the Specifications, except that the minimum wire size for discrete signal wiring may be 1□ AWG, and for analog wiring may be 18 AWG. For each pair of parallel terminal blocks, the field wiring shall be between the blocks.

H. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. Where applicable, terminal strips for different voltages of discrete signal wiring shall also be separated. Terminal strips shall be labeled as to voltage and function.

I. All wiring shall be bundled and run open or enclosed in vented plastic wireway as required. Wireways shall be oversized by a minimum of 10□ □overfilled wireways shall not be acceptable. All conductors run open shall be bundled and bound at regular intervals, not exceeding 12 inches, with nylon cable ties. Care shall be taken to separate electronic signal, discrete signal, and power wiring.

J. Spare field wiring shall be bundled, tied, and labeled as specified above, and shall be neatly coiled in the bottom of the cabinet.

K. All installed spare I/O hardware shall be wired along with live I/O wiring to the field wiring terminal blocks within the cabinet. Where space for spare I/O modules has been provided with the PLC backplane or DIN-rail mounting system, corresponding space for wiring, surge protection, and terminations shall be furnished within the cabinet.

L. A copper ground bus shall be installed in each cabinet, and shall be connected to the building power ground.

M. Interior panel wiring shall be tagged at all terminations with machine-printed self-laminating labels. Labeling system shall be Brady TLS 2200 Printer with TLS

2200□/TLS PC Link™ labels, or equivalent system by Seton or Panduit. The wire numbering system and identification tags shall be as specified in Section 1□123 - Building Wire and Cable. Field wiring terminating in panels shall be labeled in accordance with the requirements of Section 1□123. Where applicable, the wire number shall be the ID number listed in the input/output schedules.

N. Wires shall be color coded as follows:

Equipment Ground - GREEN

120 VAC Power - BLACK
120 VAC Power Neutral - WHITE

120 VAC Control (Internally Powered) - RED
120 VAC Control (Externally Powered) - YELLOW

24 VAC Control - ORANGE

DC Power (+) - RED
DC Power (-) - BLACK
DC Control - BLUE

Analog Signal – BLACK/WHITE or BLACK/RED

Intrinsically Safe – LIGHT BLUE.

O. Enclosures shall be provided with a main circuit breaker and a circuit breaker on each individual branch circuit distributed from the panel. Main breaker and branch breaker sizes shall be coordinated such that an overload in a branch circuit will trip only the branch breaker but not the main breaker.

P. Enclosures with any dimension larger than 3□ inches shall be provided with 120-volt duplex receptacles for service equipment and an LED panel light. Provide a switch to turn panel light on when panel door opens. Power to these devices shall be independent from the PLC power supply and its associated uninterruptible power system.

Q. Where applicable, enclosures shall be furnished with red laminated plastic warning signs in each section. The sign shall be inscribed "WARNING - This Device Is Connected to Multiple Sources of Power". Letters in the word "WARNING" shall be 0.75 inch high, white.

R. The interconnection between equipment and panel shall be by means of flexible cables provided to permit withdrawal of the equipment from the cabinet without disconnecting the plugs.

3.02 PAINTING/FINISHING

A. All steel enclosures shall be free from dirt, grease, and burrs and shall be treated with a phosphatizing metal conditioner before painting. All surfaces shall be filled, sanded, and finish coated by spraying a 1-2 mil epoxy prime coat and smooth, level, high grade textured finish between flat and semi-gloss shine. The colors shall be selected by the City from a minimum of six color samples provided. Refer to Division 9 for additional requirements.

B. Materials and techni□ues shall □e of t□pes specificall□designed to produce a finish of superior □ualit□with respect to adherence, as well as impact and corrosion resistance.

C. Panels fa□ricated from stainless steel shall not □e painted.

D. Panels fa□ricated from non-metallic materials □e.g., FRP□shall □e gel-coated and shall not □e painted.

3.03 INSTALLATION

A. Refer to Section 17000 for additional re□uirements.

END OF SECTION

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SECTION 17510

CABINETS AND PANELS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the cabinets and panels, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17100 – Control and Information System Hardware, General

C. Section 17500 – Enclosures, General

D. Section 17910 – Instrument Schedule

E. Section 17950 – Functional Control Descriptions

PART 2 - PRODUCTS

2.01 CABINETS AND PANELS

A. Cabinets and panels shall be formed or welded construction, reinforced with Unistrut, Powerstrut, or equal to facilitate mounting of internal components or equipment. Sufficient access plates and doors shall be provided to facilitate maintenance and testing of the cabinet's equipment. Doors shall be removable. Cabinets and panels with any dimension 3□ inches or greater shall be provided with removable lifting lugs designed to facilitate safe moving and lifting of the panel during installation. All doors shall be fitted with common-keyed locks.

B. Cabinets and panels shall be minimum 14 USS gauge. Cabinets and panels with any dimension greater than 3□ inches shall be 12 USS gauge.

C. Cabinets and panels located inside buildings, but located in areas other than climate controlled (heated and air conditioned) electrical or control rooms, shall be as a minimum 31□ stainless steel NEMA 4X construction, or as specified or shown on the Drawings for hazardous area classification (Class, Division, Group), or submersible (NEMA □) applications. Epoxy coated cast copper-free aluminum construction shall also be acceptable for NEMA 4, □ and 7 applications. Cabinets located in storage/feed areas for chlorine or other applicable corrosive chemicals shall be of non-metallic construction, rated NEMA 4X, and fully compatible with the associated chemical.

D. Cabinets and panels within climate controlled (heated and air-conditioned) electrical or control rooms shall be all steel fully enclosed NEMA 12 units with gasketed doors.

E. Cabinets and panels shall have doors on the front and shall be designed for front access. NEMA 12 cabinets shall be fitted with three-point door latches. Doors for NEMA 4X cabinets shall be all stainless steel with three-point latches. Door hardware on NEMA 4X cabinets located in chemical storage/feed areas shall be non-corrosive in that environment.

F. Panels and cabinets located outside fence-secured areas shall be fitted with padlockable latch kits.

G. All cabinets and panels shall be provided with drawing pockets for as-built panel drawings. One copy of the appropriate panel as-built drawings shall be furnished and left in the pocket of each panel.

H. Panels with any dimension greater than 3□ inches that contain a programmable controller (PLC) shall be provided with a folding laptop programmer shelf on the inside of the door. When deployed, the laptop shelf shall not be greater than 48 inches above finished floor. Laptop shelf shall be fitted to door with factory applied weld-studs. Weld discoloration and enclosure penetrations will not be accepted.

I. Unless otherwise noted, panel-mounted control devices (OIUs, hand switches, etc.) requiring operator access shall be mounted between 48 and □0 inches above the floor or work platform.

J. Cabinets and panels shall be prefabricated cabinets and panels by Hoffman or Saginaw Control and Engineering (SCE). The Contractor may optionally provide cabinets that are custom-fabricated by the instrumentation subcontractor or by a reputable panel fabrication shop acceptable to the Engineer.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17500 for additional requirements.

END OF SECTION

SECTION 17520

FIELD PANELS

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation the field panels, with all spare parts, accessories, and appurtenances as specified or shown.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 17500 – Enclosures, General

C. Section 17910 – Instrument Schedule

D. Section 17950 – Functional Control Descriptions

PART 2 - PRODUCTS

2.01 FIELD PANELS

A. Field panels for outdoor service shall □e suita□le for wall or pipe mounting. Panels shall have the following features:

1. T□pe 31□L stainless steel NEMA 4□ construction unless located in chlorine environments. Chlorine environment shall □e nonmetallic NEMA 4□ construction.

2. Hinged and foamed-in-place continuous gasketed door□s□. Door material shall match enclosure and shall have piano hinge□s□and three-point latches.

3. Field panels located outside fence-secured areas shall □e fitted with staple and hasp. Provide padlock and coordinate ke□ing with Cit□.

4. Thermal insulation and thermostaticall□controlled space heaters where re□uired to prevent condensation or maintain environmental conditions for installed components.

5. E□ternal sun shields or shades constructed of the same materials as the associated enclosure, unless otherwise specified. Sun shield or shade shall □e fitted to enclosure supports and not to enclosure. Sun shield or shade shall have a slightl□ sloped top to shed water and shall e□tend past the front of the enclosure □□at least □ inches and e□tend down the side and □ack of enclosure.

B. All e□ternal sample/process piping, including valves and appurtenances, shall □e insulated with weather-proof insulation and heat-taped to prevent freezing. Heat taping shall □e thermostaticall□controlled and self-regulating, and shall ad□ust its heat output to the temperature of the lines. Heat tape shall □e powered from a GFCI circuit from within panel, unless otherwise shown or specified.

C. Field panels shall □e ade□uatel□ sized to house instruments, power supplies, surge protection, and appurtenant e□uipment re□uired for operation. Sufficient space shall □e provided for servicing instruments without removal of e□uipment from the enclosure.

D. Field panels shall □e as manufactured □□ Hoffman, Saginaw Control and Engineering □SCE□, or e□ual.

PART 3 - E□ECUTION

3.01 RE□UIREMENTS

A. Refer to Section 17500 for additional re□uirements.

END OF SECTION

SECTION 17550

PANEL INSTRUMENTS AND ACCESSORIES

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation the panel instruments and accessories, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 17100 – Control and Information S□stem Hardware, General

C. Section 17500 – Enclosures, General

D. Section 17910 – Instrument Schedule

E. Section 17950 – Functional Control Descriptions

1.03 GENERAL INFORMATION AND DESCRIPTION

A. All e□uipment mounted on the face of a panel shall conform to the same NEMA rating specified for the panel construction.

1.04 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall □e provided as specified in Section 17050 - Tools, Supplies and Spare Parts.

PART 2 - PRODUCTS

2.01 ELECTRONIC INDICATORS

A. Electronic indicators shall □e 3.5 or □ digit, as appropriate, with 0.5□" high red LED displa□. Indicators shall □e provided with nameplate and scale cali□rated to match the cali□ration of the primar□element. The unit shall □e designed primaril□for use with 4-20 mA current loop signal circuits. Indicator operating voltage shall □e 115 VAC 10□, □0 Hz. Indicator controls shall include three □3□front-panel push□uttons for modif□ing alarm values and other indicator setup. Two □2□form-C rela□s shall □e provided for each indicator. Rela□contact outputs shall □e rated 5A, 120/240 VAC, resistive load. Where re□uired, a regulated and isolated 24 V e□citation power suppl□shall □e provided. Indicators shall □e suita□le for indoor or outdoor service as re□uired and shall have the same NEMA enclosure rating as the associated enclosure. Indicators shall □e Red Lion Model PA□P or e□ual.

2.02 SIGNAL CONVERTERS

A. Signal converters shall □e provided as re□uired to provide control functions and to interface instrumentation and controls, e□uipment panels, motor control centers and other instrumentation and controls supplied under other Divisions to the controls provided herein.

B. General Re□uirements – Converters shall □e of the miniature t□pe, utilizing all solid-state circuitr□ suita□le for mounting within new or e□isting ca□inetr□. Where sufficient ca□inet space is not availa□le, su□ panels or supplemental enclosures shall □e provided. Power suppl□ shall □e 120V, □0 hertz where re□uired □□ the converter. Repeata□ilit□ shall □e 0.1□ of span, dead□and shall □e 0.1□ span, ma□imum. Where specific converters are not listed, □ut are re□uired to interface with the process control s□stem, the□ shall compl□ with the general re□uirements stated herein.

C. Current to Current Isolators – Current to current isolators shall □e furnished where necessar□ to provide an isolated current loop, calculations or signal amplification □etween the plant process control s□stem and instrumentation and control loops. Isolators shall □e sized such that resistance of e□isting loops shall not e□ceed ma□imum rated resistance. Isolators shall □e as manufactured □□ Phoeni□ Contact, Weidmuller, Acromag, or e□ual.

D. Voltage to Current Transducers – Voltage to current □or current to voltage□ transducers shall convert a voltage signal of one magnitude to a 4-20 milliamp DC current signal. The output current shall □e directl□ proportional to the input signal voltage. Transducers shall □e sized such that loop resistance does not e□ceed ma□imum rated resistance. Transducers shall □e as manufactured □□ Phoeni□ Contact, Weidmuller, Acromag, or e□ual.

E. Fre□uenc□ to Current Transducers – Fre□uenc□ to current transducers shall convert pulse-rate and pulse-duration signals to 4-20 mA, 24 VDC analog signals. Converters shall include field-ad□usta□le input fre□uenc□ range. Converter power shall □e 120 VAC, □0 hertz. Transducers shall □e sized such that loop resistance does not e□ceed ma□imum rated resistance. Transducers shall □e suita□le for signal transmission via leased telephone lines. Transducers shall □e Series 5100 as manufactured □□ Phoeni□ Contact, Weidmuller, Acromag, or e□ual.

F. Current to Fre□uenc□ Transducers – Current to fre□uenc□ transducers shall convert 4-20 mA, 24 VDC analog signals to pulse-rate and pulse-duration signals. Converters shall include field-ad□usta□le output fre□uenc□ range. Converter power shall □e 120 VAC, □0 hertz. Transducers shall □e sized such that loop resistance does not e□ceed ma□imum rated resistance. Transducers shall □e suita□le for signal transmission via leased telephone lines. Transducers shall □e Series 501□ as manufactured □□ Phoeni□ Contact, Weidmuller, Acromag, or e□ual.

G. Integrators – Integrators shall □e provided as interchangea□le plug-in modules with zero and span ad□ustment availa□le on the front plate of the units. Output shall range from 0 to 0.1 through 0 to 10 pulses per second. Accurac□ shall □e □0.1□ of input span. Integrators shall convert linear analog signals to pulse rate and provide a solid-state output. Integrators shall □e as manufactured □□ Phoeni□ Contact, Weidmuller, Acromag, or e□ual.

H. Electronic Switches (Alarm Relays) – Electronic switches shall be furnished with a calibrated dial for adjusting set points. The input to the switch shall be 4-20 mADC, and the set point shall be adjustable over the full range. Unless otherwise noted, the dead band shall be fixed at less than 2 percent of span. The set point stability shall be ±0.1% per degree F. The repeatability shall be ±0.1% of span. The units shall be furnished with SPDT relays rated at 10 amperes at 115 VAC. Electronic switches shall be as manufactured by Phoenix Contact, Weidmuller, Acromag, or equal.

I. RTD to Current Signal Converters – RTD to current signal converters shall convert a 3-wire RTD input signal to an isolated 4-20 mADC output signal. Each converter shall operate from a 120 VAC power source. Accuracy shall be 0.10 percent of span or better. Calibrated span of each converter shall be as indicated on the instrument list. The Contractor shall coordinate calibration of the signal converters with existing RTD elements. The signal converters shall be furnished in the manufacturer's standard enclosure for installation in an existing indoor electrical cabinet. Signal converters shall be as manufactured by Phoenix Contact, Weidmuller, Acromag, or equal.

J. Interposing Relays – Where required to interface between motor control centers, equipment controls, and control panels, interposing relays and associated control wiring circuitry shall be furnished and installed to provide the monitoring and/or control functions specified herein. Interposing relays shall be small format type, DPDT, minimum 10 amp, 120 VAC contact rating. Relay coils shall be 120 VAC or 24 VDC as required. Relays shall have a flag indicator to show relay status, a pushbutton to allow manual operation of the relay, and an internal pilot light to indicate power to the coil. Relays shall be as manufactured by Square D, Potter & Brumfield, Allen-Bradley, or equal.

K. Timing Relays – Timing Relays (TR) shall be the general purpose plug-in type, Type XCK as manufactured by Square D Company, Cutler-Hammer/Westinghouse Electric Corporation equivalent, Allen-Bradley equivalent, or equal. Timing relays shall be electronic type with 120 VAC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with a minimum of two SPDT timed output contacts and instantaneous contacts where required. Contact ratings shall be the same as for interposing relays as specified above.

L. Intrinsically Safe Relays and Barriers – Intrinsically safe relays and barriers shall be provided where required to interface with equipment such as float level switches that are located in NFPA-classified hazardous areas. Intrinsically safe barriers shall be provided with galvanic isolation (Use of passive Zener diode barriers is not permitted) and certified to be in accordance with latest edition of UL 913. Intrinsically safe relays and barriers shall be FM approved and shall be manufactured by Pepperl and Fuchs, Crouse Hinds, Square D, or equal.

2.03 ELAPSED RUNTIME METERS

A. Elapsed run time meters shall be provided with high visibility 7-Digit LCD display with backlighting capability standard, long life 3 Volt lithium battery (Typical of minimum 5 years of life), accept input signals from variety of sources (Dry contact, PNP or NPN sensors) and Non-Reset type.

B. Front panel shall be NEMA 4X/IP65 rated for washdown environments.

C. Elapsed Run time Meters shall □e manufactured □□ Eagle Signal Controls, or e□ual.

2.04 TOTALIZERS

A. Totalizing counters shall □e provided for flush panel, spring-clip mounting. Face dimensions of the totalizing counters shall □e no larger than 1-1/8-inches high □□ 2-inches wide. Totalizing counters shall contain eight digits. Height of the digits shall not □e less than 5/32-inch. Numerals shall □e white on a □lack □ackground. The counter shall □e non-resetta□le and shall □e totall□ compati□le for operation on the pulses supplied □□ the associated instrument or integrator. The totalizing counter shall □e capa□le of a ma□imum count rate of 25 counts/second.

B. Legend plates shall □e provided for each of the totalizing counters with white letters on a □lack □ackground with legends as specified □elow.

C. Totalizing counters shall □e manufactured □□ Kessler-Ellis, or e□ual.

2.05 DC POWER SUPPLIES

A. DC Power Supplies converts 120 VAC to DC power at re□uired voltage, 8□□ Minimum efficienc□, Overload short circuit protection, Din Rail mounted with enclosure □Not open frame□, Switching t□pe, temperature rating 0 to □0 Degrees C

B. DC Power Suppl□ fault Hardwired dr□ contact wired to associated PLC Input for alarm.

C. Provide redundant 24 VDC modules with diode redundanc□ module for automatic switchover to stand□□ module on failure of primar□ stand□□ module.

D. UL Listed

E. DC Power Supplies Manufacturer B□ Phoeni□ Contact, Rockwell Automation, PULS, or e□ual.

2.0□ ACCESSORIES

A. Control operators such as push□uttons □PB□, selector switches □SS□, and pilot lights □PL□ shall □e Cutler-Hammer/Westinghouse T□pe E34, S□uare D Compan□ T□pe SK, or e□ual. Control operators shall □e 30.5 mm, round, heav□-dut□, oil tight NEMA 4□ corrosion resistant.

B. Push□uttons shall □e non-illuminated, spring release t□pe. Push□uttons shall include a full guard. Panic stop/alarm push□uttons shall □e red mushroom t□pe with manual-pull release. Selector switches shall □e non-illuminated, maintained contact t□pe. Pilot lights shall □e of the proper control voltage, push-to-test LED t□pe with light lens colors as specified □elow.

Color	Function
Red	Running □Open□
Green	Stopped or Off □Closed□
Am□er	Fault
White	Other

C. Control operators shall have legend plates as specified herein, indicated on the Drawings, or otherwise directed □□ the Engineer. Legend plates shall □e plastic, □lack field (background) with white lettering. Engraved nameplates shall be securely fastened above each control operator. If adequate space is not available, the nameplate shall be mounted below the operator.

D. Control operators for all equipment shall be as specified herein and of the same type and manufacturer unless otherwise specified or indicated on the Drawings.

E. Alarm horns shall be general-purpose type, panel-mounted, and shall be suitable for indoor or weatherproof service, as required. Power supply shall be either 115 VAC or 24 VDC. Horns shall be capable of producing 100 dB at 10 feet, and shall have adjustable volume. Horns shall be Vibratone series as manufactured by Federal Signal Corporation, McMaster-Carr equivalent, Edwards Signaling Company equivalent, or equal.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17500 for additional requirements.

END OF SECTION

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SECTION 175□0

SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, install and place in satisfactor□operation the surge protection devices □SPDs□as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 17100 – Control and Information S□stem Hardware, General

C. Section 17500 – Enclosures, General

D. Section 17910 – Instrument Schedule

E. Section 17950 – Functional Control Descriptions

1.03 GENERAL INFORMATION AND DESCRIPTION

A. All surge protectors of each t□pe provided under this Contract shall □e furnished □□a single manufacturer.

1.04 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall □e provided as specified in Section 17050 - Tools, Supplies and Spare Parts. In addition, the following specific spare parts items shall □e provided:

1. Five of each t□pe of surge protection device provided under this Contract.

PART 2 - PRODUCTS

2.01 SURGE PROTECTION, GENERAL

A. All electrical and electronic elements shall □e protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and near□□electrical s□stems.

B. Manufacturer□s Re□uirements: All surge protection devices shall □e manufactured □□a compan□that has □een engaged in the design, development, and manufacture of such devices for at least 5 □ears. Accepta□le manufacturers shall □e Phoeni□Contact, Schneider Electric Edco, Transtector, Weidmuller, or e□ual.

C. Surge protection device installations shall compl□with UL 94, the National Electric Code □NEC□, and all applica□le local codes.

D. Surge protection devices shall be installed as close to the equipment to be protected as practically possible.

E. Device Locations: As a minimum, provide surge protection devices at the following locations:

1. At any connections between ac power and electrical and electronic equipment, including panels, assemblies, and field mounted analog transmitters.

2. At both ends of all analog signal circuits that have any portion of the circuit extending outside of a protecting building.

3. At panel end of discrete input signals.

4. At both ends of all copper-based communication cables which extend outside of a building, including at field instruments and the field side of analog valve position signals.

5. On all external telephone communication lines.

2.02 AC POWER PROTECTION

A. Surge protection device assemblies for connections to AC power supply circuits shall:

1. Be provided with two 3-terminal barrier terminal strips capable of accepting No. 12 AWG solids or stranded copper wire. One terminal strip shall be located on each end of the unit.

2. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements. The surge protection device shall be provided with provisions for mounting to interior of equipment racks, cabinets, or to the exterior of freestanding equipment.

3. Be constructed as multistage devices consisting of gas tube arrestors, high energy metal oxide varistors, or silicon avalanche suppression diodes. Assemblies shall automatically recover from surge events, and shall have status indication lights.

4. Comply with all requirements of UL 1449, latest edition.

5. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

6. Have the following characteristics:

a. Maximum Continuous Operating Voltage: 150VAC

b. Maximum Operating Current: 20 amps

c. Ambient Temperature Range: -20 degrees C to +65 degrees C

d. Response Time: 5 nanoseconds

2.03 ANALOG SIGNAL CIRCUIT PROTECTION

A. Surge protection device assemblies for analog signal circuits shall:

1. Have four lead devices with DIN Rail mounting.
2. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.
3. Be constructed as multistage devices consisting of gas tube arrestors and silicon avalanche suppression diodes. Gas tube arrestors and diodes shall be separated by a series impedance of no more than 20 ohms. Assemblies shall automatically recover from surge events.
4. Comply with all requirements of UL 497B.
5. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.
6. Limit line-to-line voltage to 40 volts on 24VDC circuits.
7. Have the following characteristics:
   a. Maximum Continuous Operating Voltage: 28VDC
   b. Ambient Temperature Range: -20 degrees C to +65 degrees C
   c. Response Time (Line-to-Line): 5 ns

2.04 DISCRETE SIGNAL CIRCUIT PROTECTION

A. Surge protection device assemblies for discrete signal circuits shall:

   a. Mounted internally to control panels for protection of equipment connected to a discrete signal.
   b. Multi-stage hybrid solid state high performance suppression system.
   c. Designed for series connection.
   d. Enclosure: Metallic or plastic, flange or DIN rail mounting.
   e. Field connection: Provide unit with external terminal screws for line and ground conductors.
   f. Operating voltage: 24 VDC or 24 VAC or 120 VAC or as indicated on the Drawings.
   g. Modes of protection: All modes:
      1) AC applications: L-N, L-G, N-G
      2) DC applications: Pos-Neg, Pos-Gnd, Neg-Gnd.

h. Ma□imum continuous operating voltage: Less than 130□ of s□stem peak voltage.

i. Ma□imum surge current: 10,000 A.

□. Compl□ with all re□uirements of UL 497B.

2.05 COMMUNICATION CIRCUIT PROTECTION

A. Surge protection devices for copper-□ased data communication circuits shall:

1. Be designed for the specific data communication media and protocol to □e protected □i.e. telephone, serial, parallel, network, data highwa□, coa□, twina□ial, twisted pair, RF, etc.□.

2. Provide protection of equipment to within the equipment's surge withstand levels for applica□le standard test wave forms of the following standards:

a. IEC □0-1 / DIN VDE 0432 part 2

□. CCITT K17 / DIN VDE 0845 part 2

c. IEEE C□2.31

3. Have a nonflamma□le enclosure that meets or e□ceeds UL 94 V0 flamma□ilit□ re□uirements.

4. Provide automatic recover□.

<u>PART 3 - E□ECUTION</u>

3.01 RE□UIREMENTS

A. Refer to Section 17500 for additional re□uirements.

END OF SECTION

SECTION 17□00

UNPOWERED INSTRUMENTS, GENERAL

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The instrumentation subcontractor shall furnish, install, test and place in operation process instrumentation (flow elements, pressure switches, etc.) as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface all instrumentation, panels, controls and process equipment control panels with the process controls as shown on the Drawings and as specified. The Contractor may elect to install primary elements (flowmeters, etc.) on process lines provided that the instrumentation subcontractor provides full on-site supervision during installation. Mounting of associated transmitters, indicators, power supplies, brackets and appurtenances shall be provided as specified herein and shown on the Drawings.

B. It is the intent of the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The instrumentation subcontractor shall supervise installation of equipment provided under this Division where installation is provided by others.

C. Tapping and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. The Contractor shall ensure that the location, supports, orientation and dimensions of the connections and tapping for instrumentation furnished under this Division are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at <u>all</u> process taps.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17500 – Enclosures, General

C. Section 17□98 – Instrumentation and Control System Accessories

D. Section 17700 – Powered Instruments, General

E. Unpowered instruments furnished with mechanical equipment shall be furnished, installed, tested and calibrated as specified elsewhere in the Contract Documents.

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 17050.

B. In addition to the a□ove re□uirements, the instrumentation su□contractor shall provide spare parts as specified in individual instrument specification sections.

PART 2 - PRODUCTS

2.01 GENERAL

A. Unless otherwise specified, instruments shall □e provided with enclosures to suit specified environmental conditions. Field-mounted devices shall □e rugged and mounted on walls or pipe stanchions.

B. E□uipment installed in a hazardous area shall meet Class, Group, and Division as shown on the drawings, to compl□ with the national electrical code.

PART 3 - E□ECUTION

3.01 INSTALLATION

A. E□uipment shall □e located so that it is accessi□le for operation and maintenance. The instrumentation su□contractor shall e□amine the Drawings and Shop Drawings for various items of e□uipment in order to determine the □est arrangement for the work as a whole, and shall supervise the installation of process instrumentation supplied under this Division.

B. Field e□uipment shall □e wall mounted or mounted on two-inch diameter pipe stands welded to a 10-inch s□uare 1/2-inch thick □ase plate unless shown ad□acent to a wall or otherwise noted. Materials of construction shall □e aluminum or 31□ stainless steel. Instruments attached directl□ to concrete shall □e spaced out from the mounting surface not less than 1/2-inch □□ use of phenolic spacers. E□pansion anchors in walls shall □e used for securing e□uipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall □e mounted □etween 48 and □0 inches a□ove the floor or work platform.

C. Em□edded pipe supports and sleeves shall □e Schedule 40, T□pe 31□ stainless steel pipe, ASA B-3□.19, with stainless steel □lind flange for e□uipment mounting as shown on the Drawings.

D. Materials for miscellaneous mounting □rackets and supports shall □e 31□ stainless steel construction.

E. Pipe stands, miscellaneous mounting □rackets and supports shall compl□ with the re□uirements of Division 5 of the specifications.

3.02 AD□USTMENT AND CLEANING

A. The instrumentation su□contractor shall compl□ with the re□uirements of Division 1 of these Specifications and all instrumentation and control s□stem tests, inspection, and cali□ration re□uirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his designated representative□s□, reserves the right to witness an□ test, inspection, cali□ration or start-up activit□.

Acceptance by the Engineer of any plan, report or documentation relating to any testing or commissioning activity specified herein shall not relieve the Contractor of his responsibility for meeting all specified requirements.

B. The instrumentation subcontractor shall provide the services of factory trained technicians, tools and equipment to field calibrate, test, inspect and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirements, or any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Engineer, at no cost to the City. The Contractor shall bear all costs and provide all personnel, equipment and materials necessary to implement all installation tests and inspection activities for equipment specified herein.

C. At least □0 days before the anticipated initiation of installation testing, the Contractor shall submit to the Engineer a detailed description, of the installation tests to be conducted to demonstrate the correct operation of the instrumentation and control system.

D. Field instrument calibration requirements shall conform to the following:

1. The instrumentation subcontractor shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate each instrument supplied under this Contract to its specified accuracy in accordance with the manufacturer's specification and instructions for calibration.

2. Each instrument shall be calibrated at 0, 25, 50, 75 and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracy's as set forth by the National Institute for Standards and Technology (NIST).

3. The instrumentation subcontractor shall provide a written calibration sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Engineer approval prior to the start of calibration. This sheet shall include but not be limited to date, instrument tag numbers, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made.

4. If doubt exists as to the correct method for calibrating or checking the calibration of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Engineer.

5. Upon completion of calibration, devices shall not be subjected to sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to

overvoltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and recalibrated at no cost to the City.

END OF SECTION

SECTION 17□70

LEVEL SWITCHES □SUSPENDED FLOAT T□PE□

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation the float level switches, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 17□00 – Unpowered Instruments, General

PART 2 - PRODUCTS

2.01 LEVEL SWITCHES □SUSPENDED FLOAT T□PE□

A. Level switches of the direct acting float-operated design shall □e comprised of a hermeticall□sealed, appro□imatel□5 inch diameter plastic casing float, containing microswitches and fle□i□l□supported □□means of a heav□neoprene or PVC □acket, with three conductor ca□le a minimum of 20 feet in length. Unless otherwise specified, media specific gravit□is 0.95 to 1.05. Microswitches shall □e one normall□open and one normall□closed, 5A-115V AC capacit□. Float hangers and supports shall □e provided as shown on the installation detail drawings

B. All elements shall □e Factor□Mutual certified for use in Class 1, Division 1, Group C and D.

C. . Float switches shall □e Model ENM as manufactured □□Fl□gt, or e□ual.

PART 3 - E□ECUTION

3.01 RE□UIREMENTS

A. Refer to Section 17□00, Part 3 of the specifications.

END OF SECTION

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SECTION 17□98

INSTRUMENTATION AND CONTROL S□STEM ACCESSORIES

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation the instrumentation and control s□stem accessories with all spare parts, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 17□00 – Unpowered Instruments, General

C. Section 17700 – Powered Instruments, General

D. Section 1□902 – Electric Controls and Rela□s

PART 2 - PRODUCTS

2.01 INSTRUMENTATION AND CONTROL S□STEM ACCESSORIES

A. General: Accessories include various items of e□uipment that ma□ □e re□uired in the s□stem □ut are not scheduled. Accessories are shown on details, flow sheets or plans. Accessories are also called out in specifications for scheduled instruments and in the installation specifications. It is not intended, however, that each piece of hardware re□uired will □e specificall□descri□ed herein. This su□article shall □e used as a guide to □ualif□re□uirements for miscellaneous hardware whether the specific item is descri□ed or not.

B. Process Tu□ing: Process tu□ing shall □e 1/2 □0.0□5-inch seamless, annealed, ASTM A-2□9 T□pe 31□L stainless steel with T□pe 31□ - 37 degrees stainless steel flared fittings or Swagelock or Parker-CPI flareless fittings.

C. Power, Control and Signal Ca□les: Power, control and signal wiring shall □e provided under Division 1□ of the Specifications.

D. Chemical Diaphragm Seals: Diaphragm seals shall □e provided for isolation of pressure gauges, switches and transmitters attached to s□stems containing chemical solutions or corrosive fluids. As a minimum, seals shall □e of all 31□ stainless steel construction. In general, diaphragms shall □e 31□L stainless steel for operating pressures at or a□ove 15 psi and elastomers for operating pressures □elow 15 psi. However, all components shall □e non-reactive with the process fluid in all cases. Refer to the Instrument Schedules for specific materials re□uirements. Seal shall have fill connection, 1/4-inch NPT valved flush port and capa□le of disassem□l□without loss of filler fluid. Where specified, diaphragm seals shall compl□with the a□ove requirements and shall be provided with 316 SS factory filled capillaries. Seals shall be Helicoid Type 100 HA, Mansfield & Green, Ashcroft, or equal.

E. Isolating Ring Seals: For solids bearing fluids, line pressure shall be sensed by a flexible cylinder lining and transmitted via a captive sensing liquid to the associated pressure sensing instrument(s).

1. Full Line Size Isolating Ring Seals - For all grit/sludge/slurry/scum applications or wherever the associated pressure instrument is used for control purposes, the sensor body shall be full line size wafer design. Except where noted on the Drawings and/or Instrument Schedule, full line size ring seals will not be required for return activated sludge (RAS) lines, but will have tapped ring seals as specified in Item 2, below. Full line size isolating ring seals shall have 316 stainless steel housing and assembly flanges and Buna N flexible cylinder lining for in-line mounting. The wafer shall have through bolt holes or centerline gauge for positive alignment with the associated flanged piping. The captive liquid chamber and associated instrument(s) shall be furnished with threaded drain tap and plug. Isolating ring seals shall be RED Valve Series 40, Ronningen-Petter Iso-Ring, Moyno RKL Series W, Onyx Isolator Ring, or equal.

2. Tapped Isolating Ring Seals - For all other solids bearing fluids, pressure shall be sensed via a minimum 1/2" diameter spool-type isolating ring seal mounted on a 1/2" pipe nipple at 90° from the process piping. An isolation ball valve shall be provided between the process piping and the ring seal, and a cleanout ball valve shall be provided between the ring seal and the atmosphere. The pressure instrument shall be back or side mounted to the ring seal such that the gauge or readout may be viewed normally. Tapped isolating ring seals for solids service shall be Red Valve Series 42/742, Ronningen-Petter Iso-Spool, Onyx Isolator Ring, or equal.

F. Filling Medium: The filling medium between instruments, isolating ring seals and diaphragm seals shall be a liquid suitable for operation in an ambient temperature ranging from -10°F to +150°F. Filling medium shall be silicone unless oxidizing agents such as sodium hypochlorite are present, where halocarbon shall be used.

G. Isolation Valves: Isolation valves shall be 1/2 - inch diameter ball valves with 316 stainless steel body, 316 stainless steel ball, except that materials of construction shall be suitable for the associated process fluid where applicable (i.e., chemical service).

H. Sirens: Sirens shall be UL Listed, heavy duty, AC motor driven, weatherproof type capable of producing a minimum of 111 dBA at 10 feet. Power supply shall be 120 VAC, 60 hertz. Siren shall be McMaster-Carr Model 6392T11, Federal Signal Corporation equivalent, Edwards Signaling Company equivalent, or equal.

I. Strobe Lights: Strobe lights shall be high profile with Type 304 stainless steel base. Light is rated NEMA 4X. Light shall have an outer dome to provide extra lens protection. Lens color shall be red. Surface mount hardware shall be included. Power supply shall be 120 VAC, 60 hertz. Strobe light shall be McMaster-Carr Model 5848T71, Federal Signal Corporation equivalent, Edwards Signaling Company equivalent, or equal.

PART 3 - E□ECUTION

3.01 RE□UIREMENTS

A. Refer to Section 17□00, Part 3 of the specifications.

END OF SECTION

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SECTION 17700

POWERED INSTRUMENTS, GENERAL

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The instrumentation su□contractor shall furnish, install, test and place in operation powered process instrumentation □flow elements, level transmitters, etc.□as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface all instrumentation, panels, controls and process e□uipment control panels with the process control s□stem as shown on the Drawings and as specified. Powered instruments are those instruments that re□uire power □120 VAC or 24 VDC loop power□ to operate. The Contractor ma□elect to install primar□elements □flowmeters, etc.□on process lines provided that the instrumentation su□contractor provides full on-site supervision during installation. Mounting of associated transmitters, indicators, power supplies, □rackets and appurtenances shall □e provided as specified herein and shown on the Drawings.

B. It is the intent of the Contract Documents that all process taps, isolation valves, nipples, penetrations, em□edded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall □e provided under this Contract. The instrumentation su□contractor shall supervise installation of e□uipment provided under this Division where installation is provided □□ others.

C. Tapping and connections for primar□process sensors shall □e sized to suit each individual installation and the re□uirements of the instrument served. The Contractor shall ensure that the location, supports, orientation and dimensions of the connections and tapping for instrumentation furnished under this Division are such as to provide the proper □racing, the re□uired accurac□of measurement, protection of the sensor from accidental damage, and accessi□ilit□for maintenance while the plant is in operation. Isolation valves shall □e provided at <u>all</u> process taps.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 17500 – Enclosures, General

C. Section 17□00 – Unpowered Instruments, General

D. Section 17□98 – Instrumentation and Control S□stem Accessories

E. Powered instruments furnished with mechanical e□uipment shall □e furnished, installed, tested and cali□rated as specified elsewhere in the Contract Documents.

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall □e provided as specified in Section 17050.

B. In addition to the above requirements, the instrumentation subcontractor shall provide one remote handheld configuration device for communication with all "smart" instruments furnished under this Contract. The devices shall be capable of performing configuration, test, and format functions from anywhere on the 4-20 mA signal loop for a particular transmitter or by direct connection. The configuration device shall be Fischer & Porter Model 50HC1000, Rosemount Model 375, or equal.

PART 2 - PRODUCTS

2.01 GENERAL

A. All instrumentation supplied shall be the manufacturer's latest design. Unless otherwise specified, instruments shall be solid state, electronic, using enclosures to suit specified environmental conditions. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings, or as required.

B. Equipment installed in a hazardous area shall meet Class, Group, and Division as shown on the Drawings, to comply with the National Electrical Code.

C. All field instrumentation for outdoor service shall be provided with enclosures which are suitable for outdoor service, as follows:

1. Where the manufacturer's enclosures are suitable for outdoor service, they shall be provided with instrument sunshades. Sunshades shall be Style E as manufactured by O'Brien Corporation, or equal. Where possible, these instruments shall be mounted in a north facing direction.

2. Where the manufacturer's standard enclosures are not suitable for outdoor service, instruments shall be mounted in Field Panels in accordance with Section 17520, Field Panels, or may be furnished with Vipak instrument field enclosures as manufactured by O'Brien Corporation, equivalent by Intertec, or equal. It shall not be necessary to provide the manufacturer's NEMA 4 or 4X enclosures for instruments that will be subsequently mounted in separate field panels.

D. All instruments shall return to accurate measurement without manual resetting upon restoration of power after a power failure.

E. Unless otherwise shown or specified, local indicators shall be provided for all instruments. Where instruments are located in inaccessible locations, local indicators shall be provided and shall be mounted as specified in Subsection 3.01 (B) herein. All indicator readouts shall be linear in process units. Readouts of 0-100% shall not be acceptable (except for speed and valve position). Isolated outputs shall be provided for all transmitters.

F. Unless otherwise specified, field instrument and power supply enclosures shall be 316 stainless steel, fiberglass or PVC coated copper-free cast aluminum NEMA 4X construction.

G. Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.

H. Electronic equipment shall utilize printed circuitry and shall be coated (tropicalized) to prevent contamination by dust, moisture and fungus. Solid-state components shall be conservatively rated for long-term performance and dependability over ambient atmosphere fluctuations. Ambient conditions shall be -20 to 50 degrees C and 20 to 100 percent relative humidity, unless otherwise specified. Field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.

I. All devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production. All equipment provided, where applicable, shall be of modular construction and shall be capable of field expansion.

J. All non-loop-powered instruments and equipment shall be designed to operate on a 60 Hz AC power source at a nominal 117 V, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

K. All analog transmitter and controller outputs shall be isolated, 4-20 milliamps into a load of 0-750 ohms, unless specifically noted otherwise. All switches shall have double-pole, double-throw contacts rated at a minimum of □00 VA, unless specified otherwise.

L. Materials and equipment used shall be UL approved wherever such approved equipment and materials are available.

<u>PART 3 - EXECUTION</u>

3.01 INSTALLATION

A. General

1. Equipment shall be located so that it is accessible for operation and maintenance. The instrumentation subcontractor shall examine the Drawings and shop drawings for various items of equipment in order to determine the best arrangement for the work as a whole, and shall supervise the installation of process instrumentation supplied under this Division.

2. Electrical work shall be performed in compliance with all applicable local codes and practices. Where the Contract Documents do not delineate precise installation procedures, API RP550 shall be used as a guide to installation procedures.

B. Equipment Mounting and Support

1. Field equipment shall be wall mounted or mounted on two-inch diameter pipe stands welded to a 10-inch square by 1/2-inch thick base plate unless shown

ad□acent to a wall or otherwise noted. Materials of construction shall □e aluminum or 31□ stainless steel. Instruments attached directl□ to concrete shall □e spaced out from the mounting surface not less than 1/2-inch □□ use of phenolic spacers. E□pansion anchors in walls shall □e used for securing e□uipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall □e mounted □etween 48 and □0 inches a□ove the floor or work platform.

2. Em□edded pipe supports and sleeves shall □e schedule 40, 31□ stainless steel pipe, ASA B-3□.19, with stainless steel □lind flange for e□uipment mounting as shown on the Drawings.

3. Materials for miscellaneous mounting □rackets and supports shall □e 31□ stainless steel construction.

4. Pipe stands, miscellaneous mounting □rackets and supports shall compl□ with the re□uirements of Division 5 of the specifications.

5. Transmitters shall □e oriented such that output indicators are readil□ visi□le.

C. Control and Signal Wiring

1. Electrical, control and signal wiring connections to transmitters and elements mounted on process piping or e□uipment shall □e made through li□uid-tight fle□i□le conduit. Conduit seals shall □e provided where conduits enter all field instrument enclosures and all ca□inetr□ housing electrical or electronic e□uipment.

3.02 AD□USTMENT AND CLEANING

A. General

1. The instrumentation su□contractor shall compl□ with the re□uirements of Division 1 of these Specifications and all instrumentation and control s□stem tests, inspection, and cali□ration re□uirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his designated representative□s□, reserves the right to witness an□ test, inspection, cali□ration or start-up activit□. Acceptance □□ the Engineer of an□ plan, report or documentation relating to an□ testing or commissioning activit□ specified herein shall not relieve the Contractor of his responsi□ilit□ for meeting all specified re□uirements.

2. The instrumentation su□contractor shall provide the services of factor□ trained technicians, tools and e□uipment to field cali□rate, test, inspect and ad□ust each instrument to its specified performance re□uirement in accordance with manufacturer□s specifications and instructions. An□ instrument which fails to meet an□ Contract re□uirements, or an□ pu□lished manufacturer performance specification for functional and operational parameters, shall □e repaired or replaced, at the discretion of the Engineer, at no cost to the Cit□. The Contractor shall □ear all costs and provide all personnel, e□uipment and materials necessar□ to implement all installation tests and inspection activities for e□uipment specified herein.

3. At least □0 da□s □efore the anticipated initiation of installation testing, the Contractor shall su□mit to the Engineer a detailed description, of the installation

tests to be conducted to demonstrate the correct operation of the instrumentation supplied hereunder.

B. Field Instrument Calibration Requirements

1. The instrumentation subcontractor shall provide the services of factory trained instrumentation technicians, tools and equipment to field calibrate each instrument supplied under this Contract to its specified accuracy in accordance with the manufacturer's specification and instructions for calibration.

2. If the manufacturer's recommendations require calibration, each instrument shall be calibrated at 0, 25, 50, 75 and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five (5) times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracy's as set forth by the National Institute for Standards and Technology (NIST).

3. The instrumentation subcontractor shall provide a written calibration sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. The Contractor shall submit proposed calibration sheets for various types of instruments for Engineer approval prior to the start of calibration. This sheet shall include but not be limited to date, instrument tag numbers, calibration data for the various procedures described herein, name of person performing the calibration, a listing of the published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required and corrections made.

4. If doubt exists as to the correct method for calibrating or checking the calibration of an instrument, the manufacturer's printed recommendations shall be used as an acceptable standard, subject to the approval of the Engineer.

5. Upon completion of calibration, devices calibrated hereunder shall not be subjected to sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices from being subjected to overvoltages, incorrect voltages, overpressure or incorrect air. Damaged equipment shall be replaced and recalibrated at no cost to the City.

6. After completion of instrumentation installation, the instrumentation subcontractor shall perform a loop check. The Contractor shall submit final loop test results with all instruments listed in the loop. Loop test results shall be signed by all representatives involved for each loop test.

END OF SECTION

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SECTION 17745

RADAR LEVEL MEASUREMENT SYSTEMS

PART 1 - GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the radar liquid level measurement systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17700 – Powered Instruments, General

PART 2 - PRODUCTS

2.01 NON-CONTACT RADAR LEVEL TRANSMITTER

A. The radar level sensor shall operate on the frequency modulated continuous wave (FMCW) radar signaling technology at approximately 80 GHz frequency sweep. Sensor accuracy shall be a minimum of ±0.4 inches. Resolution shall be at least 0.1 percent of full range or ±0.01 inch, whichever is greater. The instrument shall be repeatable to ±0.02 inch.

B. The radar level transmitter shall allow complete field configuration of all settings and control modes of the system via Bluetooth. The unit shall provide level monitoring and volumetric calculation. Output level signal shall be linear, isolated 4-20 mA DC superimposed with a HART digital signal. Power requirement for the transmitter shall be 24 VDC, two-wire design.

C. All elements shall be Factory Mutual certified for use in Class 1, Division 1, Groups C and D.

D. Each radar level measurement system shall include a radar level sensor/transmitter with the following specifications:

1. Enclosure: IP66/IP68, NEMA Type 4X
2. Read Mounting Threads: 1” NPT
3. Sensor/Transmitter Signal Output: Two-wire 4-20mA/HART
4. Radar Beam Angle: 8°
5. Radar Frequency: 80 GHz
6. Radar Range: 0-49.2’

7. Antenna T□pe: Plastic Horn Antenna
8. Sensor Materials: PVDF
9. Wireless Ad□ustment: via radar manufacturer Bluetooth phone or ta□let app.
10. Displa□: None
11. Approvals: c-UL-us
12. Certificates: Factor□approved inspection certificate with test data
13. Temperature: Suita□le for operating in am□ient temperature range of -40 to 17□□F.
14. Manufacturers: Radar level sensor/transmitter shall □e VEGAPULS C 21 as manufactured □□VEGA, or Engineer approved e□ual 80 GHz e□uivalent □□ Siemens, or Endress and Hauser.

<u>PART 3 - E□ECUTION</u>

3.01 RE□UIREMENTS

A. Refer to Section 17700, Part 3 of the Specifications.

END OF SECTION

SECTION 177□0

PRESSURE INDICATING TRANSMITTERS

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation the pressure indicating transmitters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information S□stem Scope and General Re□uirements

B. Section 17700 – Powered Instruments, General

PART 2 - PRODUCTS

2.01 GAUGE PRESSURE INDICATING TRANSMITTERS

A. Gauge pressure transmitters shall □e of the capacitance t□pe with a process-isolated diaphragm with silicone oil fill, microprocessor-□ased "smart" electronics, and a field ad□usta□le rangea□ilit□of 100:1 input range. Span and zero shall □e continuousl□ ad□usta□le e□ternall□over the entire range. Span and zero ad□ustments shall □e capa□le of □eing disa□led internall□. Transmitters shall □e NEMA 4□ weatherproof and corrosion resistant construction with low-copper aluminum □od□and 31□stainless steel process wetted parts. Accurac□, including nonlinearit□, h□steresis and repeata□ilit□ errors shall □e plus or minus 0.025 percent of cali□rated span, zero □ased. The ma□imum zero elevation and ma□imum zero suppression shall □e ad□usta□le to an□where within sensor limits. Output shall □e linear isolated 4-20 milliamperes 24 VDC. Power suppl□shall □e 24 VDC, two-wire design. Each transmitter shall □e furnished with a 4-digit LCD indicator capa□le of displa□ing engineering units and/or milliamps and mounting hardware as re□uired. Overload capacit□shall □e rated at a minimum of 25 MPa. Environmental limits shall □e -40 to 85 degrees Celsius at 0-100□ relative humidit□. Each transmitter shall have a stainless steel tag with cali□ration data attached to □od□.

B. The piezoresistive silicon pressure sensor shall □e mechanicall□, electricall□, and thermall□isolated from the process and the environment, shall include an integral temperature compensation sensor, and shall provide a digital signal to the transmitter□s electronics for further processing. Factor□set correction coefficients shall □e stored in the sensor□s non-volatile memor□for correction and linearization of the sensor output in the electronics section. The electronics section shall correct the digital signal from the sensor and convert it into a 4-20 mA analog signal for transmission to receiving devices. The electronics section shall contain configuration parameters and diagnostic data in non-volatile EEPROM memor□and shall □e capa□le of communicating, via a digital signal superimposed on the 4-20 mA output signal, with a remote interface device. Output signal damping shall □e provided, with an ad□usta□le time constant of

0-3□ seconds. Total long term stability (frequency of calibration) shall be not less than 0.20□ URL for 15 years.

C. Where scheduled, gauge pressure indicating transmitters shall be calibrated in feet of liquid for liquid level service.

D. All elements shall be Factory Mutual certified for use in Class 1, Division 1, Group C and D.

E. Gauge pressure indicating transmitters shall be Model 3051S1TG as manufactured by Emerson Process Management (Rosemount), or equal.

2.02 PRESSURE INDICATORS

A. Pressure Gauge - Mechanical:

1. Manufacturers:

   a. Ametek / USGauge (Solfrunt Model 1980).

   b. Ashcroft (Type 1279 or 1379).

2. Materials:

   a. Bourdon tube, socket, connecting tube: 316 stainless steel.

   b. Case: Phenolic.

   c. Pressure snubber:

      1) Filter disc: 316 stainless steel.

      2) Housing:316 stainless steel.

3. Accessories:

   a. Provide valve at point of connection to equipment and at panel if panel mounted.

   b. Utilize pressure snubber with porous metal discs to provide pulsation dampening on gauge applications as shown on schedule.

   c. Provide 1/2 inches stainless steel anti-siphon pigtail inlet connection for hot water and steam applications.

4. Design and fabrication:

   a. All components suitable for service at:

      1) 250 degrees F.

      2) The maximum process temperature to which the gauge is to be exposed.

   b. Provide viewer protection from element rupture.

c. Calibrate gauges at jobsite for pressure and temperature in accordance with manufacturer's instructions.

d. Unless otherwise required by codes, provide stem mounted or flush mounted, as required, with dial diameter as follows:

PIPE SIZE	DIAL SIZE	GAUGE CONNECTION
1-1/2 inches or less	2-1/2 inches	1/4 inches
Larger than 1-1/2 inches	4-1/2 inches	1/2 inches

e. Equip with white faces, black numerals and black pointers.

f. Gauge tapping position to be clear of equipment functions and movements, and protected from maintenance and operation of equipment.

   1) Gauge to be readable from an accessible standing position.

g. Gauge accuracy: 1% of full range.

h. Select gauge range so that:

   1) The normal operating value is in the middle third of the dial.

   2) Maximum operating pressure does not exceed 75% of the full scale range.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 17700, Part 3 of the Specifications.

END OF SECTION

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SECTION 17910

INSTRUMENT SCHEDULE

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation all instrumentation as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17920 – Control S□stem Input/Output Schedule

B. Section 17950 – Functional Control Descriptions

PART 2 - INSTRUMENT SCHEDULE

LEVEL SWITCHES □SUSPENDED FLOAT□- SECTION 17□70			
Tag Num□er	Service Description	State/Span	Remarks
LSHH-1011	Pump Station High-High Level	□4.0 FT	
LSLL-1011	Pump Station Low-Low Level	-9.0 FT	
LSH-1011	Sump Level Alarm High	□2.5 FT	
PRESSURE TRANSMITTERS - SECTION 177□0			
Tag Num□er	Service Description	State/Span	Remarks
PI-1001	Storm Water Pump No. 1 Discharge Pressure	0-50 PSI	
PI-1002	Storm Water Pump No. 2 Discharge Pressure	0-50 PSI	
PI-1003	Storm Water Pump No. 3 Discharge Pressure	0-50 PSI	
PIT-1001	Storm Water Pump No. 2 Discharge Pressure	0-50 PSI	
Radar Level Transmitters - Section 17745			
Tag Num□er	Service Description	State/Span	Remarks
LIT-1011	Pump Station Level	-13.0 FT to □4.0 FT	

END OF SECTION

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SECTION 17920

CONTROL S□STEM INPUT-OUTPUT SCHEDULE

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation all control s□stem inputs and outputs as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17910 – Instrument Schedule

B. Section 17920 – Control S□stem Input/Output Schedule

C. Section 17950 – Functional Control Descriptions

PART 2 - CONTROL S□STEM INPUT / OUTPUT SCHEDULE

TAG NUMBER	SERVICE DESCRIPTION	STATE/SPAN	T□PE	REMARKS
LI-1011	WET WELL PUMP STATION LEVEL	-13.0 FT to □4.0 FT	AI	
LAHH-1011	WET WELL PUMP STATION HIGH-HIGH LEVEL ALARM	□4.0 FT	DI	
LALL-1011	WET WELL PUMP STATION LOW-LOW LEVEL ALARM	-9.0 FT	DI	
LAH-1011	SUMP HIGH LEVEL	□2.5 FT	DI	
PI-1001	WET WELL PUMPS DISCHARGE PRESSURE	0-50 PSI	AI	
TAH-1001	WET WELL PUMP NO. 1 HIGH TEMPERATURE ALARM		DI	
MAH-1001	WET WELL PUMP NO. 1 MOISTURE ALARM HIGH		DI	
□CR-1001	WET WELL PUMP NO. 1 START/STOP		DO	
□LR-1001	WET WELL PUMP NO. 1 RUN STATUS		DI	
□A-1001	WET WELL PUMP NO. 1 FAULT		DI	
□L-1001	WET WELL PUMP NO. 1 IN REMOTE		DI	
□L-1001A	WETWELL PUMP NO.1 IN AUTO □RVSS□		DI	
TAH-1002	WET WELL PUMP NO. 2 HIGH TEMPERATURE ALARM		DI	
MAH-1002	WET WELL PUMP NO. 2 MOISTURE ALARM HIGH		DI	
□CR-1002	WET WELL PUMP NO. 2 START/STOP		DO	
□LR-1002	WET WELL PUMP NO. 2 RUN STATUS		DI	

TAG NUMBER	SERVICE DESCRIPTION	STATE/SPAN	T□PE	REMARKS
□A-1002	WET WELL PUMP NO. 2 FAULT		DI	
□L-1002	WET WELL PUMP NO. 2 IN REMOTE		DI	
□L-1002A	WETWELL NO.2 IN AUTO □RVSS□		DI	
TAH-1003	WET WELL PUMP NO. 3 HIGH TEMPERATURE ALARM		DI	
MAH-1003	WET WELL PUMP NO. 3 MOISTURE ALARM HIGH		DI	
□CR-1003	WET WELL PUMP NO. 3 START/STOP		DO	
□LR-1003	WET WELL PUMP NO. 3 RUN STATUS		DI	
□A-1003	WET WELL PUMP NO. 3 FAULT		DI	
□L-1003	WET WELL PUMP NO. 3 IN REMOTE		DI	
□L-1003A	WETWELL PUMP NO.3 IN AUTO □RVSS□		DI	
□A-1001B	PERSONNEL EMERGENC□ □E-STOP ENGAGED□		DI	
□□-1051	GENERATOR LOW VOLTAGE IN BATTER□		DI	
□LR-1051	GENERATOR RUNNING		DI	
LAL-1051	GENERATOR LEVEL ALARM LOW FUEL		DI	
LA-1051	GENERATOR LEAK ALARM		DI	
LAH-1051	LEVEL ALARM HIGH FUEL			
□A-1051	GENERATOR FAULT		DI	
□□-1051	ATS POWER STATUS		DI	
ZLO-1051	ATS OPEN POSITION		DI	
□A□-1051	ATS MALFUNCTION		DI	
□A-1001A	UPS LOSS OF AC		DI	
□A-1001B	UPS LOW BATTER□		DI	
□A-1001C	24 VDC POWER SUPPL□ NO.1 FAIL		DI	
□A-1001D	24 VDC POWER SUPPL□ NO.1 FAIL		DI	
ZAO-10□1	ELECTRICAL BUILDING INTRUSION DETECTION ALARM		DI	

Notes:

1. Input/Output t□pes are as follows:
   - DI - Discrete Input
   - DO - Discrete Output
   - AI - Analog Input
   - AO - Analog Output

END OF SECTION

SECTION 17950

FUNCTIONAL CONTROL DESCRIPTIONS

PART 1 - GENERAL

1.01 THE RE□UIREMENT

A. The Contractor shall furnish, test, install and place in satisfactor□operation all e□uipment as herein specified and as shown on the Drawings. THE CONTRACTOR SHALL BE RESPONSIBLE FOR FURNISHING COMPLETE FUNCTIONING S□STEMS AS DESCRIBED HEREIN.

B. Together with the control s□stem input/output schedule, the e□uipment specifications □including functional descriptions for local e□uipment control panels□, and the Drawings, the functional control descriptions descri□e the re□uired operation, monitoring, and control of the facilities included in this Contract.

C. THE FUNCTIONAL DESCRIPTIONS CONTAIN RE□UIREMENTS FOR FURNISHING AND INSTALLING LABOR AND MATERIALS THAT MA□ NOT APPEAR ELSEWHERE IN THE CONTRACT DOCUMENTS.

D. All e□uipment and services re□uired in e□uipment local control panels provided to implement the monitoring and control functions descri□ed herein or in the process input/output schedules shall □e provided □□the Contractor through individual e□uipment suppliers.

E. Unless specificall□stated otherwise, all interconnected wiring □etween all instruments, panels, controls, and other devices listed in the functional descriptions as re□uired to provide all functions specified herein shall □e furnished □□the electrical su□contractor under Division 1□. The electrical su□contractor shall provide all ca□le and conduit re□uired to carr□all signals listed in the process input/output schedules. Special ca□les that are re□uired for interconnection □etween sensors or pro□es and transmitters or signal conditioners shall □e furnished with the instrumentation devices □□the e□uipment supplier.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01520 – Maintenance of Utilit□Operations During Construction

B. Section 17910 – Instrument Schedule

C. Section 17920 – Control S□stem Input/Output Schedule

PART 2 - FUNCTIONAL CONTROL DESCRIPTIONS, GENERAL

2.01 DEFINITIONS

A. RUNNING status signals shall □e from au□iliar□contacts provided with the motor control e□uipment □i.e., starter, VFD, SCR, etc.□.

B. AUTO status signals shall be defined as HAND-OFF-AUTO switch in the AUTO position or process control system in AUTO (versus MANUAL).

C. FAIL status signals shall be defined as motor overload and/or any other shut down mode such as overtorque, overtemperature, low oil pressure, high vibration, etc.

D. READY status signal shall be defined as all conditions, including equipment control power, satisfied to permit remote control of the equipment.

2.02 CONVENTIONS

A. Operator workstation graphic display symbols and indicator lights on all MCC's, control panels, starter enclosures, etc. shall conform to the following color convention:

Condition	Color
Running/On/Open	Red
Auto/Ready	White
Stopped/Off/Closed	Green
Fail/Alarm	Amber
Generic Status	Blue or White

2.03 PROCESS CONTROL

A. Where setpoints, operating limits, and other control settings are provided by the functional descriptions, these settings shall be initial settings only and shall be used for assistance in the initial startup of the plant. All such settings shall be fully adjustable and, based on actual operating conditions, the instrumentation subcontractor shall make all necessary adjustments to provide smooth, stable operation at no additional cost to the Owner.

B. Provision shall be made in PLC logic to suppress nuisance alarms and control actions by the following means:

1. For alarms and control actions derived from analog input signals, use adjustable time delays and deadbands.

2. For alarms and control actions derived from discrete input signals, use adjustable time delays.

3. Initial settings for time delays shall be 10 seconds (range 0-120 seconds). Initial settings for deadbands shall be 5% of span (range 0-100%).

4. Equipment that is started or stopped manually by the operator shall start or stop immediately, with no time delay.

C. All setpoint control shall be by PID control algorithms. Where only proportional control is specified, tuning constants shall be used to reduce the Integral and Derivative functions to zero. All setpoints, sequence times, sequence orders, dead bands, PID tuning parameters, PLC delay timers, variable speed operating range limits, and similar control constants shall be accessible and alterable from the operator workstations.

D. Unless otherwise specified, all equipment shall automatically restart after a power failure utilizing adjustable start delay timers in PLC control logic. Unless otherwise specified, all PLC control strategies shall be based upon automatic restart after a power failure and shall return to a normal control mode upon restoration of power.

E. The PLC shall be capable of receiving initial run-time values for existing and proposed equipment. Initial run-time shall not automatically be assumed to be zero.

F. A control discrepancy alarm shall be generated through the PLC for any drive, motor, etc. for which a command has been issued, but for which the PLC is not receiving a confirming status signal (e.g., start command with no run feedback). The failure shall be logged.

G. An instrument failure alarm shall be generated for any instrument which is generating a signal that is less than 4 mA or greater than 20 mA.

H. Unless otherwise specified in an individual control description, an instrument failure or control discrepancy alarm shall cause the control strategy to maintain last values and to generate an alarm. Manual initiation of the automatic control strategy shall be required.

I. A control program that controls multiple pieces of equipment shall not be prevented from running because not all of the equipment is in AUTO. If equipment within an equipment chain is required to be running for program operation and it is running in HAND or MANUAL, then the program shall run and control the other equipment that is in AUTO.

J. All PLC wait states (internal time delays, etc.) after an operator action shall be displayed on the operator workstation.

PART 3 - FUNCTIONAL CONTROL DESCRIPTIONS

3.01 FUNCTIONAL / EQUIPMENT TITLE

A. Stormwater Pumps

1. General Description:

   a. The Progresso Village Pump Station shall convey stormwater received in the station wetwell to an effluent force main. The pump station shall be equipped with three submersible pumps powered by reduced voltage solid state starters (RVSSs) and controlled by a local control panel, LCP-11843, equipped with a programmable logic controller, PLC-11843.

   b. PLC-11843 shall monitor wetwell level via a radar level indicating transmitter, LIT-1011, and automatically start and stop pumps based on operator adjustable wetwell elevations defined herein.

   c. LCP-11843 shall be equipped with an operator interface terminal (OIT) for pump station monitoring and set-point adjustment.

2. Major Equipment:

   a. Stormwater Pumps: P-1001, P-1002, P-1003

   b. Local Control Panel: LCP-11843

3. Major Instrumentation:

a. Level Transmitter: LIT-1011

b. Level Switches: LSHH-1011, LSLL-1011, LSH-1011

c. Pressure Transmitter: PIT-1001

d. Pump Motor High Temperature Switches: TSH-1001, TSH-1002, TSH-1003

e. Pump Motor Leak Detection Switches: MSH-1001, MSH-1002, MSH-1003

4. Control Modes:

a. Local Manual

b. Local Auto

c. SCADA Manual

d. SCADA Auto

5. Detailed Control Strategy:

a. Local Manual (RVSS):

1) Control is from HAND/OFF/AUTO selector switch on the pump RVSS.

2) When the HAND/OFF/AUTO selector switch on the RVSS is in HAND, the pump can be started and stopped by pressing the START/STOP pushbuttons on the front of the RVSS enclosure.

3) When the HAND/OFF/AUTO selector switch on the RVSS is in OFF the pump shall be inhibited from starting from any location.

4) When the HAND/OFF/AUTO selector switch on the RVSS is in AUTO, control of the pump is transferred to LCP-11843.

b. Local Auto (Pump station LCP-11843):

1) Control is from the LOCAL/REMOTE selector switch located on LCP-11843.

2) When the HAND/OFF/AUTO selector switch on the RVSS is in AUTO, and the LOCAL/REMOTE selector switch at LCP-11843 is LOCAL, control of the pump shall be from PLC-11843. Remote control of the pump from the SCADA HMI shall be disabled.

3) The pumps shall be called to start/stop in a LEAD-LAG1-LAG2 configuration based on the wetwell level following an operator adjustable delay timer (initially set at 3 seconds). The pump start/stop level setpoints and delay timer shall be adjustable from the local OIT and remotely from the SCADA HMI. The pump start/stop level setpoints shall be initially set to the values shown in Table 1 below.

Table 1 Pump Control Elevations

CONTROL ACTION	LEVEL SETPOINT

HIGH-HIGH LEVEL ALARM (FLOAT)	EL. 4.0
LAG2 PUMP ON	EL. 3.0
LAG1 PUMP ON	EL. 2.0
LEAD PUMP ON	EL. 1.0
ALL PUMP OFF	EL. -□.0
LOW LEVEL ALARM	EL. -7.0
LOW-LOW LEVEL ALARM (FLOAT)	EL. -9.0

c. SCADA Manual:

1) Control is from the LOCAL/REMOTE selector switch located at LCP-11843 and a MANUAL/AUTO software switch located on the SCADA HMI.

2) When the HAND/OFF/AUTO selector switch on the RVSS is in AUTO, the LOCAL/REMOTE switch at LCP-11843 is in REMOTE, and the MANUAL/AUTO software switch on the SCADA HMI is in MANUAL, the operator shall be able to start/stop the pump from the SCADA HMI.

d. SCADA Auto:

1) Control is from the LOCAL/REMOTE selector switch located at LCP-11843 and a MANUAL/AUTO software switch located on the SCADA HMI.

2) When the HAND/OFF/AUTO selector switch on the RVSS is in AUTO, the LOCAL/REMOTE switch at LCP-11843 is in REMOTE, and the MANUAL/AUTO software switch on the SCADA HMI is in AUTO, control of the pump shall be from PLC-11843.

3) The pumps shall be called to start/stop in a LEAD-LAG1-LAG2 configuration based on the wetwell level following an operator adjustable delay timer (initially set at 3 seconds). The pump start/stop level setpoints and delay timer shall be adjustable from the local OIT and remotely from the SCADA HMI. The pump start/stop level setpoints shall be initially set to the values shown in Table 1 above.

e. For pump rotation, a MANUAL/AUTO pump designation software switch shall be shown on the OIT and SCADA HMI. In MANUAL, the operator shall be able to designate the LEAD-LAG1-LAG2 pumps manually. In AUTO, the PLC shall automatically alternate the LEAD-LAG1-LAG2 pump designations based on an operator adjustable timer, or after each pump shutdown.

□. Interlocks:

a. Hardwired Interlocks:

1) None.

b. Software Interlocks:

1) High Temperature: A High Temperature indication will automatically shut down the respective pump and a “High Temperature” alarm shall be displayed on the local OIT and SCADA HMI.

2) Motor Leak: A Motor Leak indication will automatically shut down the respective pump and a “Motor Leak” alarm shall be displayed on the local OIT and SCADA HMI.

3) Wetwell Low-Low Level: When the Low-Low level switch is activated, an alarm shall be displayed on the local OIT and SCADA HMI. The Low-Low level alarm shall be configured as a selectable software interlock from the local OIT and SCADA HMI that will disable all pumps.

7. Displays at City SCADA HMI and Local OIT:

a. Stormwater Pumps (3):

1) Status:

a) Running

b) In Remote

2) Alarms:

a) Fault

b) High Temperature

c) Motor Leak

3) Control:

a) Remote Pump Control (Manual/Auto)

b) Pump Rotation (Manual/Auto)

c) Low-Low Level Software Interlock (Enable/Disable)

d) Pump Level Setpoints (See Table 1)

b. Additional Instrumentation and Equipment:

1) Status:

a) Wetwell Level

b) Force Main Discharge Pressure

2) Alarms:

a) Wetwell High-High Level

b) Wetwell Low-Low Level

c) Vault High Level

3) Control:

a) None

B. Generator and ATS

1. General Description:

a. The Progresso Village Pump Station Generator system shall consist of a diesel standby generator, GEN-1051, housed in the generator enclosure adjacent to the pump station building. The generator shall be equipped with a vendor furnished generator control panel which shall monitor and control all generator functions and monitor the automatic transfer switch, ATS-1051. LCP-1051 shall provide generator status indication to the City's SCADA system.

2. Major Equipment

a. Generator: GEN-1051

3. Major Instrumentation

a. Level Switches: LS-1051, LSL-1051, LSH-1051

4. Control Modes:

a. By Generator Vendor.

5. Detailed Control Description:

a. By Generator Vendor.

6. Interlocks:

a. By Generator Vendor.

7. Displays at City SCADA HMI and Local OIT:

a. Generator and ATS:

1) Status:

a) Generator Running

b) ATS Power Status

c) ATS Open

2) Alarms:

a) Generator Fault

b) ATS Malfunction

c) Generator Low Voltage in Battery

d) Generator High Fuel Level

e. Generator Low Fuel Level

f. Generator Enclosure Leak Detected

3. Control:

a. None

END OF SECTION

APPENDIX D

Geotechnical Services Report

RADISE International, LC

February 8, 2018

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RADISE
Infrastructure Engineers • Software Developers

February 8, 2018

Hazen and Sawyer
4000 Hollywood Blvd., Suite 750N
Hollywood, Florida 33201

Attn: Mr. Robert B. Taylor, Jr., P.E.
Office: (954) 987- 0066
Cell: (772) 595- 2535
Email: rbtaylor@hazenandsawyer.com

RE: Geotechnical Services Report
City of Fort Lauderdale
Stormwater Master Plan Modeling and Design Implementation
Broward County, Florida
RADISE Project No: 170901

Dear Mr. Taylor,

RADISE International, LC (RADISE) is pleased to submit this *Geotechnical Services Report* for the above-referenced project. The purpose of this report is to provide geotechnical information and recommendations to aid in the design and construction of the project. This report describes the field exploration and laboratory testing performed, presents the data obtained, and provides our recommendations regarding geotechnical aspects of the of the proposed project.

The study was performed in general accordance with our agreement executed on August 30, 2017 and our scope of work for geotechnical services.

We appreciate the opportunity to work with Hazen and Sawyer on this project, and trust that the information presented is clear. Should you have any questions regarding this report, or if we can be of additional assistance as this project develops, please contact us at (561) 841-0103.

Sincerely,
RADISE International
Infrastructure Engineers & Software Developers

Akash Bissoon, P.E.
Project Engineer
Florida Registration No. 74582

Thomas F. Mullin LICENSE No. 43366 STATE OF FLORIDA PROFESSIONAL ENGINEER

6/11/18

Thomas F. Mullin, P.E.
Chief Engineer &
Geotechnical Services Group Manager
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Thomas F Mullin
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This document has been digitally signed and sealed by Thomas F. Mullin, P.E. on June 11, 2018 using Identrust. Printed copies of this document are not considered signed and sealed and the signature must be verified on any electronic copies.

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Sheets 3A and 3B – Durrs Subsurface Profiles
Sheets 4A and 4B – Dorsey Riverbend Subsurface Profiles
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APPENDIX A
Table A-1 – Laboratory Test Results Summary
Grain Size Distribution

APPENDIX B
Preliminary Design Geotechnical Services Report

1.0 INTRODUCTION

RADISE understands that the City of Fort Lauderdale is performing a study for seawall replacement designs, stormwater master plan modeling, and design implementation within the City of Fort Lauderdale. To aid in the evaluation and design of the project, RADISE was requested to provide subsoil investigation and evaluation services that included drilling of exploratory borings to determine the subsurface stratigraphy, groundwater levels and physical properties of the soils underlying the site.

The information presented in this report is based upon our interpretation of the subsurface information revealed by the test borings. The report does not reflect variations in subsurface conditions that may exist between or beyond these borings. Variations in soil and groundwater conditions should be expected, the nature and extent of which might not become evident until construction is undertaken. If variations are encountered, and/or the scope of the project altered, we should be consulted for additional recommendations.

2.0 PROJECT DESCRIPTION

The project is located in the City of Fort Lauderdale, Florida and includes seven (7) neighborhoods and twelve (12) seawall segments located east of interstate highway (I-95) and between the Port Everglades Expressway and Sunrise Boulevard. The approximate locations and limits of the seawall and neighborhood projects are shown on the attached *Vicinity Map*, Sheet 1.

The stormwater systems for the seven (7) neighborhoods are proposed to provide improved flood protection and enhanced water quality treatment by using Best Management Practices (BMPs). The proposed stormwater collection and conveyance systems will include, but are not limited to:

- Swales
- Inlets and catch basins
- Exfiltration trenches
- Dry and wet retention systems (basins)
- Backflow prevention valves
- Underdrain systems
- Stormwater pump stations
- Electrical equipment buildings
- Outfalls
- Control structures
- Drainage wells
- Green infrastructure such as bio-swales and precast porous pavement

In addition, detailed designs for twelve (12) seawall segments are proposed. Seawall and neighborhood boring location information is summarized in Table 1 and Table 2.

Table 1 – Seawall Location Information

Seawall	Boring No.	Boring Location Remarks	Asphalt Thickness (inches)	Base Course Thickness* (inches)
Seawall 9	S-28	Inside Victoria Park. At the intersection of Broward Boulevard and North Victoria Park Road.	-	-
Seawall 10	S-29	At the intersection of SE 23rd Avenue and Del Mar Place. Approximately 450 feet north of E Las Olas Boulevard.	3.75	4.5
Seawall 12	S-15	South side of E Las Olas Boulevard, between Lido Drive and San Marco Drive.	-	-
Seawall 13	S-14	South side of E Las Olas Boulevard, between San Marco Drive and Coral Way.	-	-
Seawall 14	S-13	South side of E Las Olas Boulevard, between Coral Way and Royal Plaza Drive.	-	-
Seawall 15	S-9	On the east side of Isle of Palms Drive. Approximately 800 feet south of E Las Olas Boulevard.	4.5	6.0
	S-10	On the east side of Isle of Palms Drive. Approximately 570 feet south of E Las Olas Boulevard.	5.25	4.0
	S-11	On the east side of Isle of Palms Drive. Approximately 350 feet south of E Las Olas Boulevard.	5.75	6.0
	S-12	On the east side of Isle of Palms Drive. Approximately 120 feet south of E Las Olas Boulevard.	6.25	6.0
Seawall 17	S-8	On the south side of SE 5th Street. Approximately 75 feet west of the intersection of Riviera Isle Drive and SE 5th Street.	6.5	6.0
Seawall 29	S-17	On the east side of Cordova Road. Between SE 7th Street and SE 8th Street. Approximately 230 feet south of the intersection of Cordova Road and SE 7th Street.	12.0	6.0
	S-18	On the east side of Cordova Road. Between SE 8th Street and SE 9th Street. Approximately 175 feet south of the intersection of Cordova Road and SE 8th Street.	9.5	5.0
	S-19	On the east side of Cordova Road. Between SE 8th Street and SE 9th Street. Approximately 400 feet south of the intersection of Cordova Road and SE 8th Street.	8.25	6.0
	S-20	On the east side of Cordova Road. Between SE 8th Street and SE 9th Street. Approximately 175 feet south of the intersection of Cordova Road and SE 8th Street.	9.0	5.0
	S-21	On the east side of Cordova Road. Between SE 8th Street and SE 9th Street. Approximately 220 feet south of the intersection of Cordova Road and SE 9th Street.	5.75	6.0

Seawall	Boring No.	Boring Location Remarks	Asphalt Thickness (inches)	Base Course Thickness* (inches)
	S-22	On the east side of Cordova Road. Between SE 10th Street and SE 11th Street. Approximately 215 feet south of the intersection of Cordova Road and SE 10th Street.	5.0	5.0
	S-23	On the east side of Cordova Road. Between SE 11th Street and SE 12th Street. Approximately 160 feet south of the intersection of Cordova Road and SE 11th Street.	5.0	8.0
Seawall 30	S-26	On the south side of SE 10th Street. Approximately 2,000 feet east of the intersection of Cordova Road and SE 10th Street.	5.25	6.0
	S-27	On the south side of SE 10th Street. Approximately 2,250 feet east of the intersection of Cordova Road and SE 10th Street.	3.75	5.0
Seawall 32	S-16	On Mola Avenue. Approximately 775 feet south of the intersection of SE 17th Way and Mola Avenue.	-	-
Seawall 34	S-30	Located on the north side of Barcelona Drive. At the northeast quadrant of Barcelona Drive and NE 26th Terrace.	3.5	6.0
Seawall 35	S-24	Located on the south side of SE 8th Street. Approximately 1,000 feet east of Cordova Road.	4.5	6.0
	S-25	Located on the south side of SE 8th Street. Approximately 1,335 feet east of Cordova Road.	4.5	6.0

*Base course thicknesses were measured in the field to the nearest half inch.

Table 2 – Neighborhood Location Information

Neighborhood	Boring No.	Boring Location Remarks	Asphalt Thickness (inches)	Base Course Thickness* (inches)
Durrs	D-1	Intersection of NW 9th Street and NW 17th Avenue.	4.0	5.0
	D-2	Intersection of NW 16th Avenue and NW 8th Street.	7.0	3.0
	D-3	On NW 19th Avenue. Approximately 60 feet south of the intersection of NW 19th Avenue and NW 7th Street.	4.0	8.0
	D-4	Intersection of NW 8th Street and NW 13th Terrace.	1.3	3.0
	D-5	On the west side of NW 14th Way. Approximately 170 feet north of the intersection of NW 14th Way and NW 6th Street.	3.2	3.0

Neighborhood	Boring No.	Boring Location Remarks	Asphalt Thickness (inches)	Base Course Thickness* (inches)
Dorsey Riverbend	DR-1	Approximately 160 feet north of NW 5th Street, between NW 15th Terrace and NW 15th Avenue.	-	-
	DR-2	On the east side of NW 15th Avenue. Approximately 200 feet north of the intersection of NW 15th Street and NW 15th Avenue.	-	-
	DR-3	Intersection of NW 4th Street and NW 15th Avenue.	5.0	6.0
	DR-4	Approximately 75 feet north of the intersection of NW 4th Street and NW 18th Avenue.	5.2	1.0
	DR-5	On the west side of NW 18th Avenue, approximately 130 feet south of the intersection of NW 6th Street and NW 18th Avenue.	1.0	2.0
Edgewood	E-1	Intersection of SW 15th Avenue and SW 32nd Court.	1.2	4.0
	E-2	Intersection of SW 15th Avenue and SW 31st Street.	3.7	4.0
	E-3	Intersection of SW 15th Avenue and SW 29th Street.	2.2	4.0
	E-4	On SW 30th Street. Approximately 400 feet east of the intersection of SW 15th Avenue and SW 30th Street.	3.2	4.0
	E-5	On SW 32nd Street. Approximately 400 feet east of the intersection of SW 15th Avenue and SW 32nd Street.	2.0	6.0
	E-6	Intersection of SW 14th Avenue and SW 28th Street.	1.7	9.0
	E-7	On SW 28th Street. Approximately 620 feet east of the intersection of SW 12th Avenue and SW 28th Street.	4.7	6.0
	E-8	On SW 12th Avenue, between SW 31st Street and SW 32nd Street.	1.5	4.0
	E-9	On SW 29th Street. Approximately 240 feet east of the intersection of SW 12th Avenue and SW 29th Street.	-	-
	E-10	On SW 9th Avenue, between SW 30st Street and SW 31st Street.	6.0	3.0

Neighborhood	Boring No.	Boring Location Remarks	Asphalt Thickness (inches)	Base Course Thickness* (inches)
	E-11	Intersection of SW 8th Avenue and SW 30th Street.	3.7	4.0
	E-12	Intersection of SW 8th Avenue and SW 28th Street.	5.0	4.0
	E-13	On SW 9th Avenue, between SW 26th Court and SW 27th Court.	1.7	6.0
	E-14	On the west side of S Andrews Avenue. Near the intersection of S Andrews Avenue and SE 26th Street.	3.5	4.0
	E-15	On S Andrews Avenue. Between SE 30th Street and SE 31st Street.	3.0	4.0
Progresso	P-1	On the east side of SW 4th Avenue. Approximately 100 feet north of the intersection of Himmarshee Street and SW 4th Avenue.	3.0	4.0
	P-2	On NW 5th Avenue. Approximately 150 feet north of the intersection of Broward Boulevard and NW 5th Avenue.	3.2	2.0
	P-3	Intersection of NW 2nd Street and NW 4th Avenue.	2.7	6.0
	P-4	Intersection of NW 7th Street and NW 3rd Avenue.	1.2	8.0
	P-5	Intersection of NW 7th Street and NW 3rd Avenue.	-	-
	P-6	Approximately 130 feet north of NW 8th Street and between NW 4th Avenue and NW 3rd Avenue.	-	-
	P-7	On NW 7th Avenue. Between NW 5th Street and NW 4th Street.	2.0	7.0
	P-8	Intersection of NW 7th Street and NW 7th Terrace.	1.7	7.0
River Oaks	R-1	On SW 15th Avenue. Approximately 100 feet north of the intersection of SW 15th Avenue and Marina Boulevard.	2.7	6.0
	R-2	On SW 15th Avenue. Between SW 22nd Avenue and SW 23rd Street.	1.5	8.0
	R-3	On SW 24th Street. Between SW 18th Terrace and SW 24th Street.	1.5	6.0
	R-4	At the intersection of SW 17th Avenue and SW 22nd Street.	1.0	6.0

Neighborhood	Boring No.	Boring Location Remarks	Asphalt Thickness (inches)	Base Course Thickness* (inches)
	R-5	On SW 19th Avenue. Between SW 21st Street and SW 22nd Street.	1.7	6.0
	R-6	On SW 20th Street. Between SW 15th Avenue and Coconut Drive.	5.0	10.0
	R-7	At the intersection of SW 18th Court and SW 14th Avenue.	2.0	8.0
	R-8	At the intersection of SW 17th Street and SW 13th Avenue.	1.2	9.0
	R-9	Approximately 610 feet west of the intersection of SW 19th Avenue and SW 21st Street. Near a wooded area.	-	-
	R-10	Approximately 550 feet west of the intersection of SW 19th Avenue and SW 21st Street. Near a wooded area.	-	-
	R-11	Approximately 150 feet north west of the intersection of SW 19th Avenue and SW 23rd Court.	-	-
	R-12	Approximately 240 feet north west of the intersection of SW 19th Avenue and SW 23rd Court.	-	-
	R-13	Intersection of SW 18th Court and SW 10th Avenue.	1.7	9.0
Southeast Isles	S-1	Approximately 65 feet west of the intersection of SE 17th Way and Mola Avenue.	-	-
	S-2	On the south side of E Las Olas Boulevard, between SE 18th Avenue and Lido Drive.	-	-
	S-3	On the west side of Lido Drive, approximately 130 feet south of the intersection of E Las Olas Boulevard and Lido Drive.	-	-
	S-4	On the south side of E Las Olas Boulevard, between Royal Plaza Drive and Isle of Palms Drive.	-	-
	S-5	On the south side of E Las Olas Boulevard. Approximately 100 feet west of the intersection of E Las Olas Boulevard and Sunset Drive.	-	-

Neighborhood	Boring No.	Boring Location Remarks	Asphalt Thickness (inches)	Base Course Thickness* (inches)
	S-6	In the south east quadrant of the intersection of E Las Olas Boulevard and Poinciana Drive. In Merle Fogg Park.	-	-
	S-7	In the south east quadrant of the intersection of E Las Olas Boulevard and Poinciana Drive. In Merle Fogg Park.	-	-
Victoria Park	V-1	Intersection of NE 6th Street and NE 10th Avenue.	3.0	7.0
	V-2	Intersection of NE 6th Street and NE 16th Avenue.	7.0	4.0
	V-3	Intersection of NE 9th Street and NE 15th Avenue.	2.0	6.0
	V-4	Intersection of NE 8th Street and NE 16th Terrace.	3.8	3.0
	V-5	Intersection of NE 7th Street and NE 17th Way.	1.0	7.0
	V-6	On Victoria Trace. Approximately 250 feet north of the intersection of NE 5th Street and Victoria Way.	2.0	7.0
	V-7	Intersection of NE 20th Avenue and NE 19th Avenue.	3.0	6.0
	V-8	Intersection of NE 20th Avenue and NE 7th Street.	5.0	6.0
	V-9	Approximately 160 feet east of the intersection of NE 20th Avenue and NE 7th Street.	-	-
	V-10	On NE 20th Avenue. Approximately 900 feet north of the intersection of NE 20th Avenue and NE 7th Street.	2.2	9.0

*Base course thicknesses were measured in the field to the nearest half inch.

A review of the asphalt and base rock thicknesses data tabulated in Tables 1 and 2 for the various Seawall and Neighborhood projects, indicates that there are a number of apparent cores with either thin or thick pavement layers. Discussion of the nature and locations of deficient cores along with comparisons to more current day pavement design sections, is included in Section 7.4 - Pavement Design Considerations of this report.

3.0 PURPOSE AND SCOPE OF WORK

The purpose of this study was to perform a limited exploration of the subsurface conditions within the project proposed areas, to aid in the planning and design of the overall neighborhood site drainage infrastructure and seawalls.

More specifically, the purpose of the work included the following:

- Development of the anticipated soil profiles and the subsurface conditions within the depth of influence at the seawall structure locations and anticipated stormwater management infrastructure improvements.
- Identification of critical geotechnical design or construction considerations based on the soil and groundwater conditions encountered in the borings.

RADISE performed the following services in accordance with the proposed scope of work:

1. Visited the sites to field mark (paint or/and stake) the planned soil boring test locations and observe existing site conditions.

2. Contacted Sunshine 811 to request the field location and clearance of underground utilities in the areas of the proposed borings, as per Florida Statutes.

3. Set up Maintenance of Traffic (MOT) safety controls prior to and during the field drilling operations.

4. Mobilized drilling equipment to the site to perform:

    - Fifty (50) Standard Penetration Test (SPT) soil borings within the various seven (7) neighborhoods. Borings were drilled to depths of fifteen (15) feet

    - Thirty-six (36) SPT borings within the seawall and pump station locations. Borings were drilled to depths of 50 feet below the existing ground surface.

    - Asphalt pavement cores at sixty- eight (68) of the SPT boring locations.

    Samples of the subsurface soils encountered in the SPT borings were obtained and placed in labeled air-tight containers. The depth to the groundwater level was measured and recorded for each of the borings. Following completion of the groundwater measurements, the boreholes were backfilled with neat cement grout.

5. Visually classified the SPT soil samples retrieved from the soil borings in accordance with the Unified Soil Classification System (USCS) using the Visual-Manual Procedure in general accordance with the American Society of Testing and Materials (ASTM) test method D 2488, *Description and Identification of Soils*.

6. Reviewed, assigned and performed a limited laboratory testing program for soil index property determinations on selected SPT samples to aid in the classification process in general accordance with the ASTM test method D 2487, *Classification of Soils for Engineering Purposes*.

7. Prepared this Geotechnical Services Report to summarize the results of the field exploration and laboratory testing, and to present our findings, evaluations and design recommendations.

8. Reviewed and incorporated our Geotechnical Services Report prepared for the preliminary design of this project. The preliminary design Geotechnical Services Report is included in Appendix B of this report.

4.0 FIELD EXPLORATION

During this work phase, MOT was used to protect our field personnel, equipment, and the general public. The MOT was designed and set up in accordance with the FDOT Design Standards.

4.1 CORING

The field exploration program to evaluate the existing asphalt pavement thicknesses consisted of a total of sixty-eight (68) Pavement Cores, sampled at each of the sixty-eight of the SPT borings locations. The approximate boring locations are shown on the attached *Boring Location Plan*, Sheets 2A through 2Q.

Tables 1 and 2 in Section 1.0 presents a summary of the measured asphalt section thickness and the base thickness at the boring locations. Latitude and Longitude coordinates of the boring locations were obtained by the field crew using hand-held GPS equipment.

Pavement Core samples were obtained at sixty-eight (68) locations using a portable electric stand-up core drill with a 6-inch diameter diamond tipped core drill bit. Upon removal of the asphalt core, a hand-held power auger and a hand operated bucket-type auger were used to loosen the base course material and to clean out the borehole. Subsequent down-hole field measurements were made using a surveyor's tape to document the approximate thickness and composition of the encountered pavement base course materials.

Representative samples of the base course, obtained from the hand bucket-type auger, were placed in moisture proof bags and transported to our laboratory. The samples were then examined by a geotechnical engineer in the lab to confirm the field classifications.

4.2 SOIL BORINGS

The field exploration program to evaluate the existing subsurface conditions consisted of drilling eighty-six (86) SPT borings. Fifty (50) of the SPT soil borings were drilled to depths of fifteen (15) feet below the existing ground surface within the various seven (7) neighborhoods and thirty-six (36) of the SPT borings were drilled to depths of 50 feet in the vicinity of the seawall and pump station locations. The approximate locations of the SPT borings are depicted on the attached Boring Location Plan, Sheets 2A through 2Q. Latitude and Longitude coordinates of the test locations were obtained by the field crew using hand-held GPS equipment and are listed on the attached Subsurface Profiles, Sheets 3A through 10D.

The SPT borings were performed in general accordance with ASTM D 1586, "Standard Test Method for the Standard Penetration Test and Split-Barrel Sampling". Upon retrieval, the split-spoon, soil samples were visually classified and placed in moisture proof containers for transportation to our laboratory. Each borehole was backfilled with neat cement grout to the ground surface after the completion of drilling, sampling and monitoring operations.

4.3 GROUNDWATER LEVEL MEASUREMENTS

After completion of the borings and after a short stabilization period, the depth to the groundwater was measured from the existing ground surface in each boring. The measured groundwater depth/elevation is plotted adjacent to the soil profiles shown on the attached *Subsurface Profiles*, Sheets 3A through 10D.

5.0 LABORATORY TESTING

5.1 GENERAL

Representative soils samples collected from the borings were visually reviewed in the laboratory by a RADISE Geotechnical Engineer to confirm field classifications. The samples were classified in general accordance with the Unified Soil Classification System (USCS). The classifications were based on visual observations supplemented by laboratory test results performed on selected representative SPT samples. Laboratory index tests consisting of Full Sieve Analysis, Percent Passing No. 200 Sieve, Moisture, Atterberg limits, and Organics Content tests were performed on selected samples to further confirm and finalize field soils classifications.

5.2 LABORATORY TEST RESULTS

Test assignments were provided by a Geotechnical Engineer during the laboratory review of secured soil samples. Laboratory assignments were made to supplement and confirm soil classification at each general boring location.

The following list summarizes the types and numbers of laboratory tests performed.

- Ninety-six (96) Moisture Content Tests (ASTM D 2216).
- Sixty-two (62) Organics Content Tests (ASTM 2216 D).
- Twenty-six (26) Full Sieve Analysis Test (ASTM D422).
- Fifteen (15) Percent Passing No. 200 Sieve Tests (ASTM D 1140).
- Three (3) Atterberg limits tests (ASTM D 4318).

All of the laboratory test results are presented on the attached *Subsurface Profiles*, Sheet 3A through 10D, and on Table A - *Laboratory Test Results Summary* in Appendix A.

6.0 SURFACE AND SUBSURFACE EXPLORATION

6.1 STRATIGRAPHY

Stratification of the explored soils is based on visual examination of the recovered soil samples, index testing, laboratory classification and interpretation of the field boring logs by a geotechnical engineer in accordance with the Unified Soil Classification System (USCS). Subsurface profiles showing the soil stratification at the boring locations were developed and are presented on the attached *Subsurface Profiles*, Sheets 3A through 10D. Stratification lines represent approximate boundaries between soil types, but the actual transition between layers may be gradual or abrupt. Additionally, soil and groundwater conditions will vary between boring locations.

The soils encountered in all eighty-six (86) of the soil borings generally consist of sand with varying amounts of silt and limestone fragments mostly underlain by limestone. Some of the borings encountered a layer of soil containing appreciable amounts of organic matter. Generalized descriptions of the soil stratigraphy are provided in Table 3:

TABLE 3 - STRATIGRAPHY

Stratum No.	Description	USCS Class.
1	Brown, fine to medium SAND, occasionally with Gravel, Limestone fragments, and Silt	SP, SP-SM
2	Gray, fine to medium Silty SAND, occasionally with Gravel and Limestone fragments	SM
3	Gray, Sandy SILT	ML
4	Tan to gray, LIMESTONE	-
5	Tan, Sandy LIMESTONE	-
6	Dark Brown Organic Material	PT

It is noted that the Layer 6 Dark Brown Organic Material were primarily encountered in the borings performed in the River Oaks, Seven Isles, and Victoria Park neighborhoods. Review of the boring logs and boring locations for the River Oaks neighborhood area indicates organic material was encountered in the borings performed in an undeveloped, wooded area adjacent to the east side of Interstate I-95 and just south of the South Fork New River. It appears this area contains a layer of fill soils placed over organic soils along the south side of the South Fork New River. Review of the boring logs and boring locations for the Seven Isles and Victoria Park neighborhood areas indicates there appear to be layers of fill soils which were placed over remnant buried mangrove preserve areas along the Intracoastal Waterway. This land reclamation occurred during early development periods in the history of the coastal Ft. Lauderdale area.

Table 4 summarizes the borings, depths and thickness of the Stratum 6 soils that contain 5.3 to 67.3 percent organics encountered:

TABLE 4 – STRATUM 6 SOILS (PEAT)

Boring No.	Depth from (feet)	Depth to (feet)	Organic layer thickness (feet)
R-9	2	6	4
R-10	2	4	2
R-12	4	6	2
S-2	4	10	6
S-3	6	8	2
S-4	4	8	4
S-5	4	10	6
S-8	2	6	4
S-14	4	9	5
S-15	4	9	5
S-16	4	6	2
S-17	4	12	8
S-18	4	12	8
S-19	4	12	8
S-20	4	8	4
S-21	4	6	2
S-22	8	12	4
S-23	8	12	4
S-23	8	10	2
S-27	8	10	2
S-28	0	2	2
S-29	6	10	4
S-30	2	6	4

Boring No.	Depth from (feet)	Depth to (feet)	Organic layer thickness (feet)
S-30	10	15	5
V-1	4	8	4
V-7	4	8	4
V-8	4	10	6
V-10	8	10	2

6.2 GROUNDWATER LEVELS

Groundwater was encountered in each of the SPT borings. The groundwater level varied between 0.5 to 6.5 feet below the existing ground surface. It is our recommendation that the seasonal high groundwater table levels along the various project infrastructure alignments, be based on the normal high tide water levels of the adjacent waterways existing near the various neighborhood project areas and with additional geotechnical explorations. In inland areas not directly influenced by the water levels in the adjacent waterways and canals, normal high groundwater levels can be expected to be on the order of as much as two feet above the measured groundwater levels in the borings. It should be noted that the groundwater levels will fluctuate with variations of precipitation.

Borings P-4 and P-7 encountered groundwater at 0.5 feet below the existing ground surface. These two boings were performed in the Progresso neighborhood and the high groundwater is suspected be caused by adjacent exfiltration trenches which were filled up from recent storm events.

7.0 ENGINEERING CONSIDERATIONS AND RECOMMENDATIONS

The soils encountered in the majority of the borings performed for this study will be suitable for the proposed construction. However, it was previously noted that the portions of the River Oaks, Victoria Park and Seven Isles areas are likely historical land reclamation areas. These areas as well as several others in the surrounding region, were infilled sometime in the historical past to facilitate the construction of the present residential communities.

The presence of the buried organics will be problematic to the installation of underground utilities especially when the inverts of such systems are founded in the organic layers. Such organics have very low shear strengths and will not support significant excavations made within or through them. As such, it is anticipated that the significant use of sliding trench boxes/shoring/sheet piling will be required to install infrastructure systems in this area.

Lift station structures are anticipated to be constructed well into the underlying sands and limestones. Uplift flotation resistance may be a concern for their design and construction. The buried organics encountered are expected to have little effect on the stability of the wet well structures in the ground since the bottom of the wet wells will be bearing in the sand and limestone layers. Sheet piling will likely be required to support excavations for these deep structures.

Valve vault and pavement structures are anticipated to be constructed above the buried organics. The organic material can remain in-place and a geogrid layer can be placed below the bottom of the valve vault and pavement bedding materials during construction.

7.1 SEAWALL STRUCTURE DESIGN RECOMMENDATIONS

We understand new seawalls are proposed on to be constructed within18 inches on the water side of the existing seawalls. A #57 stone backfill is proposed for filling between the existing seawalls and the new seawalls. Twelve (12) separate seawall segments are proposed. Twenty-three (23) SPT borings were performed for the seawall structures. The adjacent roadway or park, approximate wall length, and borings performed for each wall are presented in Table 5:

Table 5 – Sea Wall Locations and Lengths

Seawall Number	Adjacent to	Approximate Length of Wall (feet)	Borings
Seawall 9	Victoria Park	110	S-28
Seawall 10	NE 23rd Avenue	275	S-29
Seawall 12	E Las Olas Boulevard	90	S-15
Seawall 13	E Las Olas Boulevard	80	S-14
Seawall 14	E Las Olas Boulevard	90	S-13
Seawall 15	Isle of Palms Drive	910	S-9 through S-12
Seawall 17	SE 5th Street	170	S-8
Seawall 29	Cordova Road	2,440	S-17 through S-23
Seawall 30	SE 10th Street	360	S-26 and S-27
Seawall 32	Mola Avenue	215	S-16
Seawall 34	Barcelona Drive	110	S-30
Seawall 35	SE 8th Street	550	S-24 and S-25

7.1.1 SOIL DESIGN PARAMETERS FOR SEAWALLS

Geotechnical soil design parameters for the seawall systems were derived based on field data, laboratory test data, established empirical correlations based on SPT N-values, and our experience. The design soil parameters were developed on an average boring soil profile/per wall basis.

The proposed seawalls will be subjected to lateral earth pressures. The final design elevation of the wall base was not decided and provided at the time of this study. The seawalls will be subjected to lateral at-rest or active earth pressures acting in the direction of the adjacent canal. We have also assumed that adequate drainage provisions will be incorporated into the wall design as needed to prevent hydrostatic build up behind the walls where practical.

The lateral active earth pressures acting on the roadway side of the seawalls, will primarily be resisted by the lateral wall resistance resulting from the wall embedment below the canal side ground elevation exterior face of the wall. The recommend soil parameters with respect to strata are presented in Tables 6 through 17. Input parameters for LPILE are also included in Tables 6 through 17. LPILE is a special-purpose program published by ENSOFT Inc and is used for analyzing a single pile (or drilled shaft) under lateral loading using the p-y method.

Table 6 – Recommended Soil Parameters for Seawall #9 (Boring S-28)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 2	4	22	75	13	11	14	0.455	2.198	0.625	–	5	–	PT
2 – 4	4	29	102	40	16	22	0.347	2.882	0.515	–	10	–	SM
4 – 6	14	36	110	48	19	26	0.260	3.852	0.412	–	30	–	Limestone
6 – 10	6	30	105	43	16	23	0.333	3.000	0.500	–	12	–	Limestone
10 – 20	15	37	110	48	20	26	0.249	4.023	0.398	–	35	–	Limestone
20 – 25	1	28	105	43	15	21	0.361	2.770	0.531	–	5	–	Limestone
25 – 30	29	40	115	53	22	26	0.217	4.599	0.357	4,000	1,000	0.004	Limestone[3]
30 – 40	76	38	115	53	17	22	0.238	4.204	0.384	–	125	–	SP
40 – 45	4	29	105	43	16	22	0.347	2.882	0.515	–	10	–	Limestone
45 – 50	12	36	110	48	19	26	0.260	3.852	0.412	–	25	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Hard Limestone layer should be modeled as Hard to Stiff Clay in LPILE software analysis.
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 7 – Recommended Soil Parameters for Seawall #10 (Boring S-29)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 6	17	32	114	52	17	22	0.307	3.255	0.470	–	40	–	SP, SP-SM
6 – 10	11	24	82	20	12	15	0.422	2.371	0.593	–	10	–	PT
10 – 40	18	38	110	48	21	26	0.238	4.204	0.384	–	45	–	Limestone
40 – 50	34	40	115	53	22	26	0.217	4.599	0.357	4,000	1,000	0.004	Limestone[3]

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Hard Limestone layer should be modeled as Hard to Stiff Clay in LPILE software analysis.
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 8 – Recommended Soil Parameters for Seawall #12 (Boring S-15)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 4	14	31	110	48	17	22	0.320	3.124	0.485	–	30	–	SP, SP-SM
4 – 9	5	22	75	13	11	14	0.455	2.198	0.625	–	5	–	PT
9 – 50	17	37	110	48	20	26	0.249	4.023	0.398	–	40	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 9 – Recommended Soil Parameters for Seawall #13 (Boring S-14)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 4	14	32	114	52	17	22	0.307	3.255	0.470	–	30	–	SP, SP-SM
4 – 9	6	22	75	13	11	14	0.455	2.198	0.625	–	5	–	PT
9 – 50	15	37	110	48	20	26	0.249	4.023	0.398	–	35	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 10 – Recommended Soil Parameters for Seawall #14 (Boring S-13)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values: Friction Angle (Degrees)	Recommended Values: Total Unit Weight (pcf)	Recommended Values: Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees): with Steel	Wall Friction Angle (Degrees): with Concrete	Earth Pressure (Rankine's) Coefficients: Active, Ka	Earth Pressure (Rankine's) Coefficients: Passive, Kp	Earth Pressure (Rankine's) Coefficients: At rest, K_O	LPILE Parameters: Cohesion (psf)	LPILE Parameters: Subgrade Modulus (k, pci)	LPILE Parameters: E50 [2]	Soil Class. (USCS/ Soil Type)
0 – 2	17	32	114	52	17	22	0.307	3.255	0.470	–	40	–	SP
2 – 8	10	30	106	44	16	22	0.333	3.000	0.500	–	20	–	SP-SM (Gravelly Sand)
8 – 10	6	30	106	44	16	22	0.333	3.000	0.500	–	12	–	SM
10 – 35	18	38	110	48	21	26	0.238	4.204	0.384	–	45	–	Limestone
35 – 40	10	30	105	43	16	22	0.333	3.000	0.500	–	20	–	Limestone
40 – 50	26	40	115	53	22	26	0.217	4.599	0.357	4,000	1,000	0.004	Limestone[3]

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Hard Limestone layer should be modeled as Hard to Stiff Clay in LPILE software analysis.
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 11 – Recommended Soil Parameters for Seawall #15 (Boring S-10)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values: Friction Angle (Degrees)	Recommended Values: Total Unit Weight (pcf)	Recommended Values: Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees): with Steel	Wall Friction Angle (Degrees): with Concrete	Earth Pressure (Rankine's) Coefficients: Active, Ka	Earth Pressure (Rankine's) Coefficients: Passive, Kp	Earth Pressure (Rankine's) Coefficients: At rest, K_O	LPILE Parameters: Cohesion (psf)	LPILE Parameters: Subgrade Modulus (k, pci)	LPILE Parameters: E50 [2]	Soil Class. (USCS/ Soil Type)
0 – 4	17	32	114	52	17	22	0.307	3.255	0.470	–	40	–	SP-SM
4 – 8	9	30	106	44	16	22	0.333	3.000	0.500	–	17	–	SP
8 – 20	15	37	110	48	20	26	0.249	4.023	0.398	–	35	–	Limestone
20 – 25	10	30	105	43	16	22	0.333	3.000	0.500	–	20	–	Limestone
25 – 45	13	36	110	48	19	26	0.260	3.852	0.412	–	30	–	Limestone
9 – 50	10	30	105	43	16	22	0.333	3.000	0.500	–	20	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 12 – Recommended Soil Parameters for Seawall #17 (Boring S-8)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 2	14	31	110	48	17	22	0.320	3.124	0.485	–	32	–	SP
2 – 6	5	22	75	13	11	14	0.455	2.198	0.625	–	5	–	PT
6 – 10	10	30	106	44	16	22	0.333	3.000	0.500	–	20	–	SP-SM
10 – 15	19	31	110	48	11	14	0.320	3.124	0.485	–	30	–	ML
15 – 40	17	37	110	48	20	26	0.249	4.023	0.398	–	40	–	Limestone
40 – 50	33	40	115	53	22	26	0.217	4.599	0.357	4,000	1,000	0.004	Limestone[3]

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Hard Limestone layer should be modeled as Hard to Stiff Clay in LPILE software analysis.
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 13 – Recommended Soil Parameters for Seawall #29 (Boring S-22)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 4	11	31	110	48	17	22	0.320	3.124	0.485	–	22	–	SP
4 – 12	1	20	66	70	8	14	0.490	2.040	0.658	–	2	–	PT/CL
12 – 20	20	38	110	48	21	26	0.238	4.204	0.384	–	50	–	Limestone
20 – 25	10	30	105	43	16	23	0.333	3.000	0.500	–	20	–	Limestone
25 – 38	11	31	110	48	17	22	0.320	3.124	0.485	–	22	–	SP
38 – 50	14	36	110	48	19	26	0.260	3.852	0.412	–	32	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 14 – Recommended Soil Parameters for Seawall #30 (Boring S-26)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values: Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees): with Steel	with Concrete	Earth Pressure (Rankine's) Coefficients: Active, Ka	Passive, Kp	At rest, K_O	LPILE Parameters: Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	Soil Class. (USCS/ Soil Type)
0 – 4	26	35	120	58	17	22	0.271	3.690	0.426	–	68	–	SP
4 – 8	15	32	114	52	17	22	0.307	3.255	0.470	–	35	–	SP-SM
8 – 10	4	22	75	13	11	14	0.455	2.198	0.625	–	5	–	PT
10 – 20	27	40	115	53	22	26	0.217	4.599	0.357	4,000	1,000	0.004	Limestone[3]
20 – 25	4	29	105	43	16	22	0.347	2.882	0.515	–	10	–	Limestone
25 – 35	14	37	110	48	20	26	0.249	4.023	0.398	–	32	–	Limestone
35 – 40	10	30	105	43	16	23	0.333	3.000	0.500	–	20	–	Limestone
40 – 50	12	36	110	48	19	26	0.260	3.852	0.412	–	25	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Hard Limestone layer should be modeled as Hard to Stiff Clay in LPILE software analysis.
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 15 – Recommended Soil Parameters for Seawall #32 (Boring S-16)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values: Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees): with Steel	with Concrete	Earth Pressure (Rankine's) Coefficients: Active, Ka	Passive, Kp	At rest, K_O	LPILE Parameters: Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	Soil Class. (USCS/ Soil Type)
0 – 4	12	31	110	48	17	22	0.320	3.124	0.485	–	25	–	SP
4 – 6	9	24	82	20	12	15	0.422	2.371	0.593	–	10	–	PT
6 – 10	6	30	106	44	16	22	0.333	3.000	0.500	–	12	–	SP
10 – 30	16	37	110	48	20	26	0.249	4.023	0.398	–	38	–	Limestone
30 – 35	29	40	115	53	22	26	0.217	4.599	0.357	4,000	1,000	0.004	Limestone[3]
35 – 50	20	38	110	48	21	26	0.238	4.204	0.384	–	50	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Hard Limestone layer should be modeled as Hard to Stiff Clay in LPILE software analysis.
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 16 – Recommended Soil Parameters for Seawall #34 (Boring S-30)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 2	16	32	114	52	17	22	0.307	3.255	0.470	–	37	–	SP
2 – 6	12	24	82	20	11	14	0.422	2.371	0.593	–	10	–	PT
6 – 10	4	29	102	40	16	22	0.347	2.882	0.515	–	10	–	SP
10 – 15	21	25	86	24	11	14	0.406	2.464	0.577	–	15	–	PT
15 – 20	15	37	110	48	20	26	0.249	4.023	0.398	–	35	–	Limestone
20 – 30	26	40	115	53	22	26	0.217	4.599	0.357	4,000	1,000	0.004	Limestone[3]
30 – 50	19	38	110	48	21	26	0.238	4.204	0.384	–	47	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Hard Limestone layer should be modeled as Hard to Stiff Clay in LPILE software analysis.
4. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

Table 17 – Recommended Soil Parameters for Seawall #35 (Boring S-25)

Depth [1] (ft. – ft.)	Average N_{ES}	Recommended Values					Earth Pressure (Rankine's) Coefficients			LPILE Parameters			Soil Class. (USCS/ Soil Type)
		Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Wall Friction Angle (Degrees) with Steel	Wall Friction Angle (Degrees) with Concrete	Active, Ka	Passive, Kp	At rest, K_O	Cohesion (psf)	Subgrade Modulus (k, pci)	E50 [2]	
0 – 4	17	32	114	52	17	22	0.307	3.255	0.470	–	40	–	SP
4 – 10	11	31	110	48	17	22	0.320	3.124	0.485	–	22	–	SP
10 – 50	16	37	110	48	20	26	0.249	4.023	0.398	–	37	–	Limestone

Note: 1. Depth below the existing ground surface.
2. E50 is soil stain parameters for LPILE software analysis.
3. Wall friction angle is based on Table 3-3 in the US Army Corps of Engineers Manual (Design of Sheet Pile Walls, EM 1110-2-2504).

7.2 FOUNDATION RECOMMENDATIONS FOR PUMP STATIONS

Based on the geotechnical exploration and providing the subgrade preparation procedures presented below are followed, it is our opinion that the sites are suitable for the planned pump station construction. The proposed structures may be supported on a mat foundation.

Following the in-situ foundation preparation recommendations below, the proposed structure foundations may bear within the prepared existing sands and limestones beneath the organic materials. The net allowable soil bearing pressures are provided in Tables 18 through 29. The net bearing pressure is defined as the soil bearing pressure at the foundation bearing level in excess of the natural overburden pressure at that level. To verify suitable bearing, we recommend that the foundation excavation subgrade be checked by a geotechnical engineer just prior to mat rebar placement. The excavation bottom should be kept as dry as practically possible during construction.

Resistance to lateral loads can be derived from 1) passive pressure acting on the sides of the foundations and any grade beams, and 2) lateral resistance along the base of the foundations. Lateral resistance derived from friction between the soil and the bases of the footings should be calculated based on a friction factor of 0.35 times the base contact bearing pressure. Passive resistance of the upper foot of soil should be neglected, unless it is confined by a slab or pavement. Passive resistance on the sides of the foundations should be ignored if these soils can be hypothetically washed away during a hurricane storm event.

A subgrade modulus of 250 psi/in may be used in the design of a mat/raft foundation provided that the subgrade and subsequent engineered granular fill is prepared as described below. A 6-inch leveling layer of clean (less than 5% passing a #200 sieve) granular fill is recommended to be placed directly below slab-on-grade floors where appropriate. The granular fill should be compacted until densities of at least 95% of the maximum dry density as determined by ASTM D1557, the Modified Proctor method. Based on our assumption of a structure supported on a shallow footing or mat foundation system, the total settlement should be less than 1.0 inches, and differential settlements should be less than 0.50 inches.

7.2.1 RECOMMENDED SOIL PARAMETERS FOR PUMP STATION DESIGN

Underground pump stations for this project will need to be designed to resist pressures exerted by the adjacent soils and hydrostatic uplift head conditions on the base of the structure. For walls that are not restrained during backfilling but are free to rotate at the top, active earth pressure should be used in design. Walls that are restrained should be designed assuming at-rest pressures. Recommended soil parameters for the soils encountered at the sites are given in Tables 18 through 29.

Table 18 – SPT BORING DR-1

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 8	7	8	30	108	46	0.333	3.000	0.500	1250
8 - 10	2	2	29	106	44	0.347	2.882	0.515	400
10 - 25	15	18	33	114	52	0.295	3.392	0.455	2500
25 - 30	13	16	32	112	50	0.307	3.255	0.470	3000
30 -50	28	34	40	128	66	0.217	4.599	0.357	4000

Table 19 – SPT BORING DR-2

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 2	7	9	30	108	46	0.333	3.000	0.500	1250
2 - 4	9	11	31	110	48	0.320	3.124	0.485	1800
4 - 6	6	7	30	108	46	0.333	3.000	0.500	1200
6 - 10	3	4	29	106	44	0.347	2.882	0.515	500
10 - 30	13	16	32	112	50	0.307	3.255	0.470	3000
30 - 50	23	29	40	128	66	0.217	4.599	0.357	4000

Table 20 – SPT BORING P-5

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 2	7	9	30	108	46	0.333	3.000	0.500	1200
2 - 4	11	14	31	110	48	0.320	3.124	0.485	2000
4 - 10	7	9	30	108	46	0.333	3.000	0.500	1500
10 - 30	13	16	32	112	50	0.307	3.255	0.470	3000
30 - 50	19	24	39	126	64	0.228	4.395	0.371	4000

Table 21 – SPT BORING P-6

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 2	4	5	29	106	44	0.347	2.882	0.515	750
2 - 4	9	11	31	110	48	0.320	3.124	0.485	1500
4 - 10	6	7	30	108	46	0.333	3.000	0.500	1000
10 - 30	13	16	32	112	50	0.307	3.255	0.470	3000
30 - 50	19	24	39	126	64	0.228	4.395	0.371	4000

Table 22 – SPT BORING R-9

Boring depth (ft - ft)	Average N_{AUTO}	Average N_{ES}	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 2	9	11	31	110	48	0.320	3.124	0.485	1500
2 - 6	7	9	27	102	40	0.376	2.663	0.546	1000
6 - 8	3	4	29	106	44	0.347	2.882	0.515	500
8 - 15	7	9	30	108	46	0.333	3.000	0.500	1500
15 - 25	14	17	32	112	50	0.307	3.255	0.470	2500
25 - 30	7	9	30	108	46	0.333	3.000	0.500	2500
30 - 50	10	12	31	110	48	0.320	3.124	0.485	3000

Table 23 – SPT BORING R-10

Boring depth (ft - ft)	Average N_{AUTO}	Average N_{ES}	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 2	9	11	31	110	48	0.320	3.124	0.485	1500
2 - 4	6	7	27	102	40	0.376	2.663	0.546	1000
4 - 6	9	11	31	110	48	0.320	3.124	0.485	1500
6 - 8	5	6	30	108	46	0.333	3.000	0.500	750
8 - 10	3	4	29	106	44	0.347	2.882	0.515	500
10 - 15	7	9	30	108	46	0.333	3.000	0.500	1250
15 - 20	9	11	31	110	48	0.320	3.124	0.485	1750
20 - 25	8	10	30	108	46	0.333	3.000	0.500	1750
25 - 50	11	14	31	110	48	0.320	3.124	0.485	2500

Table 24 – SPT BORING R-11

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 4	7	8	30	108	46	0.333	3.000	0.500	1100
4 - 6	3	4	29	106	44	0.347	2.882	0.515	500
6 - 15	7	9	30	108	46	0.333	3.000	0.500	1250
15 - 30	19	24	34	116	54	0.283	3.537	0.441	3000
30 - 40	28	35	37	122	60	0.249	4.023	0.398	4000
40 - 50	19	24	34	116	54	0.283	3.537	0.441	4000

Table 25 – SPT BORING R-12

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 4	8	10	30	108	46	0.333	3.000	0.500	1500
4 - 6	2	2	10	68	6	0.704	1.420	0.826	0
6 - 8	9	11	31	110	48	0.320	3.124	0.485	1500
8 - 15	6	7	30	108	46	0.333	3.000	0.500	1000
15 - 35	20	25	34	116	54	0.283	3.537	0.441	3000
35 - 40	29	36	35	118	56	0.271	3.690	0.426	4000
40 - 50	20	25	34	116	54	0.283	3.537	0.441	4000

Table 26 – SPT BORING S-6

Boring depth (ft - ft)	Average N_{AUTO}	Average N_{ES}	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 2	5	6	30	108	46	0.333	3.000	0.500	800
2 - 6	12	15	32	112	50	0.307	3.255	0.470	2100
6 - 8	7	9	30	108	46	0.333	3.000	0.500	1250
8 - 10	2	2	29	106	44	0.347	2.882	0.515	250
10 - 35	26	32	35	118	56	0.271	3.690	0.426	3000
35 - 50	6	7	30	108	46	0.333	3.000	0.500	2000

Table 27 – SPT BORING S-7

Boring depth (ft - ft)	Average N_{AUTO}	Average N_{ES}	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 2	5	6	30	108	46	0.333	3.000	0.500	800
2 - 6	10	12	31	110	48	0.320	3.124	0.485	1750
6 - 10	6	7	30	108	46	0.333	3.000	0.500	1000
10 - 20	31	38	40	128	66	0.217	4.599	0.357	3500
20 - 25	9	11	31	110	48	0.320	3.124	0.485	2500
25 - 35	15	19	38	124	62	0.238	4.204	0.384	2750
35 - 40	7	9	30	108	46	0.333	3.000	0.500	2500
40 - 50	12	15	37	122	60	0.249	4.023	0.398	3000

Table 28 – SPT BORING V-8

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 4	14	17	32	112	50	0.307	3.255	0.470	2500
4 - 10	3	4	10	68	6	0.704	1.420	0.826	0
10 - 20	10	12	36	120	58	0.260	3.852	0.412	1500
20 - 30	12	15	32	112	50	0.307	3.255	0.470	2500
30 - 50	35	43	40	128	66	0.217	4.599	0.357	4000

Table 29 – SPT BORING V-9

Boring depth (ft - ft)	Average NAUTO	Average NES	Recommended Values			Earth Pressure Coefficients			Bearing Capacity (psf)
			Friction Angle (Degrees)	Total Unit Weight (pcf)	Submerged Unit Weight (pcf)	Active, Ka	Passive, Kp	At rest, Ko	
0 - 6	3	3	29	106	44	0.347	2.882	0.515	400
6 - 8	11	14	31	110	48	0.320	3.124	0.485	1500
8 - 15	6	7	30	108	46	0.333	3.000	0.500	1000
15 - 35	7	9	30	108	46	0.333	3.000	0.500	1500
35 - 50	11	14	36	120	58	0.260	3.852	0.412	2000

Design should incorporate hydrostatic effects. In order to avoid wall damage due to excessive compaction, hand operated mechanical tampers should be used to densify backfill soils. Heavy vibratory compaction equipment should not be allowed within five feet of walls. The soils behind walls should consist of clean sands as described in the Select Fill Composition, Placement and Compaction section of this report and should be compacted to approximately 95 percent of the material's modified Proctor (ASTM D-1557) maximum dry density.

7.2.2 AUGER CAST PILE RECOMMENDATIONS FOR LIFT STATION DESIGN

At the time of this report, three lift stations were proposed. The proposed locations and depths of the lift stations are presented in the following Table 30:

Table 30 – Lift Station Information

Lift Station Location	Bottom Depth from existing ground surface (feet)	Borings
Merle Fogg Park	12	S-6 and S-7
River Oaks Outfall	19	R-9 through R-12
Victoria Park	16	S-28

Due to the depth of the lift stations, buoyancy is a potential concern where the weight of concrete structure is not sufficient to resist uplift without using piles in tension. Auger cast piles are reportingly being proposed to counter act the buoyancy forces. An Augered Cast-In Place (ACIP) cast pile tension capacity of 35 tons is necessary to counteract the buoyancy forces.

The pile capacity estimate considers 16-inch diameter Auger Cast Piles. Estimates indicate the following:

- For the Merle Fogg Park lift station, ACIP piles tipped 50 feet below the existing ground surface can achieve approximately fifteen (15) tons of design tension capacity each.
- For the River Oaks lift station, piles tipped 50 feet below the existing ground surface can achieve approximately eight (8) tons of tension capacity each.
- For the Victoria Park lift station, piles tipped 50 feet below the existing ground surface can achieve approximately eight (8) tons of tension capacity each.

It should also be noted that additional uplift capacity can be achieved by overbuilding the Lift Station mat so that it protrudes a few to several feet beyond the walls of the structure. Under such a design, the submerged unit weight of the soils above the outer extending foundation mat lip will help hold the structure down. If the mat is enlarged enough, the weight of the exterior submerged soils above the extending lip may be able to resist a significant portion of the uplift. For analysis purposes, an average submerged unit weight of 62.4 pcf can be used for the Lift Station backfill for that soil volume directly around the structure and above the mat. Additionally, if the Lift station were to begin to rise, it would also have to shear the soil in a box type vertical plane surrounding the structure mat perimeter. This shear will add additional uplift resistance to the structure and can be calculated using a soil Phi (ϕ) value of 32 degrees times the average normal in-situ horizontal (Ko) effective (i.e. submerged) soil pressure along the vertical plane surrounding the structure.

7.3 FOUNDATION RECOMMENDATIONS FOR ELECTRICAL EQUIPMENT BUILDINGS

Our recommendations for foundation design and construction of the electrical equipment buildings are based on the following:

1. Two buildings are proposed,
   a. One building is proposed at Merle Fogg Park, in the southeast quadrant of the intersection of E. Las Olas Boulevard and Poinciana Drive in the Southeast Isles Neighborhood. Borings S-6 and S-7 are located in this area.
   b. The second building is proposed at the River Oaks-Outfall. The River Oaks Outfall is located in the west side of the River Oaks neighborhood, adjacent to the east side of I-95 and just south of the South Fork New River. Borings R-9 through R-12 are located in this area.
2. The buildings will be one-story in height, and will house electrical equipment.
3. The floor elevation of the buildings will be approximately 6 feet above current grade.
4. The anticipated foundation system will be a combination of continuous strip footings under walls and isolated spread footing under columns.

If this information is incorrect or changes, we should be notified so we can review our recommendations and revise them if necessary.

Based on the geotechnical exploration and providing that the subgrade preparation procedures presented below are followed, it is our opinion that the site is suitable for the planned building construction.

The proposed structure may be supported on shallow footings or preferably a raft mat type of foundation.

Following the in-situ foundation preparation recommendations herein, the proposed structure foundation may be designed using a net allowable soil bearing pressure of up to 1500 pounds per square foot (psf) bearing when founded within the densified existing sands. When founded within a well compacted, elevated fill pad constructed with select engineered granular fill, a net allowable soil bearing pressure of up to 2500 pounds per square foot (psf) bearing may be utilized.

The net bearing pressure is defined as the soil bearing pressure at the foundation bearing level more than the natural overburden pressure at that level. To verify suitable bearing, we recommend that the foundation excavation subgrade be checked by a RADISE geotechnical engineer just prior to concreting. The excavation bottom should be kept as dry as practical during construction.

A subgrade modulus of 200 psi/in may be used in the design of a mat/raft foundation if the subgrade and subsequent engineered granular fill is prepared as described below. A 6-inch layer of clean (less than 5% passing a #200 sieve) granular fill is recommended to be placed directly below slab-on-grade floors where appropriate. The granular fill should be compacted until densities of at least 95% of the maximum dry density as determined by ASTM D1557, the Modified Proctor method. This layer will aid in providing a capillary moisture break below the concrete slab. We also recommend a moisture vapor barrier be placed under all areas especially where floors will have moisture sensitive coverings, or where stored materials are moisture sensitive.

To assure an adequate factor of safety against a shearing failure in the subsoils:

- Footing base should be at a depth of at least 18 inches below lowest adjacent grades.
- Continuous footings should be at least 16 inches wide.
- Isolated foundations should not be less than 30 inches wide.
- The required embedment depth may be reduced to 12 inches if a monolithic raft/ mat slab type of foundations is used.

7.3.1 RIVER OAKS OUTFALL ELECTRICAL EQUIPMENT BUILDING

For Merle Fogg Park, none of the borings performed in this location encountered any organic material. For the River Oaks Outfall, three of the four soil borings (R-9, R-10, and R-12) performed in the area of the proposed electrical equipment building encountered a 2 to 4 feet thick layer of organic material at depths ranging from 2 to 5 feet below the existing ground surface. The evaluation of the organic material layer is only relevant for the electrical equipment building, since the bearing depth of the foundation for the lift station structure is well below the organic material layer.

The foundation for the electrical equipment building is expected to bear above the organic material layer encountered in the borings. If the organic material layer is left in place below the electrical equipment building, some total and differential settlement (both short-term “immediate-type” will occur. Such settlements result from the weight of the structural fill and structure placed above the organic material and the associated short term primary settlement and long term “creep-type” secondary settlement inherent to compressible organic soil material. Settlement caused by the encountered organic material layer beneath he structure is expected to moderately affect the proposed electrical equipment building.

If moderate settlements of the electrical equipment building on the order of 3-4 inches is considered problematic, then we recommend that to eliminate settlement related issues, the organic material encountered in the borings be excavated and removed prior to construction of the electrical equipment building. Alternatively, the organic material can be left in place and the area preloaded with 5 feet of dumped and stacked fill to induce settlement similar to the increased stress caused by the construction of the proposed control building. Excavated organic material is generally not appropriate for reuse in other construction as it has a tendency to consolidate, erode and generally bio-degrade with time. Therefore, excavated organic material should be disposed of at a suitable on or off-site location.

7.4 PAVEMENT DESIGN CONSIDERATIONS

The following information is provided and intended as a guideline only, as the roadway or any replacements/repairs thereof, should be designed specifically for the vehicle load intensities for the respective roadways and frequencies anticipated during the life of the project. Flexible pavement systems in this south Florida geographic area, typically consist of an asphaltic concrete wearing course, limerock base course and a stabilized pavement subgrade. Based on our preliminary findings and analysis and experience in the area, the typical pavement section thicknesses shown in the following Table 30, are commonly used by local pavement design engineers.

TABLE 30: TYPICAL FLEXIBLE AND RIGID PAVEMENT DESIGN

TYPE OF PAVEMENT	LAYER	MATERIAL DESCRIPTION	LAYER THICKNESS		
			LIGHT DUTY	MEDIUM DUTY	HEAVY DUTY
Flexible	Asphaltic concrete	Florida DOT Asphalt Type S	1.5	1.75	2.0
	Base course	Crushed limerock with minimum LBR of 100, compacted to 98% of the Modified Proctor maximum dry density	6.0	7.0	8.0
	Stabilized subbase	Stabilized sub-base fill with a minimum LBR of 40 compacted to 95% of the Modified Proctor maximum dry density	12.0	12.0	12.0
Rigid	Concrete	Florida DOT Portland Cement Concrete	6.0	7.0	8.0
	Compacted subgrade	Natural in place soils compacted to at least 95 percent of the materials Modified Proctor maximum dry density	12.0	12.0	12.0

Comparison of the above typical design thicknesses with asphalt pavement measurements provided in Tables 1 and 2, Pages 1 through 6, indicates that most of the asphalt cores measured thickness would comply with or exceed the above typical design thicknesses for light duty pavements. The asphalt cores that do not comply with the above typical asphalt design thickness for light duty asphalt pavement were encountered at borings D-4, DR-5, E-1, P-4, R-4, R-8, and V-5. We suspect that the substandard asphalt thicknesses were likely adequate for the design traffic loading conditions at the time of the initial roadway design and construction. For the asphalt thickness that exceed the above recommended thicknesses, we suspect that asphalt mill and resurfacing overlays were installed over the original asphalt to repair distress.

From a base thickness perspective, thirty-eight (38) of the sixty-eight (68) base rock thickness measurements meet or exceeds a base rock thicknesses of 6 inches and are considered acceptable for light duty pavement design and use in light duty trafficked areas. However, given the thickness of the asphalt cores and a general rule of thumb that one inch of asphalt is equivalent to two inches of compacted limerock base, the combination of both of the measured base and asphalt material thicknesses would appear to provide a suitable pavement section thickness in most areas such that a pavement mill and re-surface program may prove cost effective. Further analyses of the pavement section will need to be provided by a civil pavement design engineer experienced with such evaluations. We suspect that the substandard base course thicknesses were adequate for the traffic loading during the initial roadway construction.

From a subgrade perspective, in our opinion the nature and composition of the subgrade soils at the location of the borings performed for this study would essentially be in compliance with typical pavement construction designs for light duty pavement section design.

Any new or re-constituted base course material should consist of crushed limestone having a minimum Limerock Bearing Ratio (LBR) of 100. Base materials should meet the requirements presented in the latest revisions of the Florida Department of Transportation "Specifications for Road and Bridge Construction", Section 911 (limestone). The base course should be compacted to at least ninety-eight (98) percent of its maximum dry modified proctor density (AASHTO T 180).

We recommend that any new pavement subgrade be stabilized to a depth of twelve (12) inches to achieve a minimum LBR of 40. If necessary, this LBR value can be achieved by blending base material (limerock) with the existing sandy subgrade soils. The required mixing ratio should be determined by laboratory testing. The stabilized subgrade should be compacted to at least ninety-eight (98) percent of its maximum dry as determined per ASTM D 1557, the Modified Proctor Method.

A Portland concrete pavement thickness in the range of eight (8) inches would also be recommended for the project if a rigid pavement is to be employed (the thickness would depend on specific pavement use). Any concrete pavement should be reinforced to withstand the anticipated traffic loadings and jointed to reduce the chances for rigid pavement crack development. The minimum rigid pavement thickness recommended above is based upon concrete with an unconfined compressive strength of at least 3,000 psi and a modulus of rupture of at least 450 psi. It should be noted that this recommendation is intended for the street pavement and not for concrete driveway aprons or sidewalks.

Actual pavement section thickness should be determined by the Design Civil Engineer based on traffic loads, volume, and the Owner's design life requirements. The above sections represent minimum thickness representative of typical local construction practices and, as such, periodic maintenance should be anticipated. All pavement materials and construction procedures should conform to FDOT, American Concrete Institute (ACI), and/or appropriate City or County requirements for roadway pavement construction.

7.4.1 PERVIOUS PAVEMENT DESIGN CONSIDERATIONS

The soil borings and laboratory test results indicate that most of the existing sands encountered are suitable for subgrade use in pervious pavement areas, as defined by the South Florida Water Management District (SFWMD). The sand subgrade soils should be compacted to a maximum density of 95% of the maximum dry density as determined by ASTM D1557, or AASHTO T180, to a minimum depth of 24 inches. As per the SFWMD specifications, subgrade stabilization is not required for sand type of soils (SP). If additional fill material is required to bring the subgrade to final elevation, it should be hydraulically clean (maximum of 10% silt or clay), and free of deleterious materials.

For redevelopment projects where the existing pavement section is to be removed; the compacted base should also be removed and the underlying subgrade soils scarified to a minimum depth of 20 inches. The subgrade should be re-graded and filled with clean (hydraulically clean and free of deleterious material) soils. The clean soils should be placed in 8-inch maximum layers and compacted to a maximum density of 95% of the Modified Proctor density within 3% of the optimum moisture content (ASTM D-1557, or AASHTO T180).

It is recommended by SFWMD that the Seasonal High Groundwater Table (SHGWT) elevation be greater than 24 inches below the bottom of any pervious pavement system. The pervious pavement system is suggested to include an underlying storage reservoir consisting of pea rock, #57 stone, etc. If utilized, the underlying storage reservoir should be wrapped with geo-fabric. SFWMD recommends that the underlying storage reservoir layer be no more than 36 inches thick. Runoff from adjacent landscaped areas should not be directed onto any pervious pavement system unless the adjacent landscape areas that drain onto the pervious pavement, will not increase sediment, silt, sand, or organic debris deposition on the pavement that increases the potential for clogging of the pervious pavement section. The site design should include measures to reduce the likelihood of silts and sands from entering and plugging the pervious pavement system void spaces.

Periodic vacuum sweeping of pervious pavements can be used and is recommended. For areas where wind transported soil (i.e. near sand dunes or other coastal areas), or other conditions where excessive soil or other material deposition can occur, vacuum sweeping should be utilized a minimum of twice a year.

7.5 CLEARING AND GRUBBING

Clearing and grubbing may be required in some of the proposed construction areas. Clearing and grubbing where required should include the complete removal and disposal of surficial grasses, associated root systems, topsoil, rubbish, debris, any demolition material/pavement and all other obstructions resting on or protruding through the surface of the existing ground and the surface of excavated areas.

7.6 UNDERGROUND UTILITIES

Existing underground utilities and structures are likely to be present in the proposed construction areas. These utilities need to be properly identified, and located and/or relocated as necessary to construct the new components of the project. The excavation bottoms of any relocated or replacement utilities should be cleaned of any undesirable materials prior to placing any engineered backfill.

Site preparation, excavation, and backfilling for new utilities or re-aligned utilities should follow all of the applicable recommendations of this report.

7.7 EXCAVATIONS

The project construction Contractor is solely responsible for making any utility or other excavations in a safe manner and to provide appropriate measures to retain side slopes to ensure that persons working in or near the excavation are protected. Any structural retaining walls shall be designed and sealed by a structural engineer registered in the State of Florida.

Excavations shall comply with Occupational Health and Safety Administration (OHSA) stipulations for Trench Excavation Safety including all temporary design and safety requirements. The soils encountered in the majority borings outside of the Victoria Park and Southeast Isles area, generally consist of relatively clean sands. OSHA 29 CFR part 1926 (Subpart P, Excavations) defines such soils as Type C soils. As such, the granular deposits encountered in the borings are readily capable of being excavated to a depth of several feet with standard backhoe construction equipment. As such, temporary side slopes in fully dewatered excavations could be made at a 1½H:1V inclination or flatter. Adjustment to this inclination and/or the use of sheeting, shoring or sliding trench boxes should be evaluated by the Contractor if other soil strata are encountered.

It is noted that in the Victoria Park, River Oaks, and Southeast Isles areas, that significant Muck deposits were encountered in the borings performed for these areas. Correspondingly, utilities installed in these areas are likely to encounter organic Muck deposits during the utility excavation and installation process requiring cleaning or removing of the Muck deposits prior to placing any engineered backfill as mentioned in section 7.10.

7.8 DEWATERING

At the time of the field exploration (i.e. September and October 2017), the groundwater encountered varied between 0.5 to 6.5 feet below the existing ground surface. In-the-dry construction of the underground utilities may require groundwater lowering and control of groundwater seepage depending on the design installation depths. Dewatering of the excavations may necessitate the use of sumps, wells, wellpoints or combinations thereof. Control of groundwater should be accomplished in a manner that preserves the integrity of the in-situ soils and limestones and does not cause instability of the excavation sidewalls. The dewatering system employed should be capable of maintaining a pre-drained surface a minimum of 24 inches below the excavation bottoms.

7.9 PIPE BEDDING

Most of the sands encountered in the borings are expected to provide good support for utility pipelines without the need for bedding when the invert elevations are at least 24 inches above the groundwater level (natural or pre-drained by dewatering). Should or where organics or other deleterious materials be encountered at or within 2 feet below the pipe invert, such soils shall be considered compressible and unsuitable for pipe support. These soils should be over-excavated and replaced with compacted clean sand or FDOT No. 57 coarse aggregate or an approved equivalent. If FDOT No. 57 stone or an approved equivalent is utilized, such stone material will need to be encapsulated and/or covered with a geosynthetic fabric especially beneath pavement areas. Such fabric material is needed to prevent granular excavation soils and trench backfill from penetrating/settling into the void volumes of the open stone resulting in loss of ground and eventual settlement of the ground surface above the piping.

The bedding surface should be uniformly compacted to a density of not less than 95 percent of the maximum dry density in accordance with ASTM D 1557, the Modified Proctor Method.

7.10 TRENCH BACKFILL AND COMPACTION

Soils used to backfill utility excavations should consist of clean sands having no materials larger than one inch in size, not more than ten (10) percent passing the U.S. Standard No. 200 sieve, and not more than three (3) percent organics or other deleterious materials by weight. Some of the subsurface soils encountered at these neighborhood sites appear to meet these criteria and are suitable for reuse as backfill once inspected, tested and approved.

Granular backfill should be placed at a moisture content within three (3) percent of its ASTM D 1557 determined optimum moisture and in level lifts whose thickness does not exceed eight (8) inches. Each fill lift should be stable, unyielding and uniformly compacted to at least 95 percent of the maximum dry density in accordance with ASTM D 1557, the Modified Proctor Method. We recommend the use of only relatively light, hand-held compaction equipment in the densification operations around utilities to limit the potential damage to the pipelines and buried structures.

7.11 SITE PREPARATION

The site preparation for any roadway modifications should consist of necessary clearing and grubbing in general accordance with Section 110 of the FDOT Standard Specifications for Road and Bridge Construction or any similar City/County standard design criteria applicable to the project. Any topsoil or other deleterious material encountered in proposed pavement areas, will need to be stripped, removed and replaced with embankment or roadway fill. If buried organic soils, debris or other unsuitable materials are encountered during the construction, which are or are not disclosed by the borings, they should be removed and replaced with a backfill material as described in following sections.

The Stratum 1 soils are select granular soils and are satisfactory to use in the subgrade and embankment when utilized in general accordance with FDOT Standard Index 505 or any similar City/County standard design criteria applicable to the project. Soils exposed at the stripped grades will require moisture conditioning to near the optimum moisture content prior to initiating the densification operations. In residential areas, the use of such heavy vibratory compaction equipment may prove problematic and disruptive or even damaging to existing/adjacent home owner's properties. In such cases, the compaction will need to be performed and achieved with lighter weight, less vibration generation capable equipment such as walk behind (e.g. Whacker) ground pounder or small vibratory rolling equipment.

Each section of the stripped grade should be subjected to multiple, overlapping coverages of the compactor as it operates at a travel speed of no more than 1.5 miles per hour (normal walking speed). Compaction should be continued until no further settlement can be visually discerned at the ground surface. The densified areas should include a 3-foot perimeter along proposed new pavement areas.

Density control should be exercised for the exposed subgrade for any roadway repairs. Soils in this interval should be compacted to not less than 95 percent of the maximum dry density in accordance with ASTM D 1557, the Modified Proctor Method. Subgrade soils that noticeably pump or deflect under the weight of the passing compaction equipment, could indicate the presence of soft, weak, overly saturated soils or compressible and loose soil zones existing in the near surface subgrade within the depth of influence of the roller. In such cases, those areas should be remedied by appropriate means to be determined by the inspecting field representative in consultation with representatives of the design team.

7.12 SELECT FILL COMPOSITION, PLACEMENT AND COMPACTION

Site structural and pavement embankment fill and backfill required for construction should consist of clean, granular materials that are free of debris, cinders, combustibles and organic matter. The fines content (i.e., material passing U.S. Standard No. 200 sieve) should not be more than ten (10) percent by weight, no particle sizes larger than one (1) inches in any direction and the organic content should not exceed three (3) percent by dry weight. The on-site sand soils appear to meet the above criteria and are suitable for use as structural fill and backfill material. Organic laidened soils encountered in several of the borings soils beneath the upper sand layer such as those encountered in the River Oaks, Victoria Park and Southeast Isles area, will not be suitable for use of Select Fill.

The granular fill should be placed at a moisture content within three (3) percent of its Modified Proctor (ASTM D 1557) determined optimum in level lifts whose loose thickness does not exceed twelve (12) inches. In areas where heavy equipment cannot be operated for compaction, the fill should be placed in six (6) inch thick level lifts. Each fill lift should be stable, unyielding and uniformly compacted to 95 percent of the ASTM D 1557 maximum dry density, as verified by the designated site construction inspecting representative.

Select fill soils will require moisture conditioning to near the optimum moisture content prior to initiating the densification operations. Similar to the subgrade preparation, the fill densification should normally be accomplished using a self-propelled vibratory compactor which imparts a dynamic drum force of not less than 44,000 pounds. However, in residential areas, the use of such heavy vibratory compaction equipment may prove problematic and disruptive or even damaging to existing/adjacent home owner's properties. In such cases, the compaction will need to be performed and achieved with lighter weight, less vibration generation capable equipment such as walk behind (e.g. Whacker) ground pounder or small vibratory rolling equipment.

7.13 OBSERVATION AND TESTING

It is recommended that a geotechnical engineer be retained to provide soil engineering inspection services during the construction excavation phase of the project. This is to observe compliance with the design concept, specifications and recommendations, and to allow design changes in the event subsurface conditions differ from those anticipated. In addition, an inspection and testing representative of a geotechnical engineer should be present to provide monitoring and testing of both fill and concrete placement during the construction phase of the project.

8.0 EXISTING UTILITIES

Existing utilities could potentially be present within or near the proposed seawalls. Precautionary measures should be taken to identify and locate any such systems impacted by the planned construction. Where encountered, mitigative design details should be provided accordingly. Consideration should be given as to what kind of utilities are present (i.e. nature and composition), and what the utility or other owner's guidelines and specifications are regarding their re-location etc. Utility locates should be in general accordance with the FDOT Plans Preparation Manual, Section 5.3 – Utility Locates.

9.0 PROTECTION OF EXISTING STRUCTURES

Ground vibrations induced upon adjacent structures, primarily by soil compaction equipment or any other construction activities such as pile driving, should be monitored to assure that they do not reach levels which prove damaging to any adjacent/nearby structures. Vibration Monitoring should be performed in general accordance with "Section 108, Protection of Existing Structures" of the current FDOT Standard Specifications for Road and Bridge Construction or other similar local City/County regulations or ordinances.

Vibration levels on adjacent facilities should generally be maintained below a 0.25 inches/second peak particle velocity level however, more restrictive/lessor levels as low as 0.10 inches/second may be specified for highly sensitive residential or historical areas. The construction Contractor will need to inventory and provide a pre-construction inspection of adjacent structures and determine suitable vibration monitoring programs and impact limits for their construction activities. Such monitoring will be particularly important for the Victoria Park and Southeast Isles area as the ground conditions will have a higher tendency and capability to transmit vibrations horizontally from the construction activities.

It is noted that the residential homes in the Victoria Park and Southeast Isles area are likely founded on short driven piles installed to sound bearing conditions beneath the buried organics. Vibrations in the lower soil/rock layers beneath the organics, from construction activities such as sheet piling installation, will have the potential to be transmitted into the residences via the piling foundations installed for the structures. Typically, for sheet piling and driven pile installations, a maximum allowable peak particle velocity of 0.10 inches/second has been used in the construction specifications for areas of similar natured residential and commercial structures that exist in this project area.

10.0 LIMITATIONS

This report is intended for geotechnical purposes only, and not to document or detect the presence, or absence of any environmental conditions at the site, or to perform an environmental assessment of the site.

The analysis and recommendations presented in this report are based upon our interpretation of the subsurface information revealed by the test borings. The report does not reflect variations in subsurface conditions that may exist between or beyond these borings. Variations in soil and groundwater conditions should be expected, the nature and extent of which might not become evident until construction is undertaken. If variations are encountered, and/or the scope of the project altered, we should be consulted for additional recommendations.

RADISE International warrants that the professional services performed and presented in this report are prepared for Hazen and Sawyer, and are based upon typical standard of care recognized principles and practices in the discipline of geotechnical engineering and hydrogeology at this place and point in time, for this project site. No other warranties are expressed or implied.

-oOo-

RADISE appreciates the opportunity to be of service to you. Please feel free to contact us at 561-841-0103 if you have any questions or comments regarding this report.

Respectfully submitted
RADISE International, L.C.

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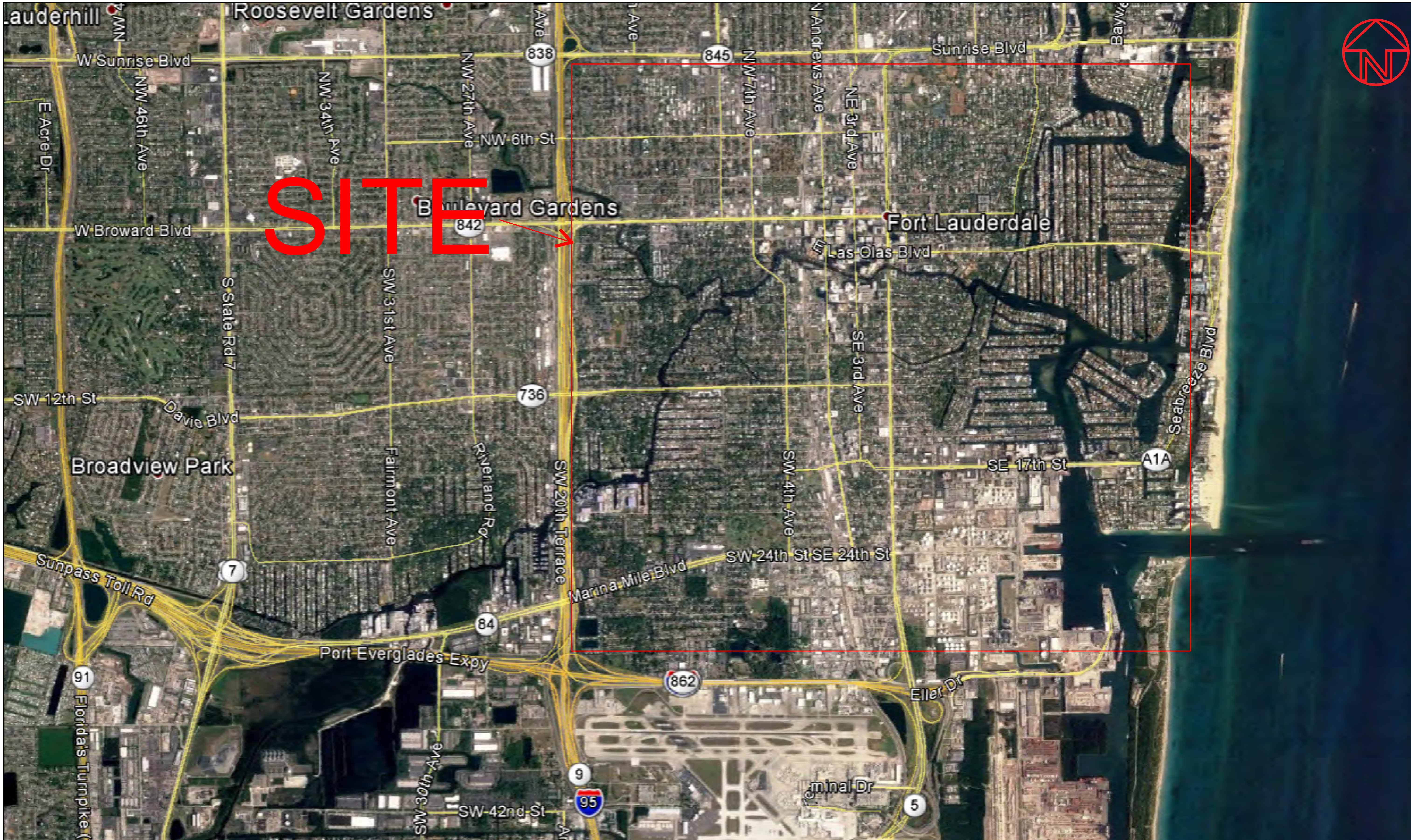

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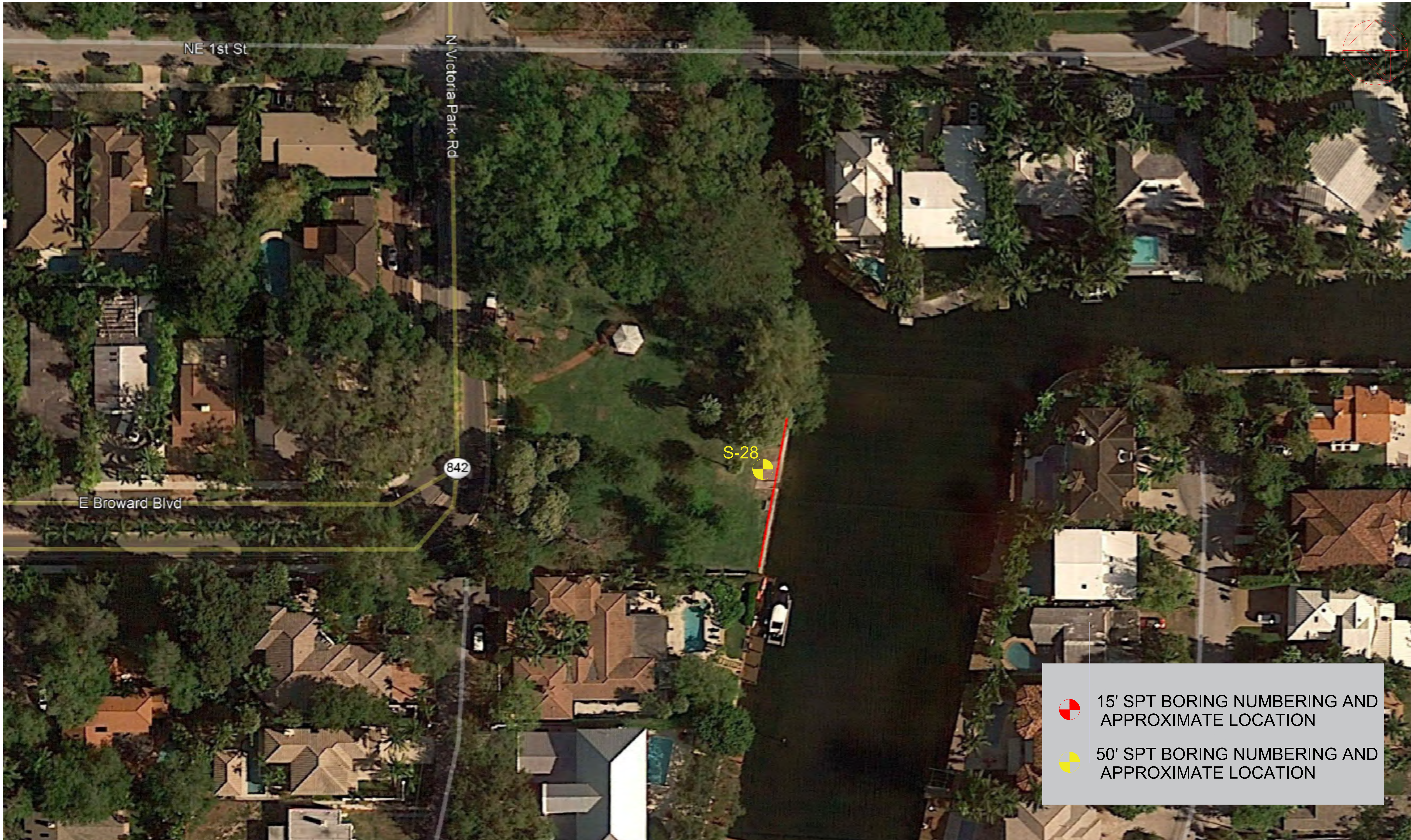
SHEET TITLE: VICINITY MAP

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 1

RADISE PROJECT NO: 170901



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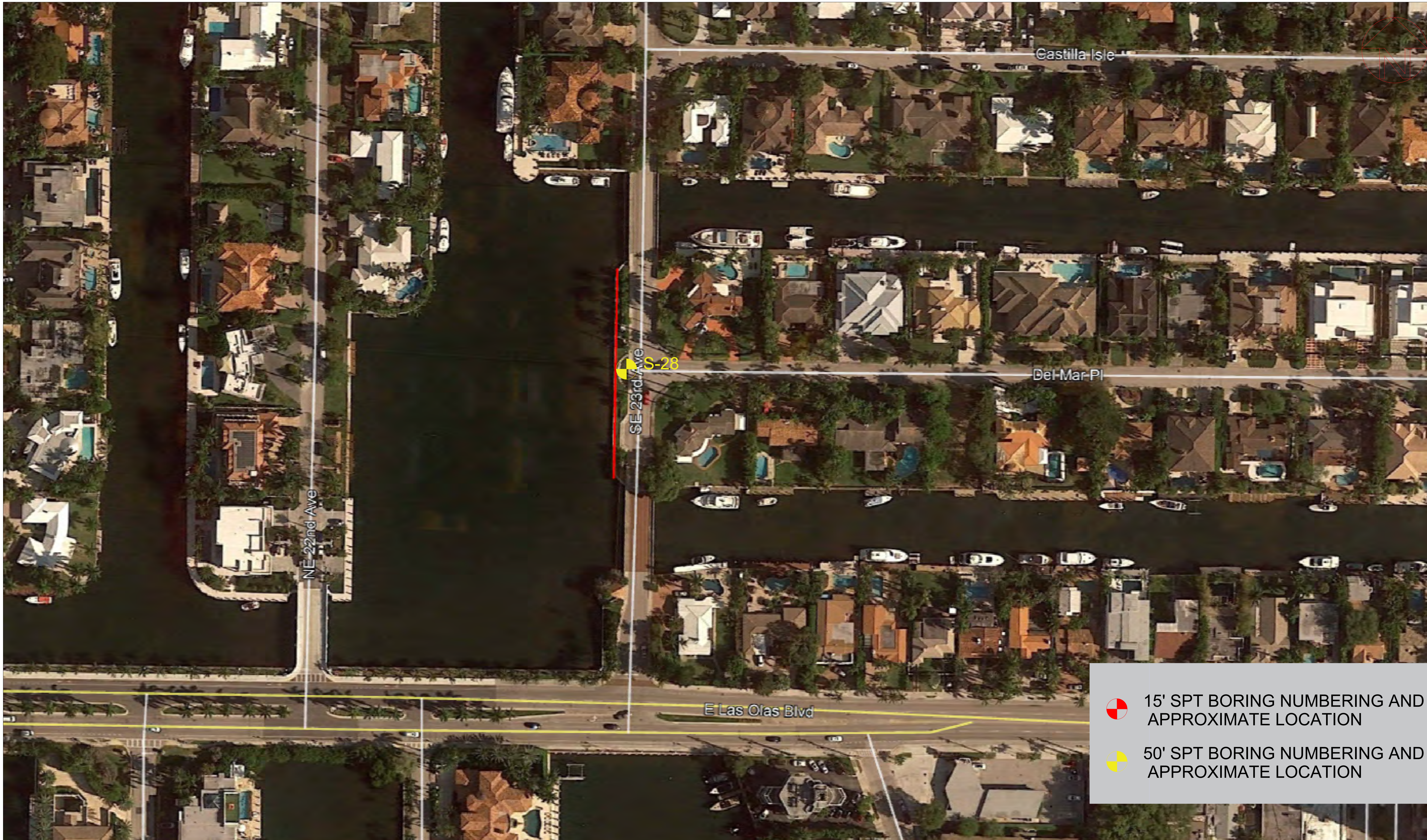
SHEET TITLE:	SHEET NO.
BORING LOCATION PLAN (SEAWALL 9)	2A
PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION	RADISE PROJECT NO: 170901



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SHEET NO. 2B

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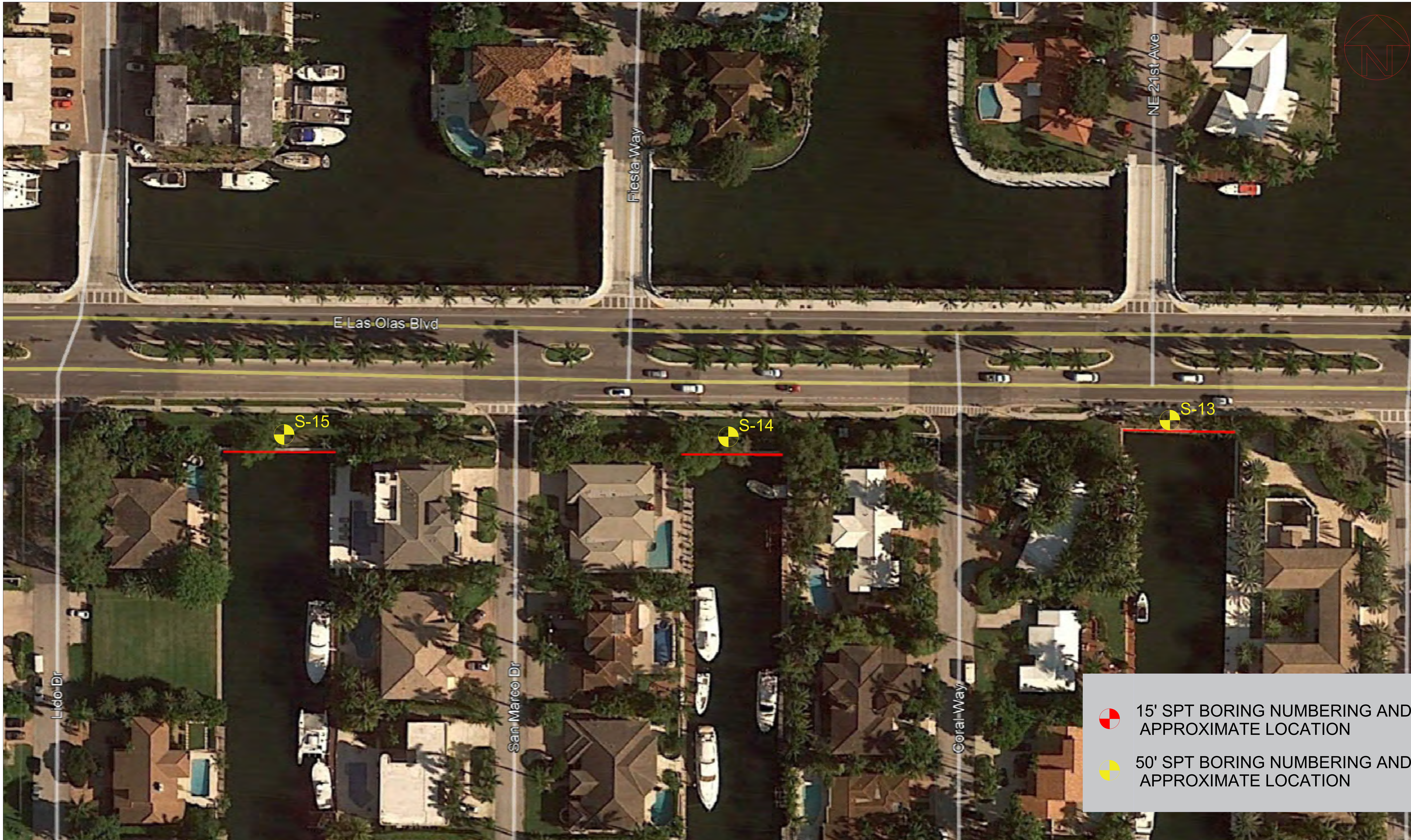

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SHEET TITLE: BORING LOCATION PLAN (SEAWALL 12, 13 AND 14)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2C

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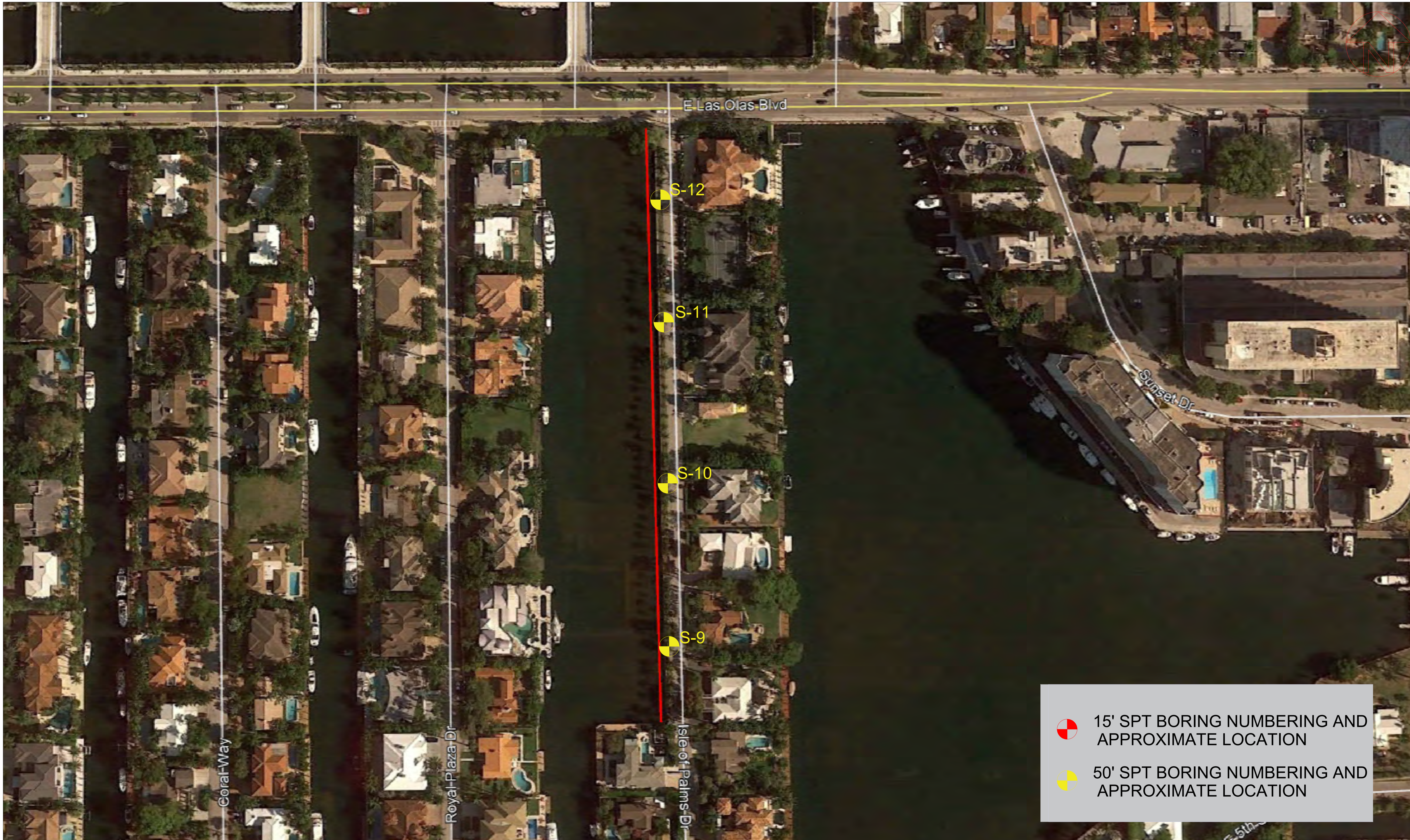

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SHEET TITLE: BORING LOCATION PLAN (SEAWALL 15)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2D

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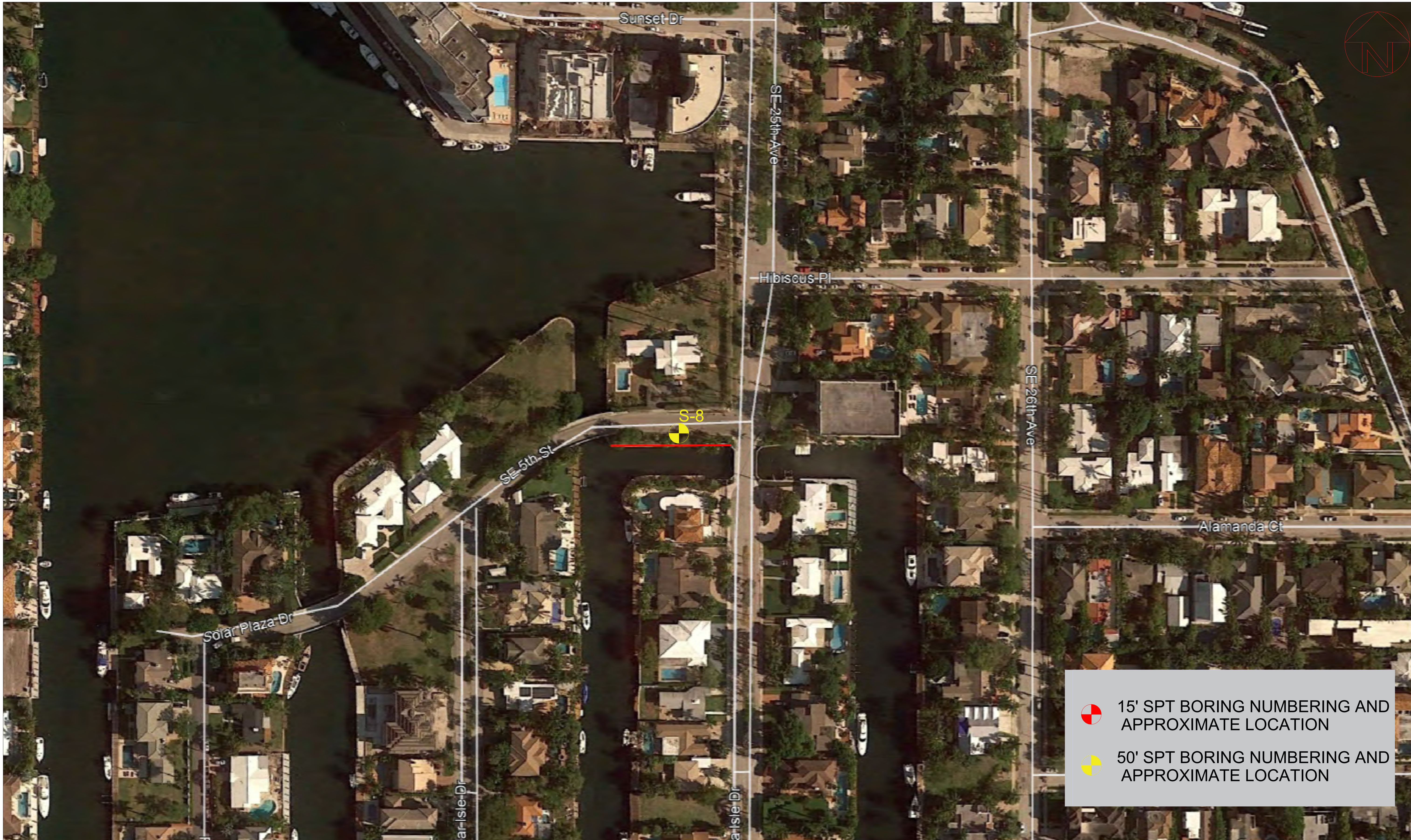

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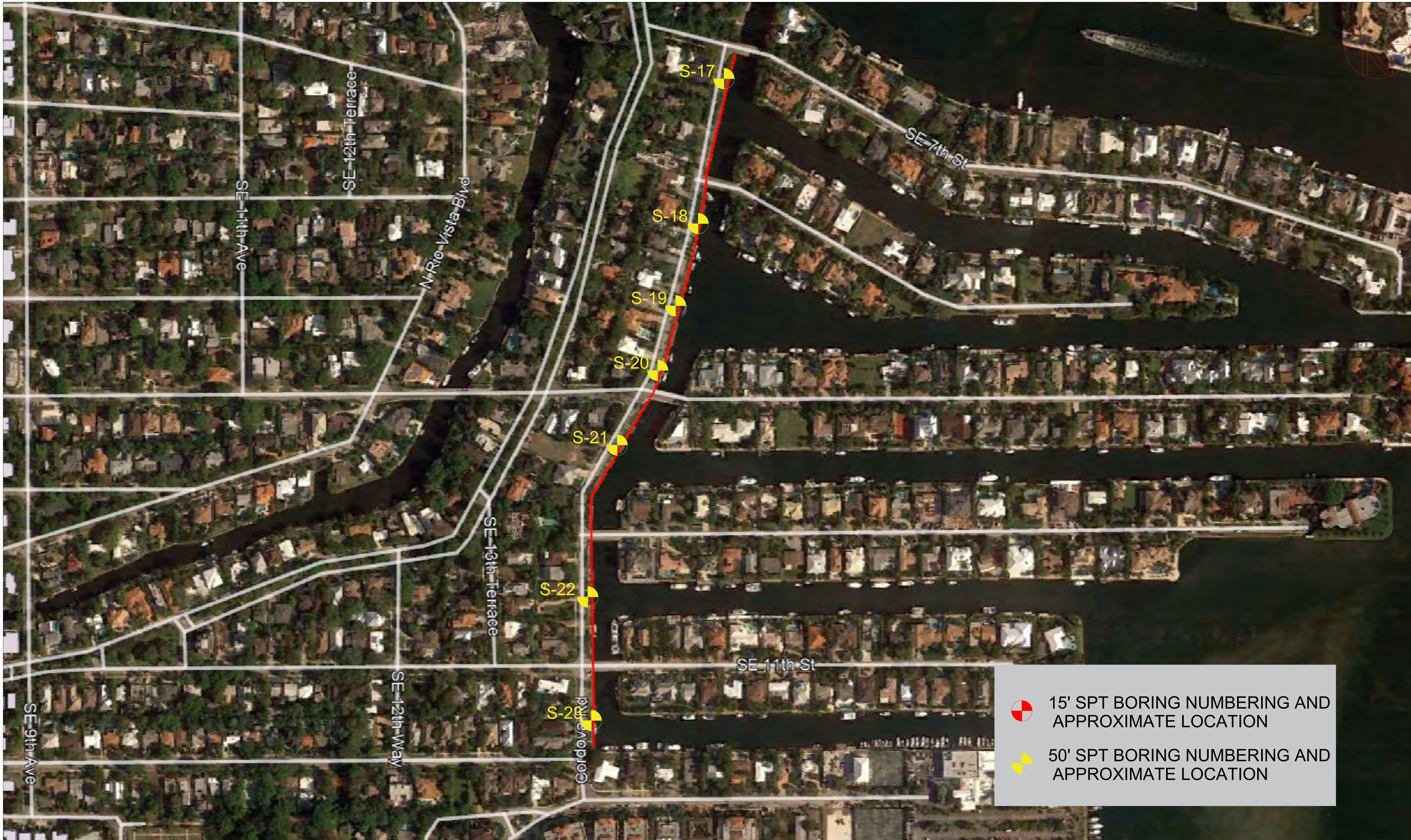

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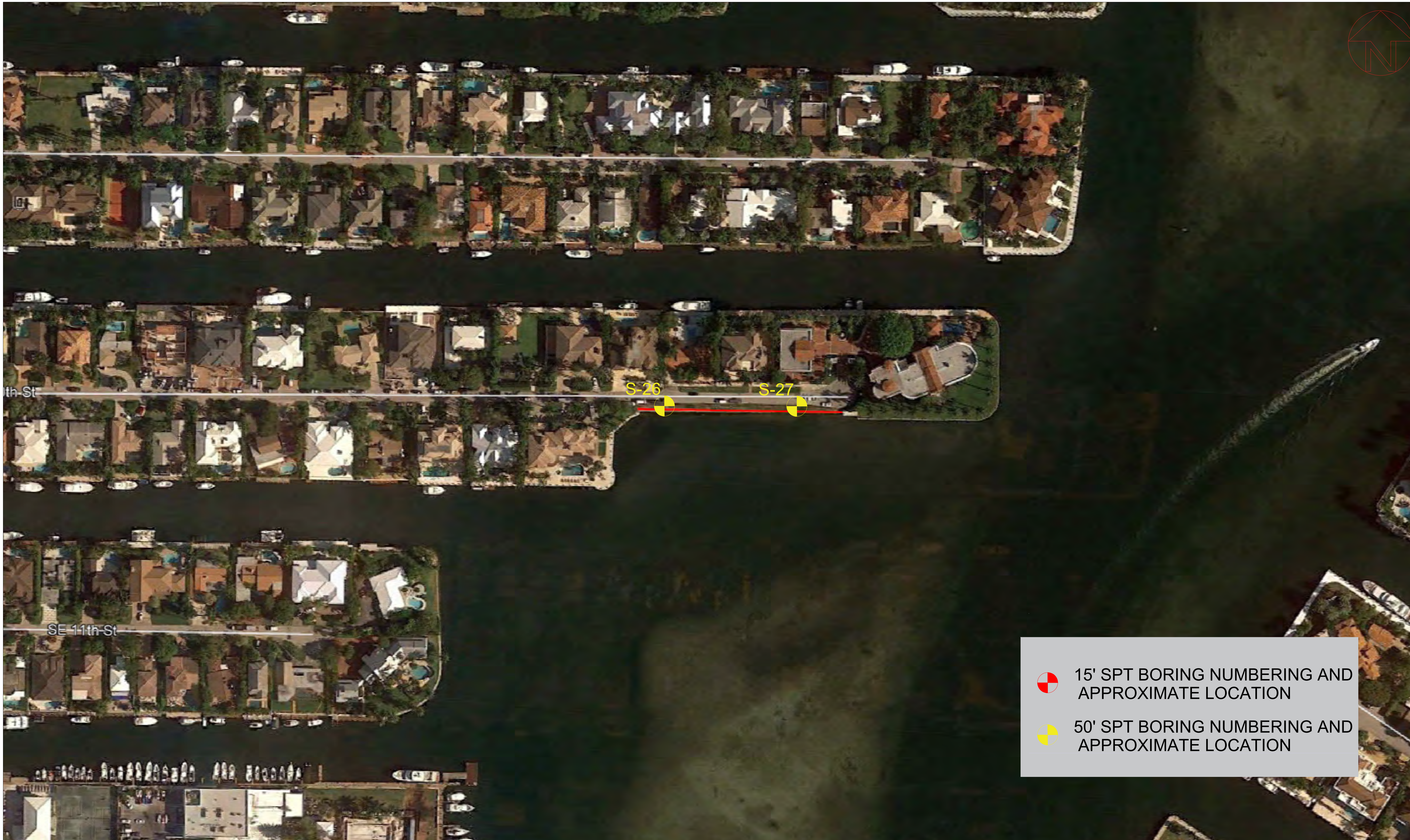
SHEET TITLE: BORING LOCATION PLAN (SEAWALL 29)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2F

RADISE PROJECT NO: 170901



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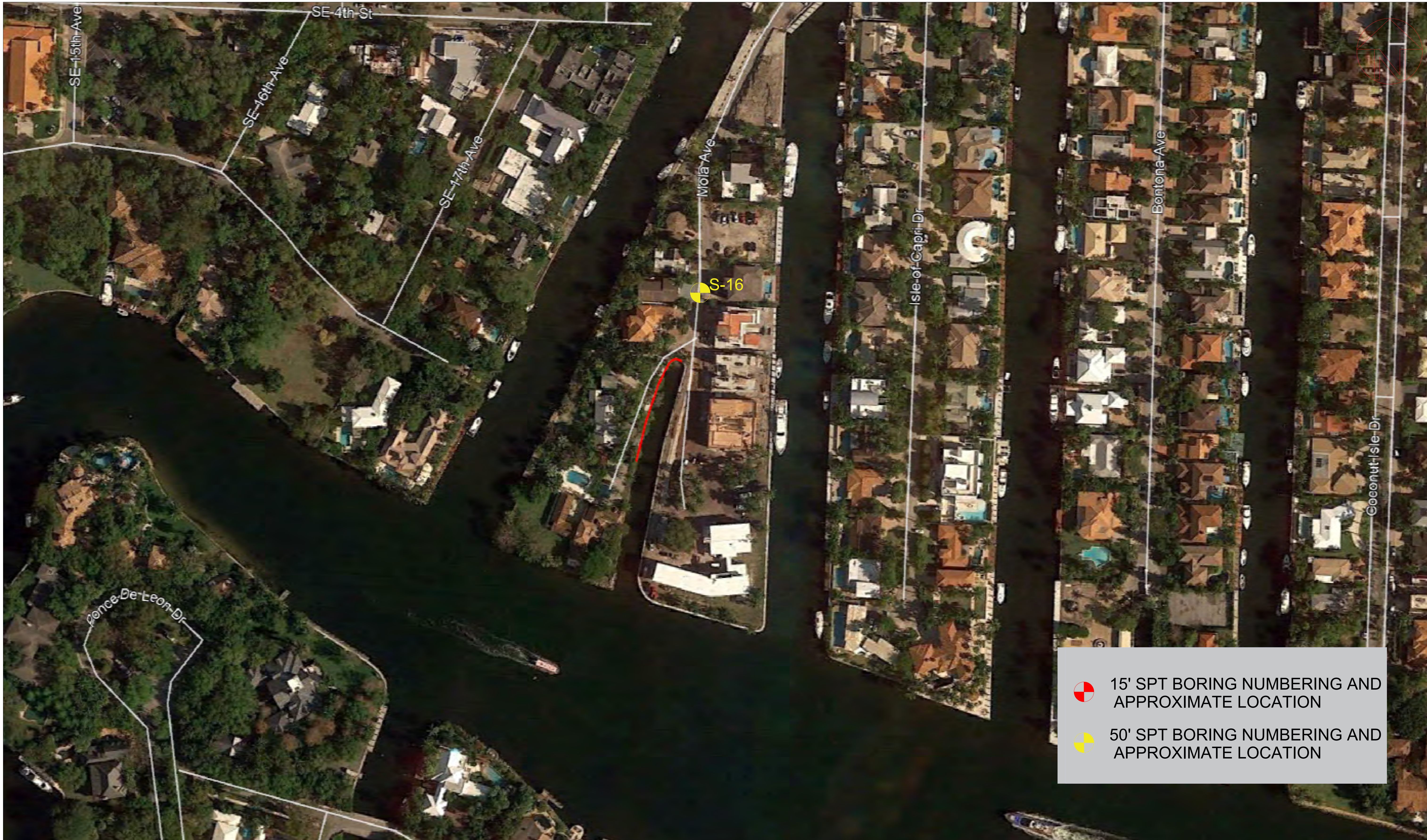
SHEET TITLE:	BORING LOCATION PLAN (SEAWALL 30)
PROJECT NAME:	STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION
SHEET NO.	2G
RADISE PROJECT NO:	170901



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SHEET TITLE: BORING LOCATION PLAN (SEAWALL 32)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2H

RADISE PROJECT NO: 170901

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CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

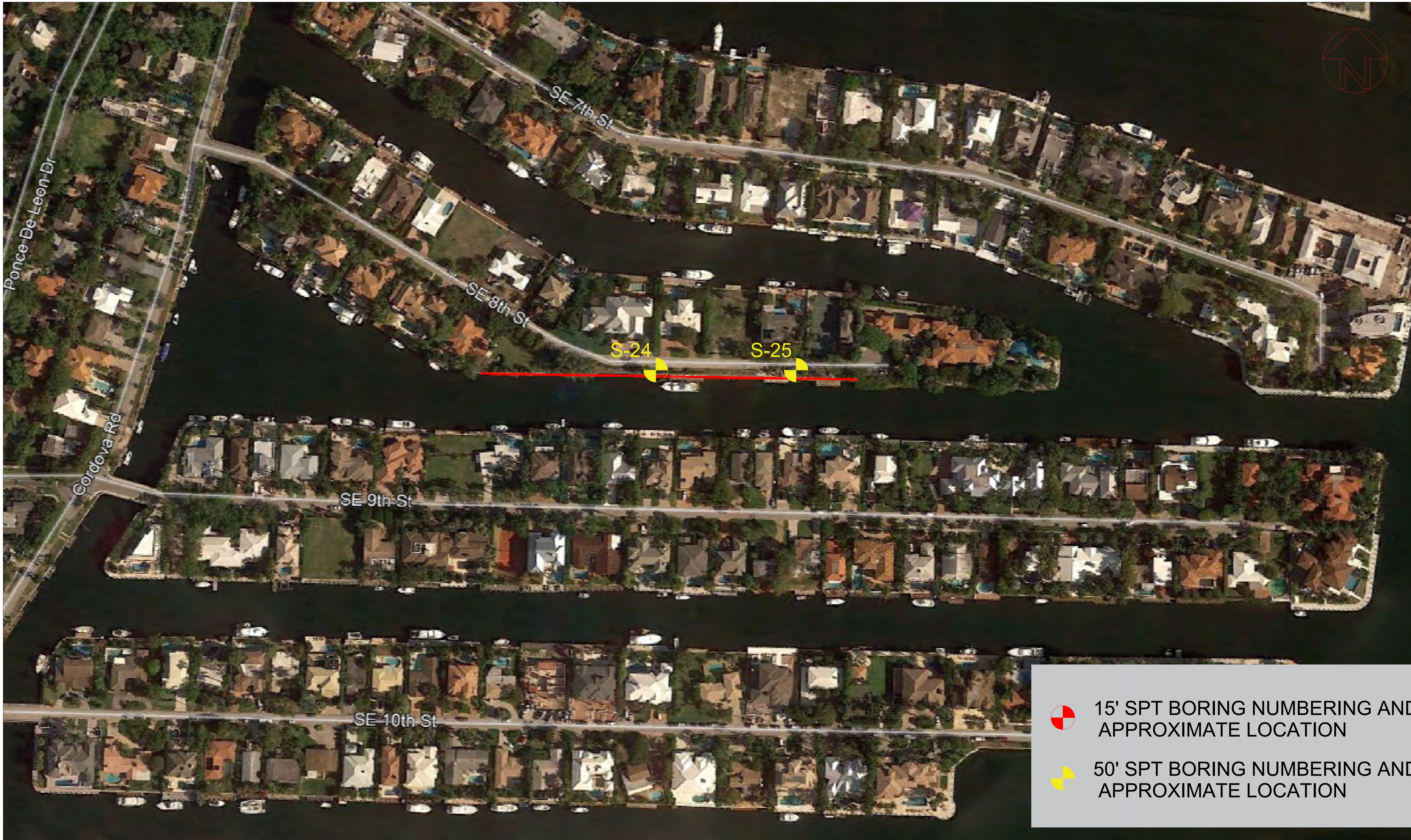
SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: BORING LOCATION PLAN (SEAWALL 34)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2I

RADISE PROJECT NO: 170901



REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
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COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: BORING LOCATION PLAN (SEAWALL 35)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2J

RADISE PROJECT NO: 170901

REVISIONS							Names	Dates
Date.	By	Descriptions	Date.	By	Descriptions	Drawn by	KA	11/15/17
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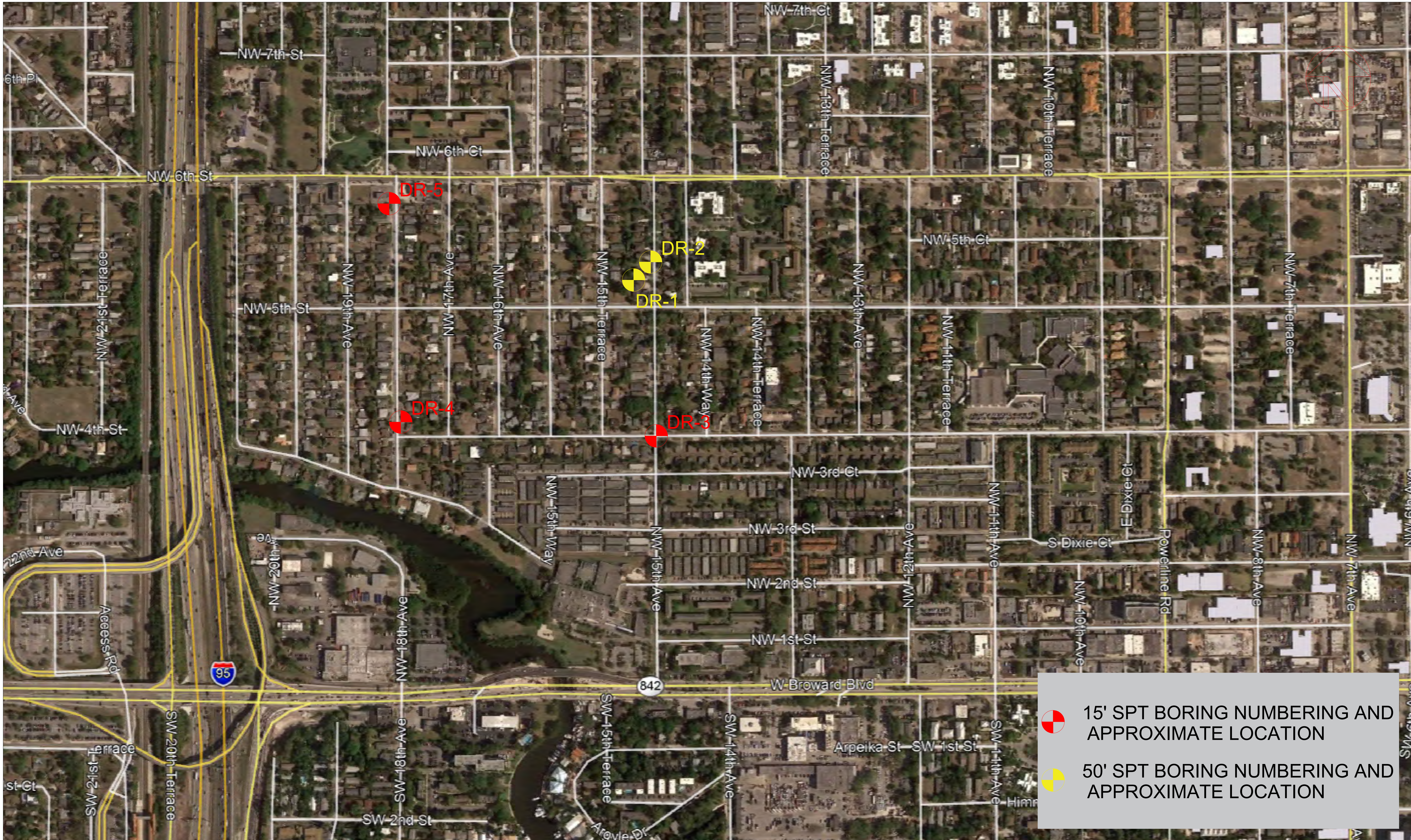
COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL	N.T.S.
SCALE: HORIZONTAL	N.T.S.
SHEET TITLE:	BORING LOCATION PLAN (SOUTHEAST ISLES)
PROJECT NAME:	STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION
SHEET NO.	2K
RADISE PROJECT NO:	170901



REVISIONS							Names	Dates
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PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: BORING LOCATION PLAN (DORSY RIVERBEND)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2L

RADISE PROJECT NO: 170901

REVISIONS							Names	Dates
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COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

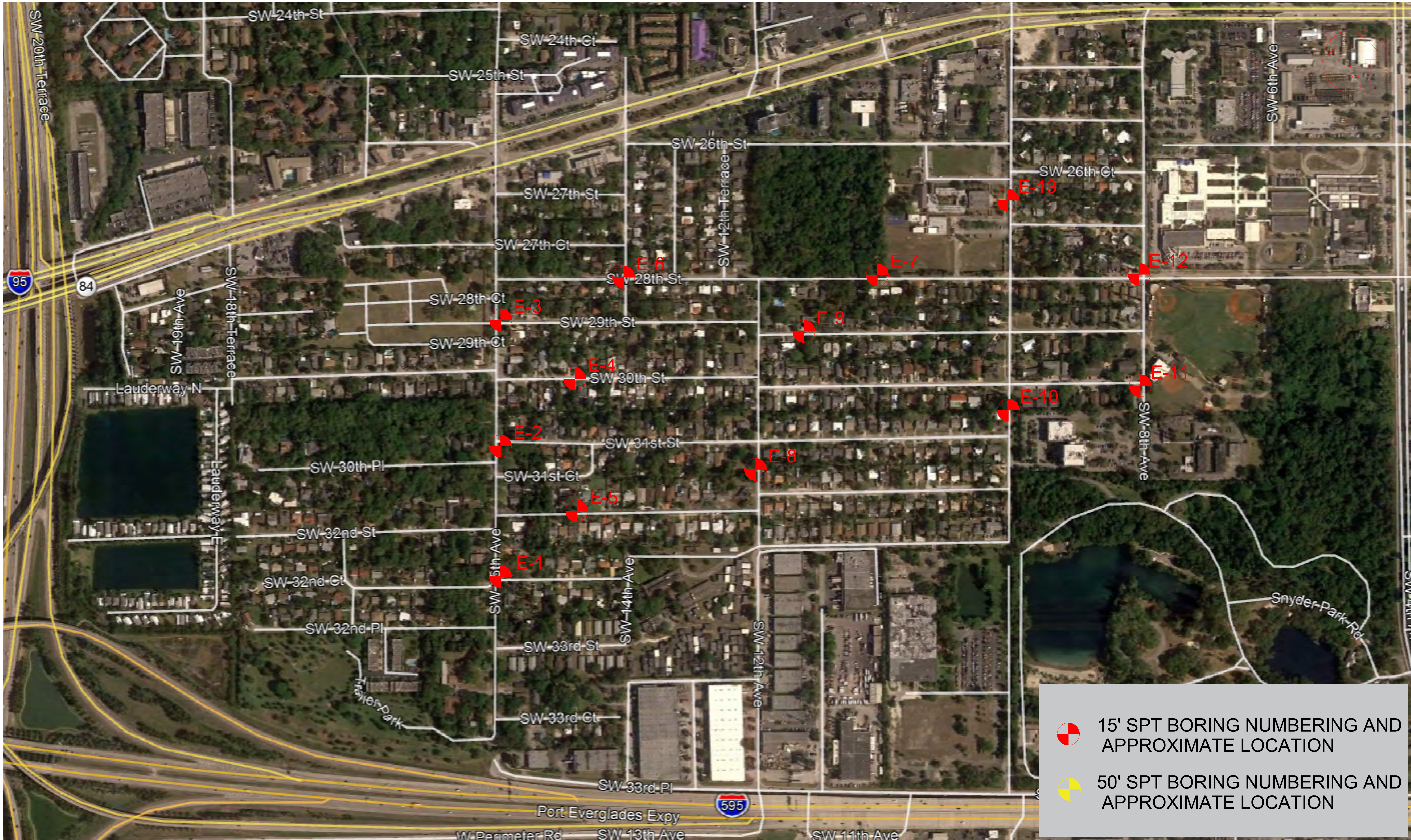
SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: BORING LOCATION PLAN (DURRS)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2M

RADISE PROJECT NO: 170901



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BROWARD	HAZEN AND SAWYER

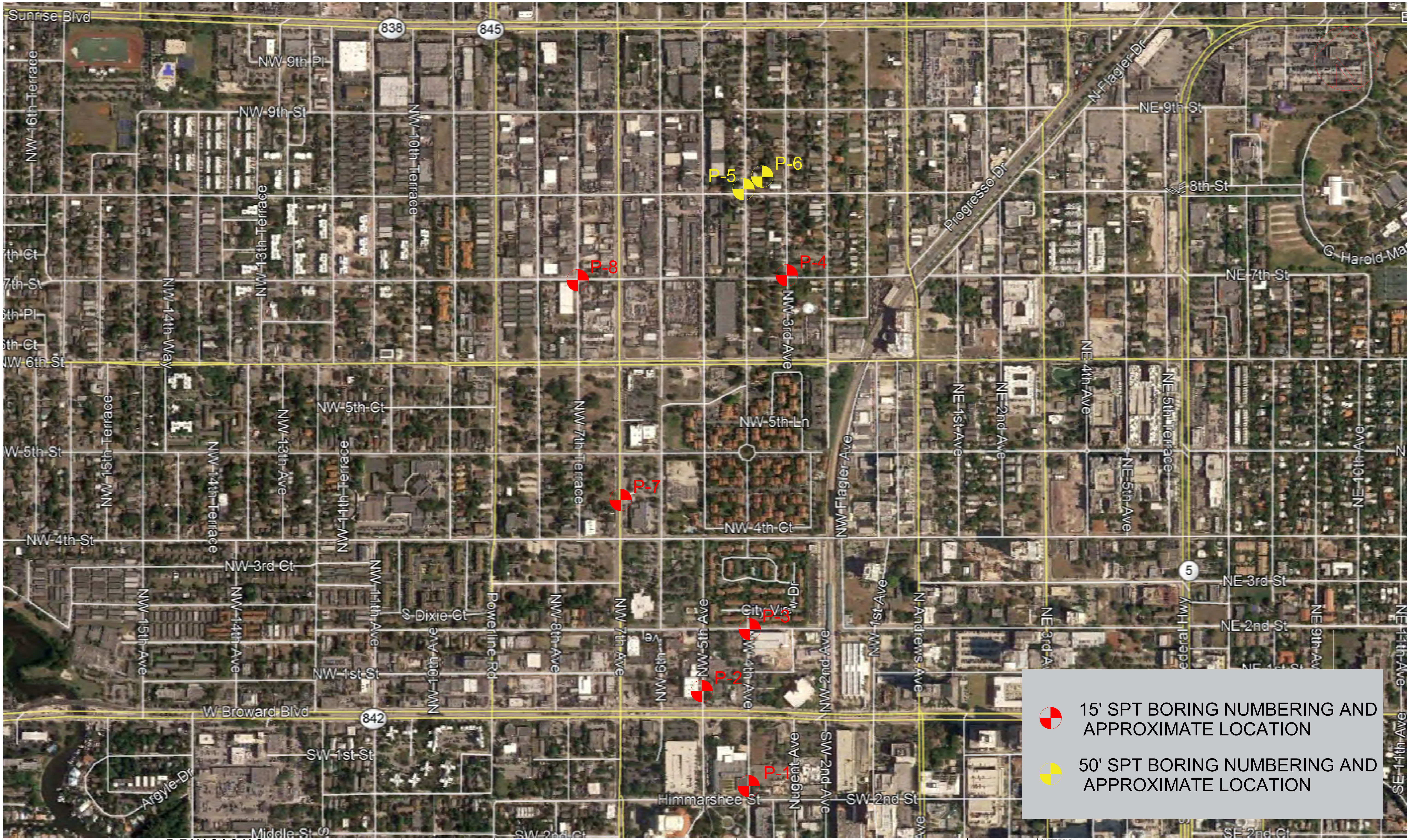
SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: BORING LOCATION PLAN (EDGEWOOD)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2N

RADISE PROJECT NO: 170901



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BROWARD	HAZEN AND SAWYER

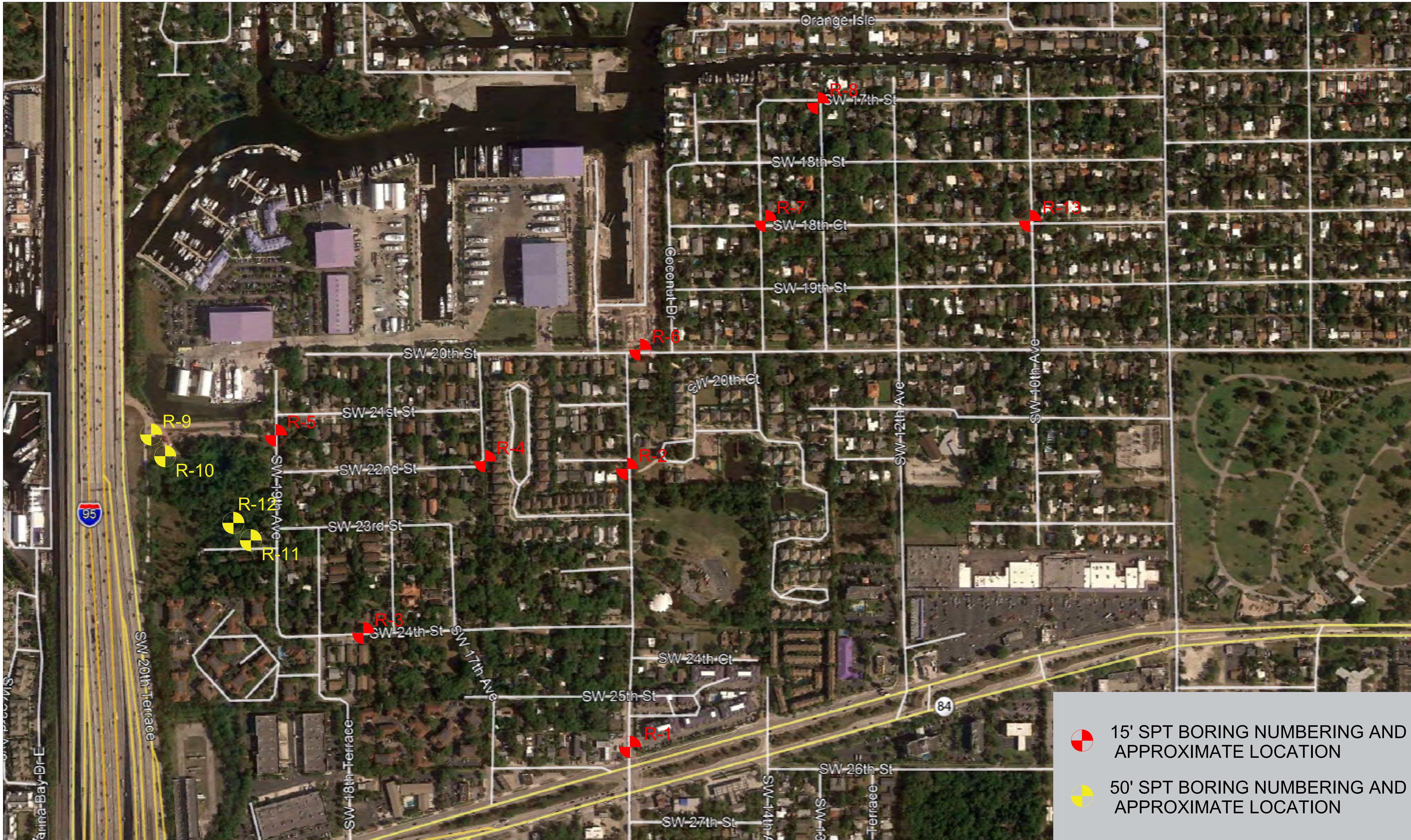
SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: BORING LOCATION PLAN (PROGRESSO)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2O

RADISE PROJECT NO: 170901



REVISIONS

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BROWARD	HAZEN AND SAWYER

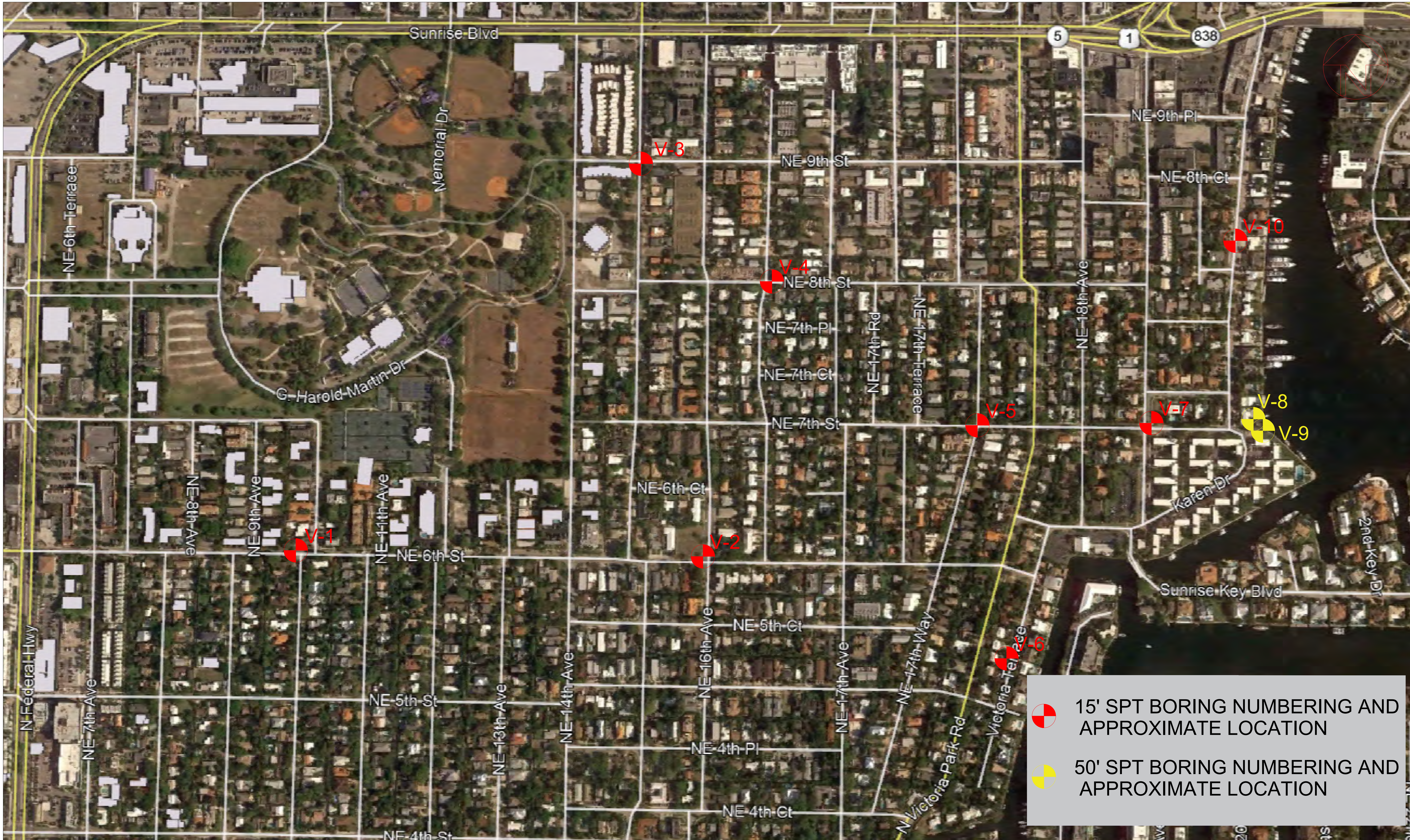
SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: BORING LOCATION PLAN (RIVER OAKS)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2P

RADISE PROJECT NO: 170901



REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

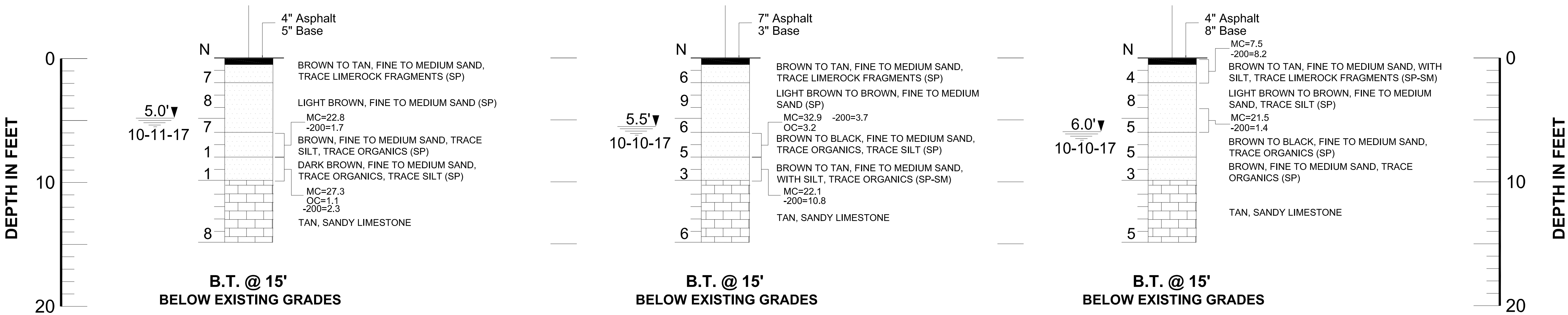
SHEET TITLE: BORING LOCATION PLAN (VICTORIA PARK)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 2Q

RADISE PROJECT NO: 170901

BORING NO.	D-1	D-2	D-3
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.1345°	26.1327°	26.1307°
LONGITUDE:	-80.1653°	-80.1639°	-80.1671°
DATE:	10/11/2017	10/10/2017	10/10/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

- ASPHALT AND BASE
- SAND
- SILTY SAND
- LIMESTONE
- GRAVEL
- ORGANIC MATERIAL
- 5.0' 10-11-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE
- N — STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, SM	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
D-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

(1) BORINGS WERE DRILLED ON OCTOBER, 2017 USING A CENTRAL MINING EQUIPMENT MODEL 45 (CME 45) AUTOMATIC HAMMER DRILL RIG.

(2) STRATA BOUNDARIES ARE APPROXIMATE AND REPRESENT SOIL AND REPRESENT SOIL STRATA AT EACH TEST HOLE LOCATION ONLY. SOIL TRANSITIONS MAY BE MORE GRADUAL THAN IMPLIED.

(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
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CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

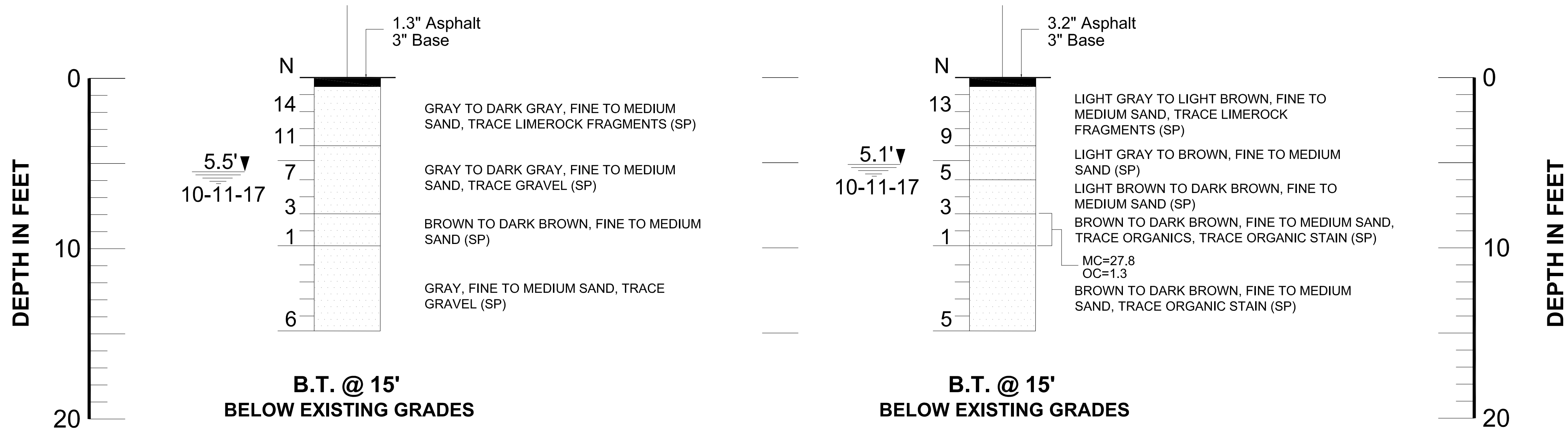
COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: SUBSURFACE PROFILES (DURRS)
PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 3A
RADISE PROJECT NO: 170901

BORING NO.	D-4	D-5
ELEVATION (NAVD 88):	N/A	N/A
LATITUDE:	26.1328°	26.1297°
LONGITUDE:	-80.1590°	-80.1613°
DATE:	10/11/2017	10/11/2017
DRILLER:	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45



LEGEND

- ASPHALT AND BASE
- SAND
- SILTY SAND
- LIMESTONE
- GRAVEL
- ORGANIC MATERIAL

5.0' 10-11-17 GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, SM	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
D-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

(1) BORINGS WERE DRILLED ON OCTOBER, 2017 USING A CENTRAL MINING EQUIPMENT MODEL 45 (CME 45) AUTOMATIC HAMMER DRILL RIG.

(2) STRATA BOUNDARIES ARE APPROXIMATE AND REPRESENT SOIL AND REPRESENT SOIL STRATA AT EACH TEST HOLE LOCATION ONLY. SOIL TRANSITIONS MAY BE MORE GRADUAL THAN IMPLIED.

(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
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CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.

SCALE: HORIZONTAL N.T.S.

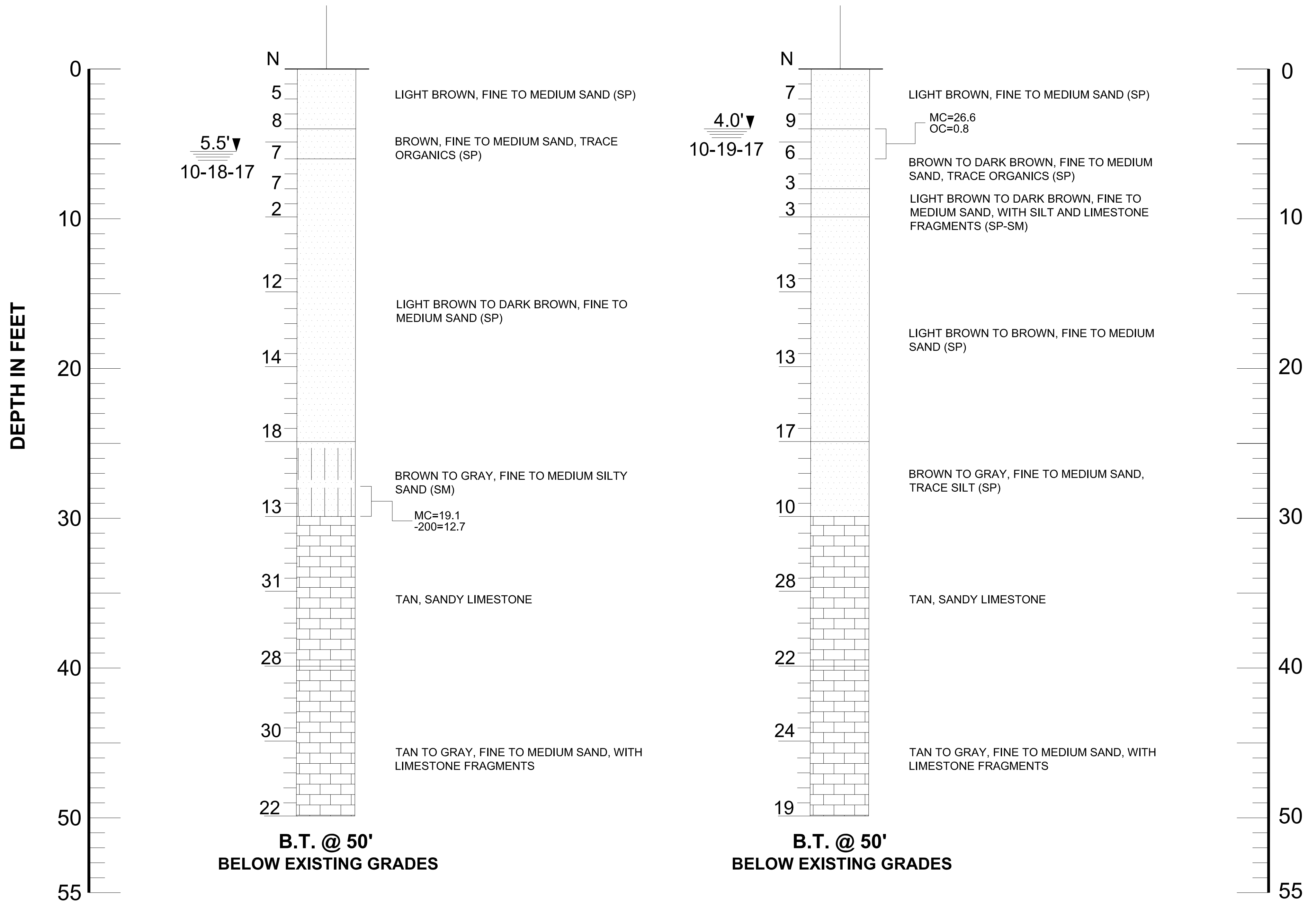
SHEET TITLE: SUBSURFACE PROFILES (DRRUS)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 3B

RADISE PROJECT NO: 170901

BORING NO.	DR-1	DR-2
ELEVATION (NAVD 88):	N/A	N/A
LATITUDE:	26.1278°	26.1279°
LONGITUDE:	-80.1621°	-80.1619°
DATE:	10/18/2017	10/19/2017
DRILLER:	R. RAMSEWACK	R. RAMSEWACK
RIG:	CME 45	CME 45



LEGEND

SAND
SHELLY SAND
SILTY SAND
LIMESTONE
ORGANIC MATERIAL
GRAVEL

5.5' 10-18-17	GROUNDWATER DEPTH IN FEET AND DRILLING DATE
N	STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER
SP, SP-SM, SM	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
DR-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 50'	BORING TERMINATED AT 50 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

(1) BORINGS WERE DRILLED ON OCTOBER, 2017 USING A CENTRAL MINING EQUIPMENT MODEL 45 (CME 45) AUTOMATIC HAMMER DRILL RIG.

(2) STRATA BOUNDARIES ARE APPROXIMATE AND REPRESENT SOIL AND REPRESENT SOIL STRATA AT EACH TEST HOLE LOCATION ONLY. SOIL TRANSITIONS MAY BE MORE GRADUAL THAN IMPLIED.

(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
Drawn by	ML	10/26/17
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CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

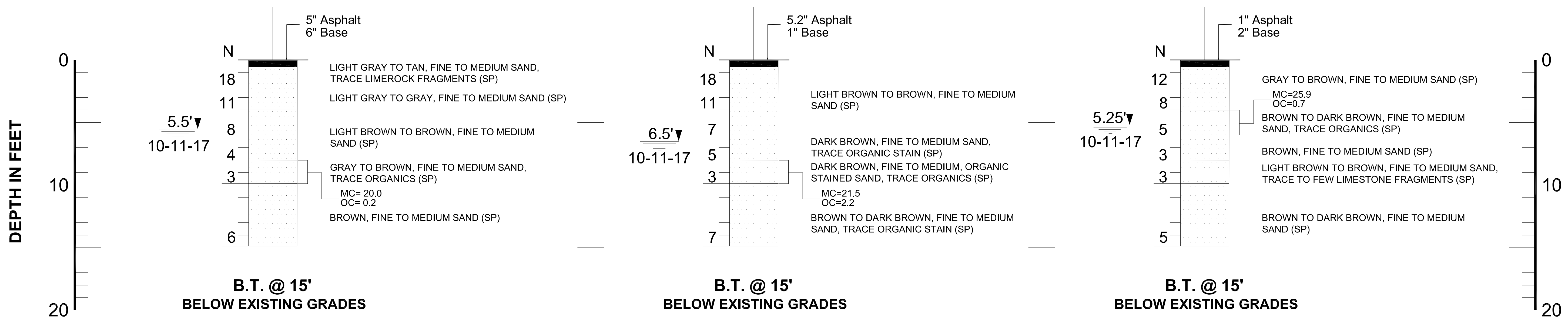
SHEET TITLE: SUBSURFACE PROFILES (DORSEY RIVERBEND)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 4A

RADISE PROJECT NO: 170901

BORING NO.	DR-3	DR-4	DR-5
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.1256°	26.1256°	26.1288°
LONGITUDE:	-80.1617°	-80.1658°	-80.1660°
DATE:	10/11/2017	10/11/2017	10/11/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

ASPHALT AND BASE

SAND

SILTY SAND

LIMESTONE

GRAVEL

ORGANIC MATERIAL

5.5' 10-11-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N — STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, SM	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
DR-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

(1) BORINGS WERE DRILLED ON OCTOBER, 2017 USING A CENTRAL MINING EQUIPMENT MODEL 45 (CME 45) AUTOMATIC HAMMER DRILL RIG.

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(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

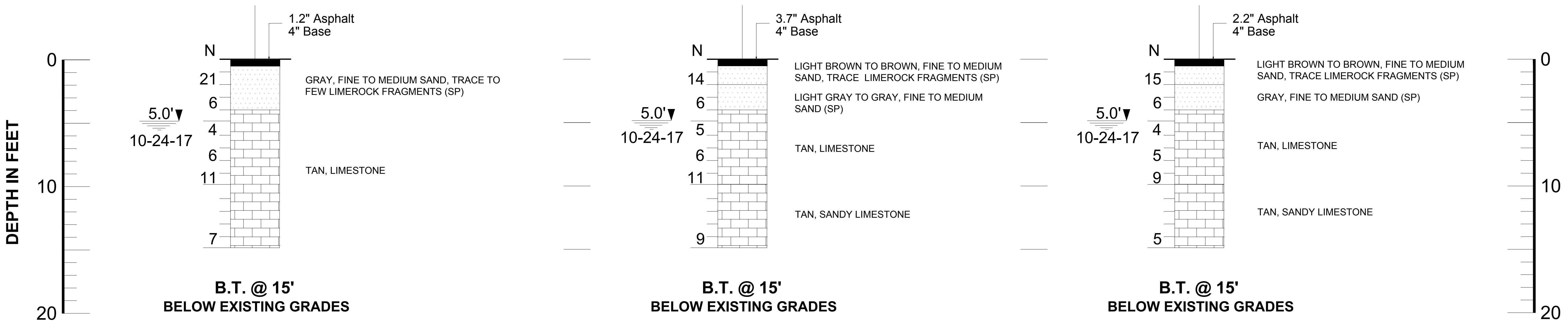
SHEET TITLE: SUBSURFACE PROFILES (DORSEY RIVERBEND)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 4B

RADISE PROJECT NO: 170901

BORING NO.	E-1	E-2	E-3
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0845°	26.0864°	26.0881°
LONGITUDE:	-80.1607°	-80.1607°	-80.1607°
DATE:	10/24/2017	10/24/2017	10/24/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

ASPHALT AND BASE
SAND
SILTY SAND
LIMESTONE
GRAVEL
ORGANIC MATERIAL

5.0' 10-24-17 GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
E-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

(1) BORINGS WERE DRILLED ON OCTOBER, 2017 USING A CENTRAL MINING EQUIPMENT MODEL 45 (CME 45) AUTOMATIC HAMMER DRILL RIG.

(2) STRATA BOUNDARIES ARE APPROXIMATE AND REPRESENT SOIL AND REPRESENT SOIL STRATA AT EACH TEST HOLE LOCATION ONLY. SOIL TRANSITIONS MAY BE MORE GRADUAL THAN IMPLIED.

(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
Drawn by	KA	11/06/17
Checked by	AB	11/06/17
Designed by		
Checked by		
Approved by		

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CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

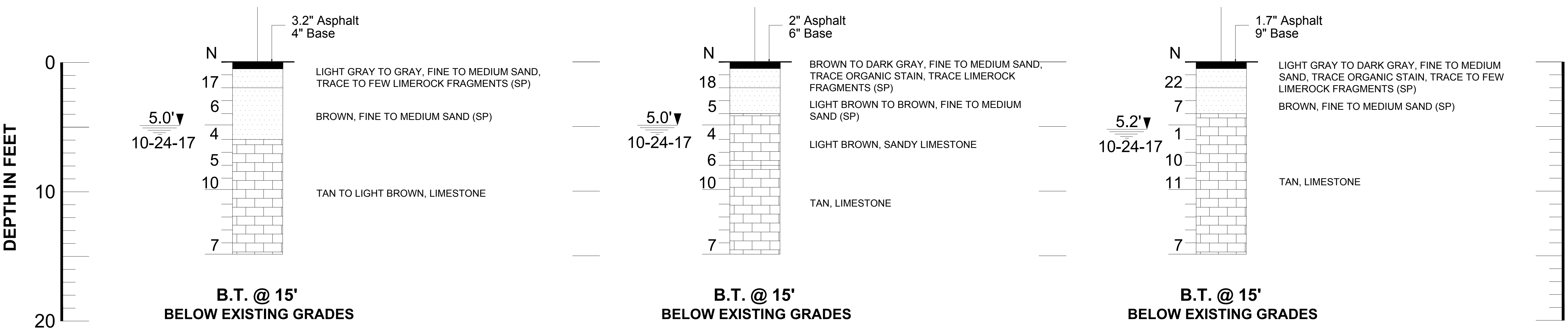
SHEET TITLE: SUBSURFACE PROFILES (EDGEWOOD)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 5A

RADISE PROJECT NO: 170901

	E-4	E-5	E-6
BORING NO.	E-4	E-5	E-6
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0873°	26.0855°	26.0888°
LONGITUDE:	-80.1595°	-80.1595°	-80.1588°
DATE:	10/24/2017	10/24/2017	10/24/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

ASPHALT AND BASE
LIMESTONE
SAND
GRAVEL
SILTY SAND
ORGANIC MATERIAL

5.0' 10-24-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N — STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
E-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

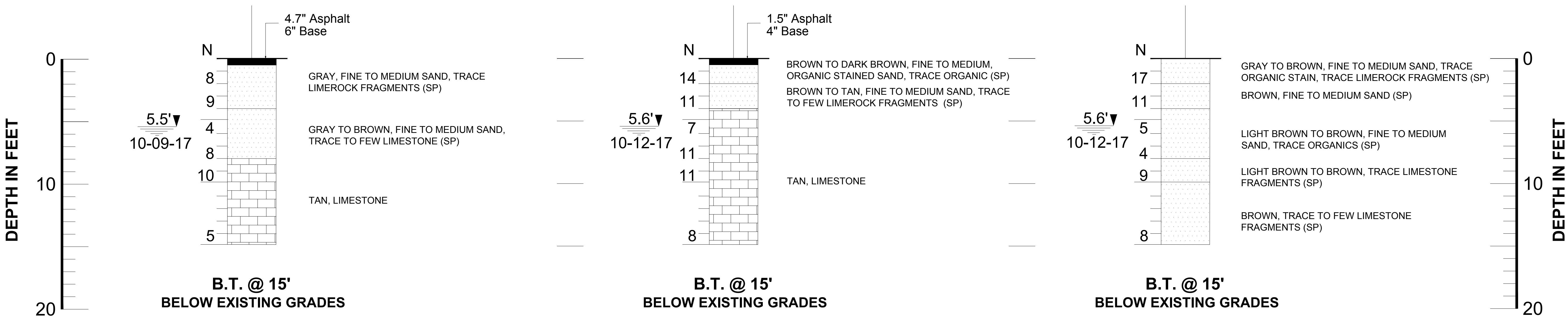
SHEET TITLE: SUBSURFACE PROFILES (EDGEWOOD)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 5B

RADISE PROJECT NO: 170901

BORING NO.	E-7	E-8	E-9
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0888°	26.0861°	26.0880°
LONGITUDE:	-80.1548°	-80.1567°	-80.1560°
DATE:	10/09/2017	10/12/2017	10/12/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

- ASPHALT AND BASE
- LIMESTONE
- SAND
- GRAVEL
- SILTY SAND
- ORGANIC MATERIAL

5.0' / 10-24-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N — STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
E-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

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COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

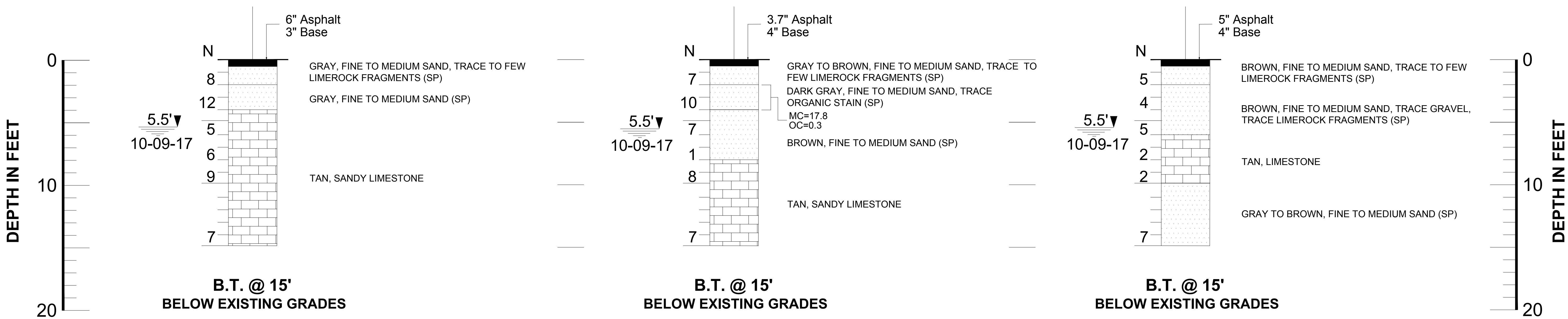
SHEET TITLE: SUBSURFACE PROFILES (EDGEWOOD)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 5C

RADISE PROJECT NO: 170901

BORING NO.	E-10	E-11	E-12
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0870°	26.0874°	26.0889°
LONGITUDE:	-80.1528°	-80.1507°	-80.1507°
DATE:	10/09/2017	10/09/2017	10/09/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

ASPHALT AND BASE

LIMESTONE

SAND

GRAVEL

SILTY SAND

ORGANIC MATERIAL

5.0' / 10-24-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N — STANDARD PENETRATION RESISTANCE-BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
E-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

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SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

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BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

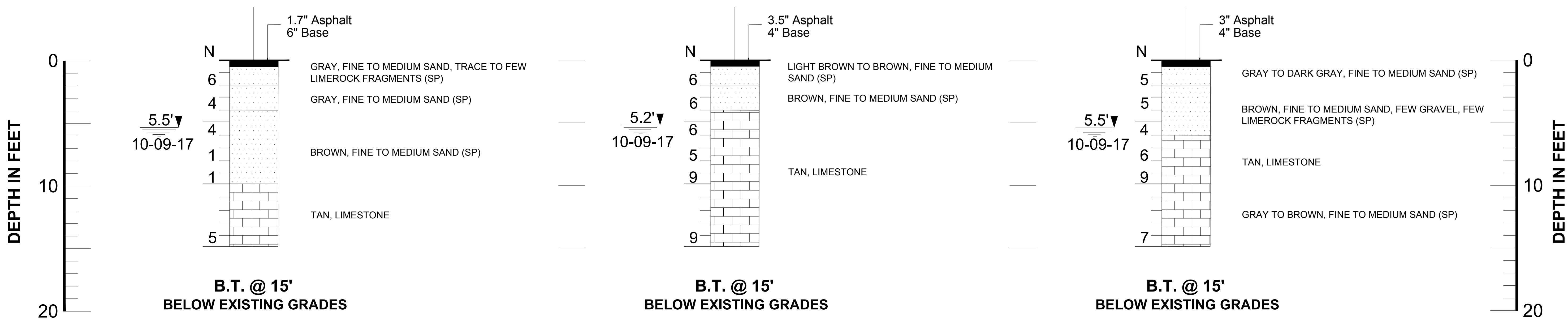
SHEET TITLE: SUBSURFACE PROFILES (EDGEWOOD)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 5D

RADISE PROJECT NO: 170901

BORING NO.	E-13	E-14	E-15
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0899°	26.0907°	26.0868°
LONGITUDE:	-80.1528°	-80.1401°	-80.1391°
DATE:	10/09/2017	10/09/2017	10/09/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

- ASPHALT AND BASE
- LIMESTONE
- SAND
- GRAVEL
- SILTY SAND
- ORGANIC MATERIAL

5.0' 10-24-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N — STANDARD PENETRATION RESISTANCE-BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
E-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

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COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

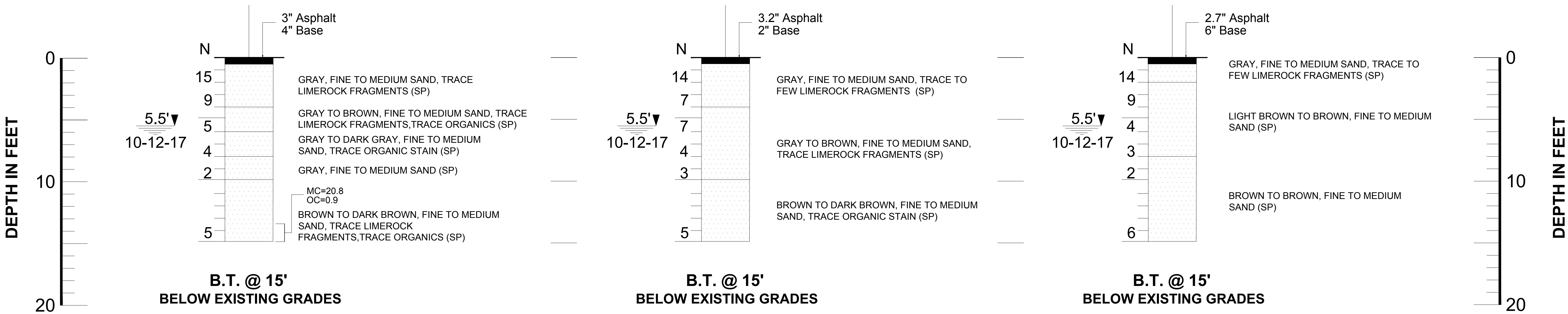
SHEET TITLE: SUBSURFACE PROFILES (EDGEWOOD)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 5E

RADISE PROJECT NO: 170901

BORING NO.	P-1	P-2	P-3
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.1207°	26.1223°	26.1239°
LONGITUDE:	-80.1474°	-80.1485°	-80.1475°
DATE:	10/12/2017	10/12/2017	10/12/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

ASPHALT AND BASE
SAND
SILTY SAND
LIMESTONE
GRAVEL
ORGANIC MATERIAL

5.5' / 10-12-17 GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
P-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

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GRANULAR MATERIALS

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VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

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SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

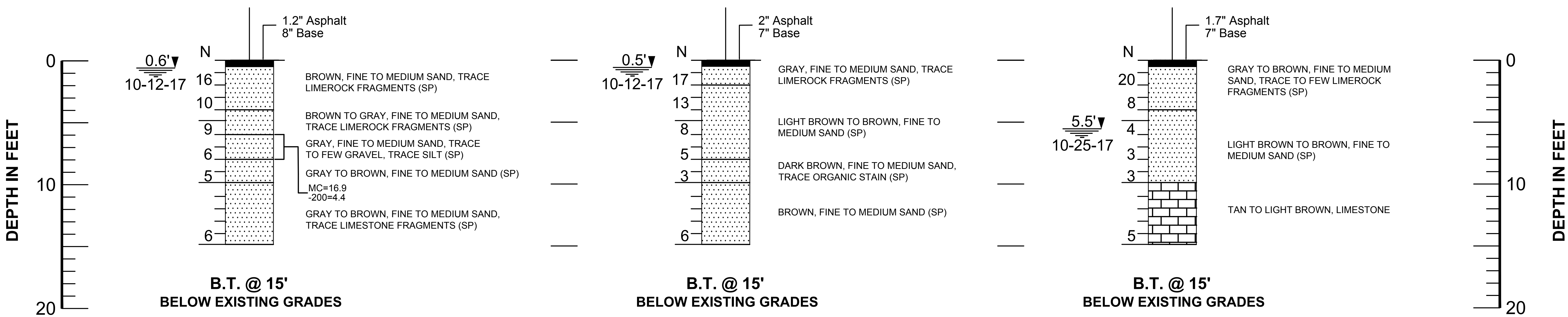
SHEET TITLE: SUBSURFACE PROFILES (PROGRESSO)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 6A

RADISE PROJECT NO: 170901

BORING NO.	P-4	P-7	P-8
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.1315°	26.1266°	26.1312°
LONGITUDE:	-80.1469°	-80.1506°	-80.1517°
DATE:	10/12/2017	10/12/2017	10/25/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



NOTES

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LEGEND

- ASPHALT AND BASE
- SAND
- SILTY SAND
- LIMESTONE
- GRAVEL
- ORGANIC MATERIAL
- 5.5' / 10-12-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE
- N — STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
P-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
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VERY DENSE	GREATER THAN 40

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HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
Drawn by	KA	11/09/17
Checked by	AB	11/09/17
Designed by		
Checked by		
Approved by		

RADISE Infrastructure Engineers & Software Developers

LICENSE NO. - 8901

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RADISE International
4152 West Blue Heron Boulevard, Suite 1114
Riviera Beach, Florida. 33404
TEL 561-841-0103 FAX 561-841-0104
URL : http:// www.radise.net

CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

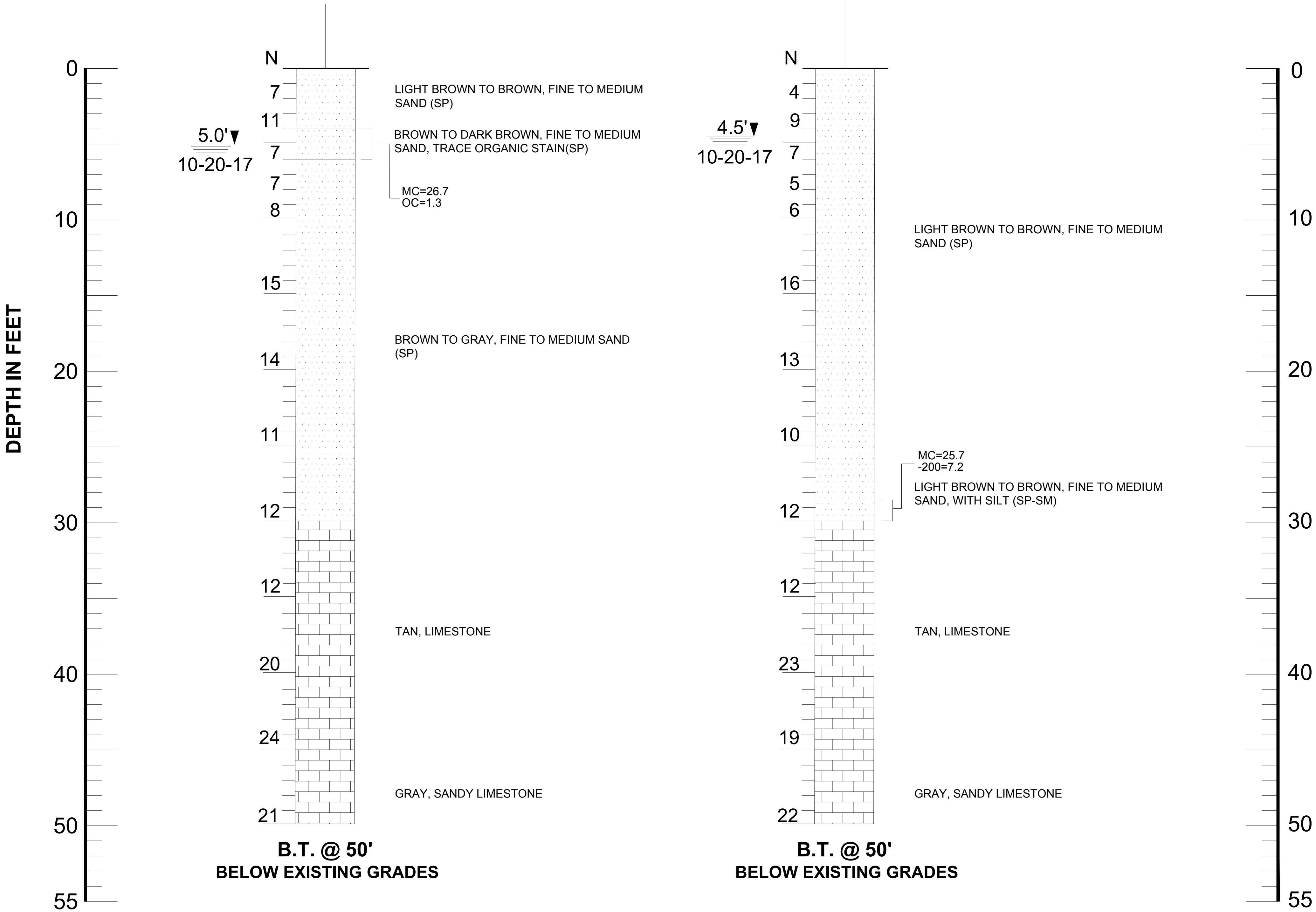
SHEET TITLE: SUBSURFACE PROFILES (PROGRESSO)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 6B

RADISE PROJECT NO: 170901

BORING NO.	P-5	P-6
ELEVATION (NAVD 88):	N/A	N/A
LATITUDE:	26.1332°	26.1335°
LONGITUDE:	-80.1479°	-80.1476°
DATE:	10/20/2017	10/20/2017
DRILLER:	R. RAMSEWACK	R. RAMSEWACK
RIG:	CME 45	CME 45



LEGEND

SAND
SHELLY SAND
SILT
LIMESTONE
ORGANIC MATERIAL
GRAVEL

5.0' 10-20-17	GROUNDWATER DEPTH IN FEET AND DRILLING DATE
N	STANDARD PENETRATION RESISTANCE-BLOWS PER FOOT USING AUTOMATIC HAMMER
SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
P-5	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 50'	BORING TERMINATED AT 50 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

(1) BORINGS WERE DRILLED ON OCTOBER, 2017 USING A CENTRAL MINING EQUIPMENT MODEL 45 (CME 45) AUTOMATIC HAMMERDRILL RIG.

(2) STRATA BOUNDARIES ARE APPROXIMATE AND REPRESENT SOIL AND REPRESENT SOIL STRATA AT EACH TEST HOLE LOCATION ONLY. SOIL TRANSITIONS MAY BE MORE GRADUAL THAN IMPLIED.

(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
Drawn by	ML	10/13/17
Checked by	AB	10/13/17
Designed by		
Checked by		
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PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

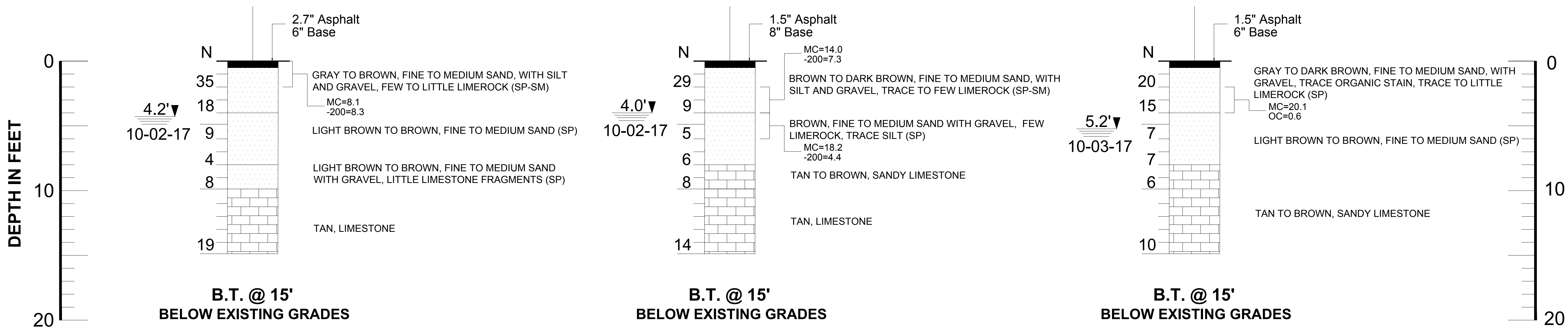
SHEET TITLE: SUBSURFACE PROFILES (PROGRESSO)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 6C

RADISE PROJECT NO: 170901

BORING NO.	R-1	R-2	R-3
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0909°	26.0945°	26.0924°
LONGITUDE:	-80.1608°	-80.1609°	-80.1648°
DATE:	10/02/2017	10/02/2017	10/03/2017
DRILLER:	P. RAMSEWACK	P. RAMSEWACK	P. RAMSEWACK
RIG:	CME 45	CME 45	CME 45



LEGEND

ASPHALT AND BASE

LIMESTONE

SAND

GRAVEL

SILTY SAND

ORGANIC MATERIAL

4.2'
10-02-17 GROUNDWATER DEPTH IN FEET AND DRILLING DATE

N STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
R-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

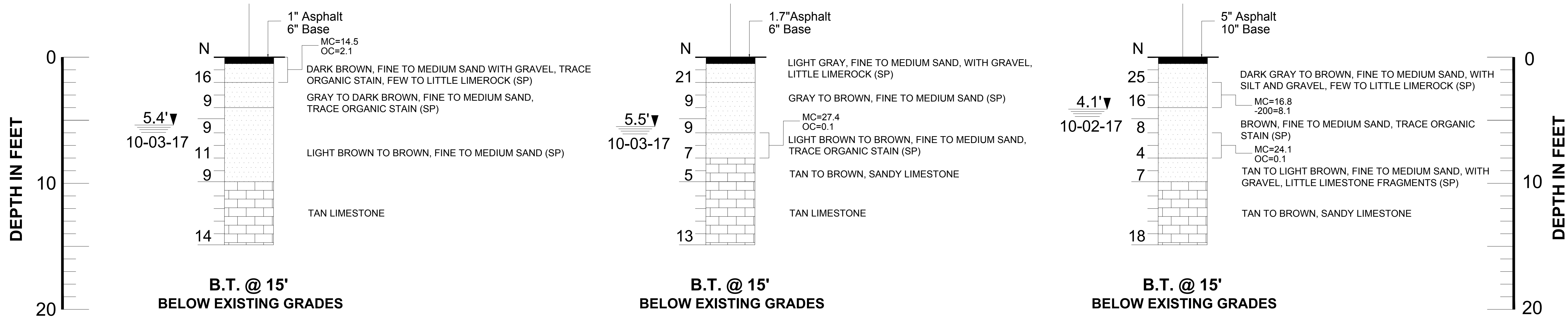
SHEET TITLE: SUBSURFACE PROFILES (RIVER OAKS)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 7A

RADISE PROJECT NO: 170901

BORING NO.	R-4	R-5	R-6
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0946°	26.0950°	26.0961°
LONGITUDE:	-80.1630°	-80.1661°	-80.1608°
DATE:	10/03/2017	10/03/2017	10/02/2017
DRILLER:	P. RAMSEWACK	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

- ASPHALT AND BASE
- LIMESTONE
- SAND
- GRAVEL
- SILTY SAND
- ORGANIC MATERIAL
- 4.2' 10-02-17 — GROUNDWATER DEPTH IN FEET AND DRILLING DATE
- N — STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
R-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

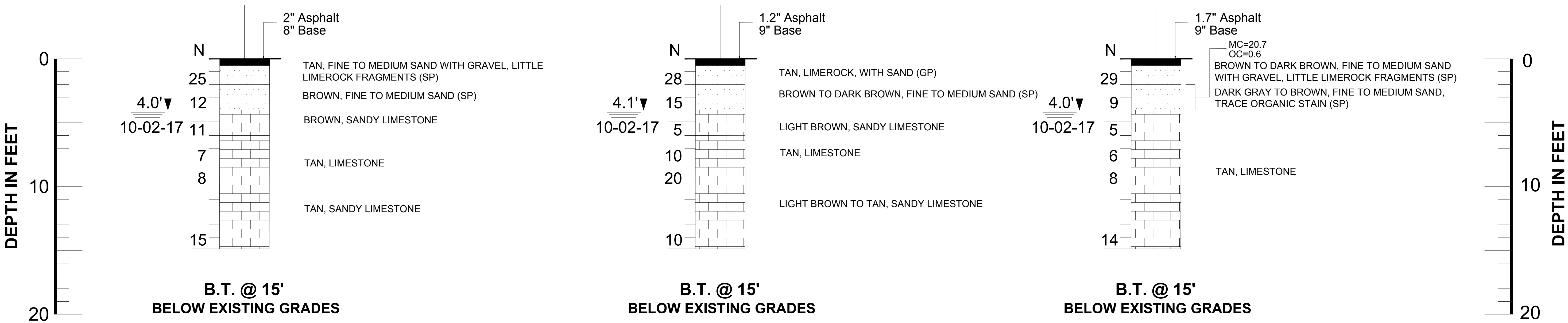
SHEET TITLE: SUBSURFACE PROFILES (RIVER OAKS)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 7B

RADISE PROJECT NO: 170901

BORING NO.	R-7	R-8	R-13
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.0979°	26.0994°	26.0979°
LONGITUDE:	-80.1589°	-80.1582°	-80.1550°
DATE:	10/02/2017	10/02/2017	10/02/2017
DRILLER:	P. RAMSEWACK	P. RAMSEWACK	P. RAMSEWACK
RIG:	CME 45	CME 45	CME 45



LEGEND

- ASPHALT AND BASE
- LIMESTONE
- SAND
- GRAVEL
- SILTY SAND
- ORGANIC MATERIAL
- 4.2' 10-02-17 GROUNDWATER DEPTH IN FEET AND DRILLING DATE
- N STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
R-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

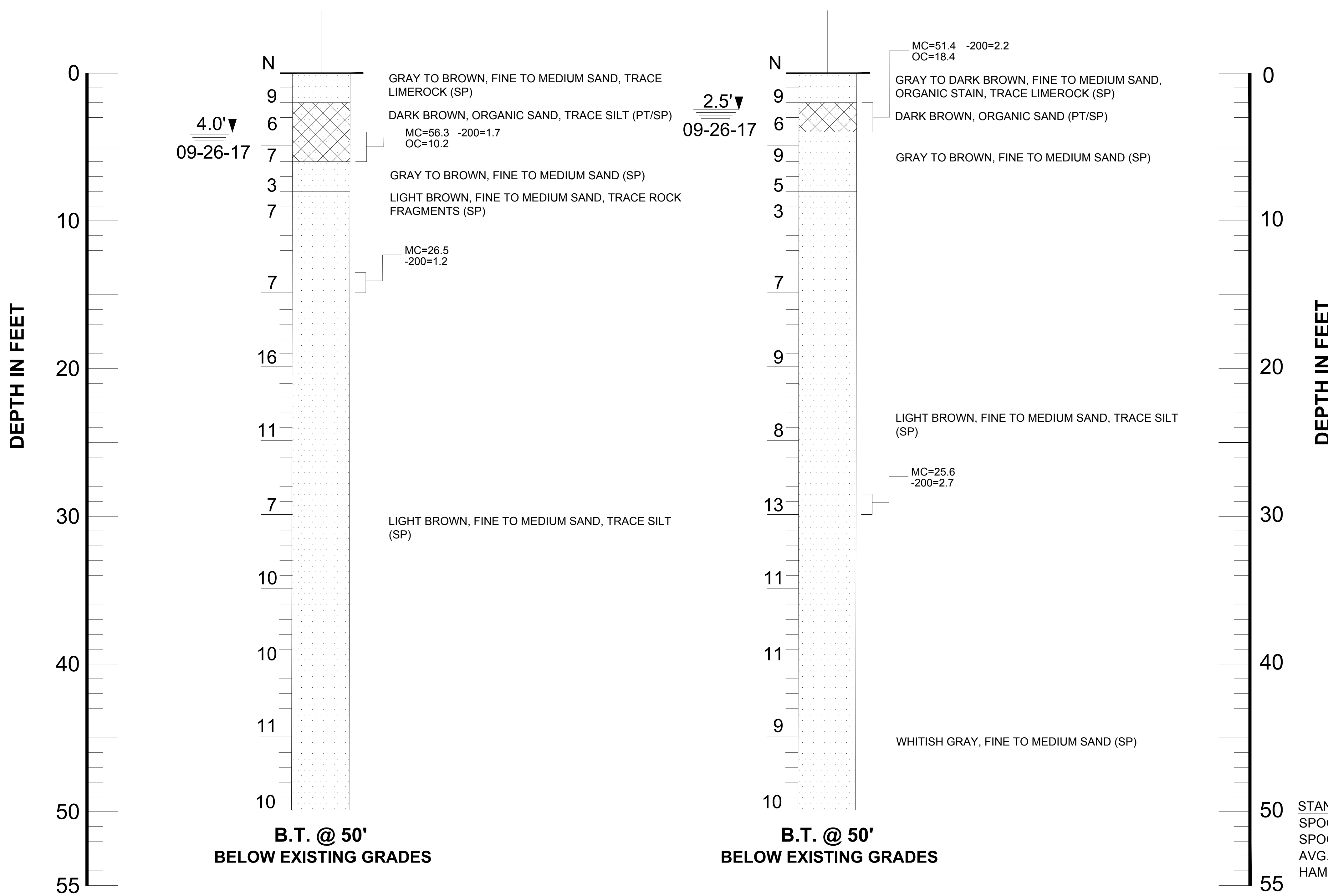
SHEET TITLE: SUBSURFACE PROFILES (RIVER OAKS)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 7C

RADISE PROJECT NO: 170901

BORING NO.	R-9	R-10
ELEVATION (NAVD 88):	N/A	N/A
LATITUDE:	26.0949°	26.0947°
LONGITUDE:	-80.1679°	-80.1677°
DATE:	09/26/2017	09/26/2017
DRILLER:	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45



LEGEND

SAND
SHELLY SAND
SILT
LIMESTONE
ORGANIC MATERIAL
GRAVEL

1.5' 09-21-17	GROUNDWATER DEPTH IN FEET AND DRILLING DATE
N	STANDARD PENETRATION RESISTANCE-BLOWS PER FOOT USING AUTOMATIC HAMMER
SP	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
S-9	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 50'	BORING TERMINATED AT 50 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

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(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

STANDARD PENETRATION TEST DATA	
SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

REVISIONS					
Date.	By	Descriptions	Date.	By	Descriptions

	Names	Dates
Drawn by	ML	10/13/17
Checked by	AB	10/13/17
Designed by		
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PUBLIC WORKS DEPARTMENT

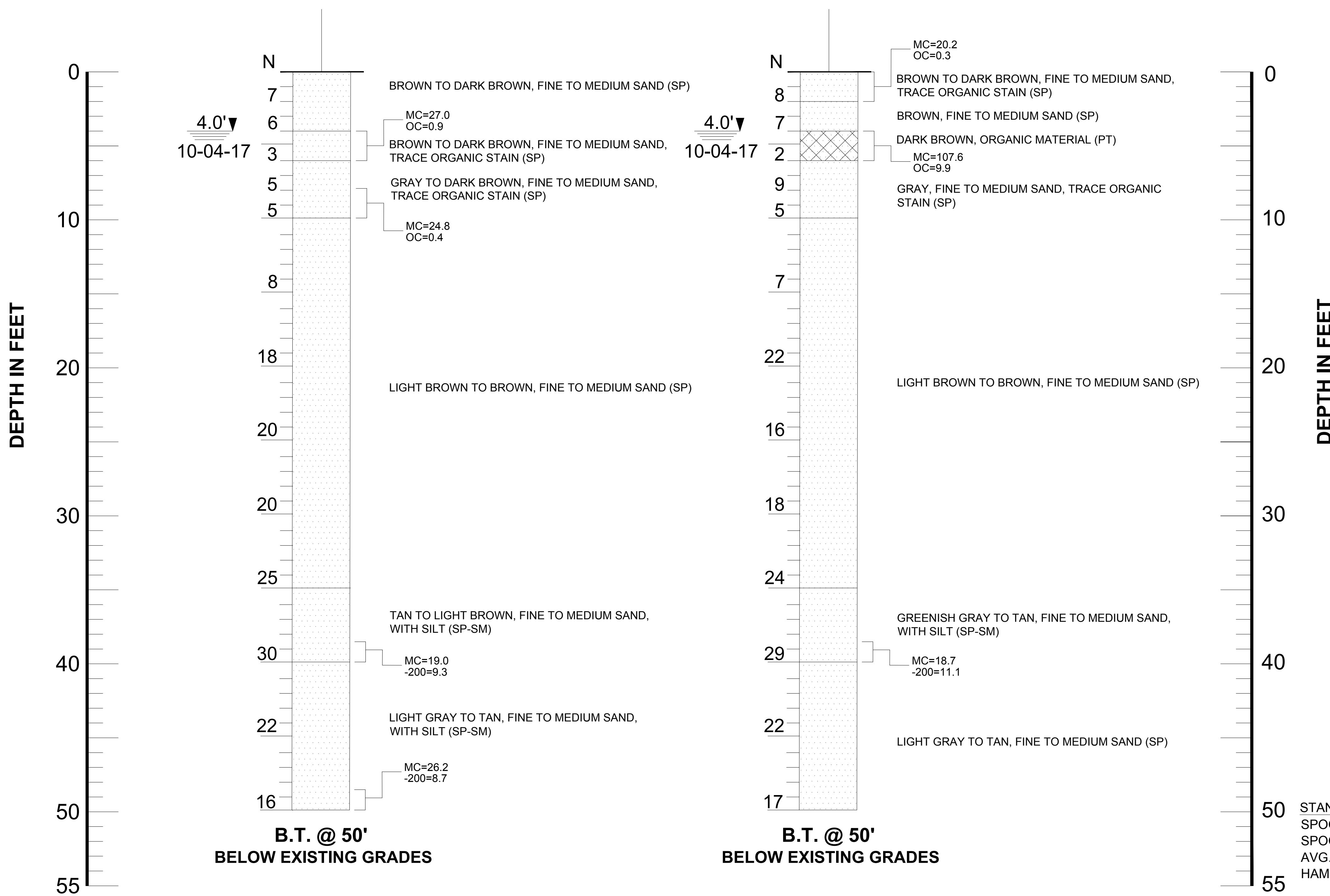
COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

SHEET TITLE: SUBSURFACE PROFILES (RIVER OAKS)
PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 7D
RADISE PROJECT NO: 170901

	R-11	R-12
BORING NO.	R-11	R-12
ELEVATION (NAVD 88):	N/A	N/A
LATITUDE:	26.0936°	26.0938°
LONGITUDE:	-80.1665°	-80.1667°
DATE:	10/04/2017	10/04/2017
DRILLER:	P. RAMSEWACK	P. RAMSEWACK
RIG:	CME 45	CME 45



LEGEND

SAND
SHELLY SAND
SILT
LIMESTONE
ORGANIC MATERIAL
GRAVEL

1.5' 09-21-17	GROUNDWATER DEPTH IN FEET AND DRILLING DATE
N	STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER
SP	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
S-9	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 50'	BORING TERMINATED AT 50 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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STANDARD PENETRATION TEST DATA	
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SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

REVISIONS

Date.	By	Descriptions	Date.	By	Descriptions

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BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

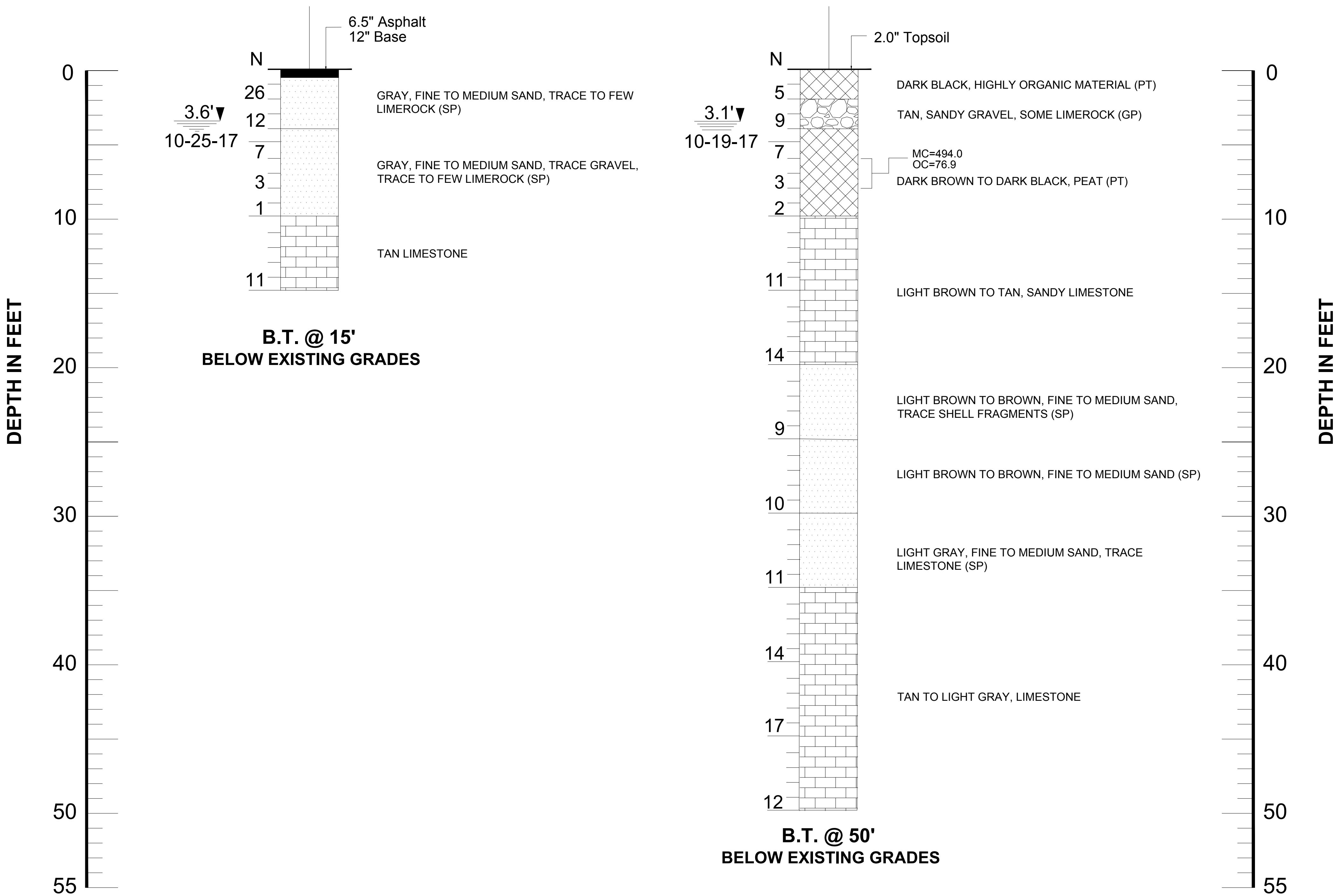
SHEET TITLE: SUBSURFACE PROFILES (RIVER OAKS)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 7E

RADISE PROJECT NO: 170901

BORING NO.	S-1	S-2
ELEVATION (NAVD 88):	N/A	N/A
LATITUDE:	26.1188°	26.1199°
LONGITUDE:	-80.1244°	-80.1208°
DATE:	10/25/2017	10/19/2017
DRILLER:	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45



LEGEND

ASPHALT AND BASE
LIMESTONE
SAND
GRAVEL
SILT
ORGANIC MATERIAL

1.5' 09-21-17	GROUNDWATER DEPTH IN FEET AND DRILLING DATE
N	STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER
SP, SP-SM, GP, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
S-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 50'	BORING TERMINATED AT 50 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

(1) BORINGS WERE DRILLED ON SEPTEMBER AND OCTOBER, 2017 USING A CENTRAL MINING EQUIPMENT MODEL 45 (CME 45) AUTOMATIC HAMMER DRILL RIG.

(2) STRATA BOUNDARIES ARE APPROXIMATE AND REPRESENT SOIL AND REPRESENT SOIL STRATA AT EACH TEST HOLE LOCATION ONLY. SOIL TRANSITIONS MAY BE MORE GRADUAL THAN IMPLIED.

(3) GROUNDWATER LEVELS SHOWN ON THE SUBSURFACE PROFILES REPRESENT GROUNDWATER SURFACES ON THE DATES SHOWN. GROUNDWATER LEVELS WILL FLUCTUATE THROUGHOUT THE YEAR.

(4) LONGITUDE AND LATITUDE COORDINATES WERE MEASURED IN THE FIELD USING A HAND HELD GPS UNIT.

(5) ELEVATIONS WERE NOT AVAILABLE

(6) AFTER COMPLETION OF DRILLING BOREHOLES WERE BACK FILLED WITH GROUT.

STANDARD PENETRATION TEST DATA

SPOON INSIDE DIA.	1.375 INCH
SPOON OUTSIDE DIA.	2.0 INCHES
AVG. HAMMER DROP	30 INCHES
HAMMER WEIGHT	140 POUNDS

GRANULAR MATERIALS

RELATIVE DENSITY	AUTOMATIC HAMMER SPT N-VALUE BLOWS/FOOT
VERY LOOSE	LESS THAN 3
LOOSE	3 - 8
MEDIUM	8 - 24
DENSE	24 - 40
VERY DENSE	GREATER THAN 40

REVISIONS						
Date.	By	Descriptions	Date.	By	Descriptions	

	Names	Dates
Drawn by	KA	11/06/17
Checked by	AB	11/06/17
Designed by		
Checked by		
Approved by		

RADISE
Infrastructure Engineers & Software Developers
LICENSE NO. - 8901

ENGINEER OF RECORD
RADISE International
4152 West Blue Heron Boulevard, Suite 1114
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URL : http:// www.radise.net

CITY OF FORT LAUDERDALE
PUBLIC WORKS DEPARTMENT

COUNTY	CLIENT
BROWARD	HAZEN AND SAWYER

SCALE: VERTICAL N.T.S.
SCALE: HORIZONTAL N.T.S.

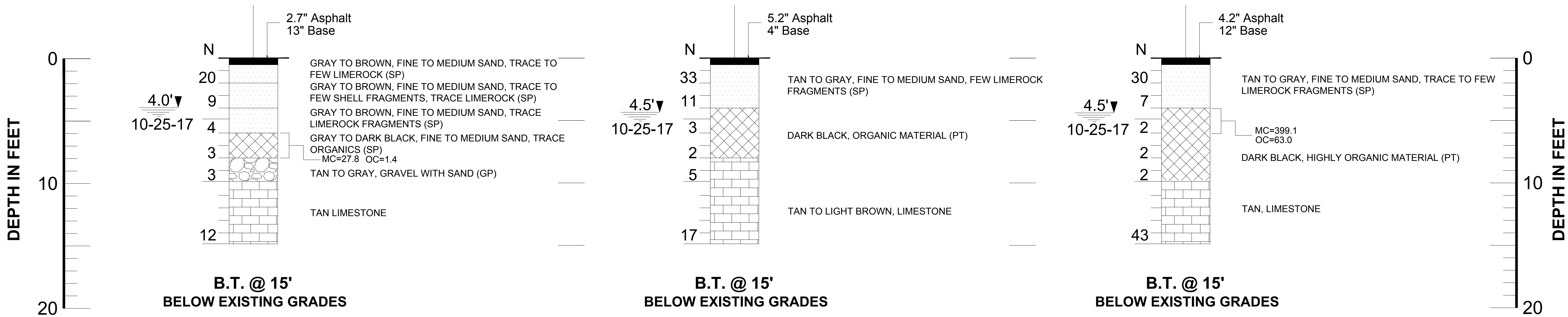
SHEET TITLE: SUBSURFACE PROFILES (SOUTHEAST ISLES)

PROJECT NAME: STORMWATER MASTER PLAN MODELING AND DESIGN IMPLEMENTATION

SHEET NO. 8A

RADISE PROJECT NO: 170901

BORING NO.	S-3	S-4	S-5
ELEVATION (NAVD 88):	N/A	N/A	N/A
LATITUDE:	26.1196°	26.1199°	26.1200°
LONGITUDE:	-80.1209°	-80.1169°	-80.1149°
DATE:	10/25/2017	10/25/2017	10/23/2017
DRILLER:	T. FICKLING	T. FICKLING	T. FICKLING
RIG:	CME 45	CME 45	CME 45



LEGEND

ASPHALT AND BASE
SAND
SILT
LIMESTONE
GRAVEL
ORGANIC MATERIAL

5.5' GROUNDWATER DEPTH IN FEET
10-12-17 AND DRILLING DATE
N STANDARD PENETRATION RESISTANCE- BLOWS PER FOOT USING AUTOMATIC HAMMER

SP, SP-SM, GP, PT	UNIFIED SOIL CLASSIFICATION SYSTEM GROUP SYMBOL (ASTM D 2488)
S-1	STANDARD PENETRATION TEST (SPT) BORING AND NUMBER
MC	MOISTURE CONTENT (%)
-200	AMOUNT PASSING US STANDARD # 200 SIEVE (%)
OC	ORGANIC CONTENTS (%)
LL	LIQUID LIMIT (%)
PI	PLASTICITY INDEX (%)
B.T. @ 15'	BORING TERMINATED AT 15 FEET BELOW THE EXISTING GROUND SURFACE

NOTES

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SHEET NO. 8B

RADISE PROJECT NO: 170901