TIP# U-4715AB
Date: 5/2/06
Revised Date:

12

POLICE

DESCRIPTION.

Furnish Police Officers and marked Police Vehicles to direct traffic in accordance with the plans and specifications.

CONSTRUCTION METHODS.

Utilize Police Officers who are outfitted with police uniforms.

Utilize marked Police Vehicles, which are equipped with police lights mounted on top of the vehicle, and police vehicle emblems.

Utilize Police Officers and marked Police Vehicles to direct or control traffic as required by the plans or by the Engineer.

METHOD OF MEASUREMENT.

The quantity of Police Officers and marked Police Vehicles to be paid for will be the actual number of hours that each Police Officer/marked Police Vehicle is provided during the life of the project as approved by the Engineer.

There will be no direct payment for marked Police Vehicles as they are considered incidental to the pay item in this special provision.

BASIS OF PAYMENT.

The quantity of Police Officers and marked Police Vehicles measured as provided above, will be paid for at the contract unit price per hour for "Police".

Payment will be made under:

Police.....Hour

13

PROJECT SPECIAL PROVISIONS

ASHEVILLE TRAFFIC SIGNAL SYSTEM

(College Street / Patton Avenue System)

T.I.P. Project: U-4715 AB

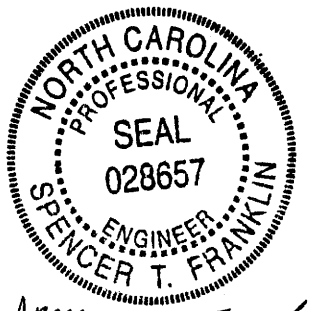
Contract: C201476

Prepared for:

North Carolina Department of Transportation
Intelligent Transportation Systems & Signals Unit

and

City of Asheville



Spencer T. Franklin
12-5-06

Prepared by:

HNTB

343 E. Six Forks Road
Suite 200
Raleigh, North Carolina 27609
Phone: (919) 546-8997

December 2006

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

1. GENERAL

1.1 SUMMARY OF WORK

This project consists of furnishing and installing a closed loop traffic signal control system in the City of Asheville, North Carolina along College Street and Patton Avenue from the I-240 Exit Ramps to NC 694 (Martin Luther King Jr. Drive). Materials to be furnished and installed for the successful completion of this project shall include upgraded traffic signal displays, local intersection controllers and cabinets, inductive loop detectors, and a wireless 900MHz communications network with all related equipment.

A total of 18 intersections will be included in the system with one controller designated as a master/local controller.

Perform the following major tasks as shown in the Plans:

- Furnish and install 900MHz Wireless Radios, and related electronics;
- Enter all controller programming data for local intersection timing and system coordination timing;
- Furnish and install new cabinets and replace existing field wiring as specified;
- Modify existing cabinet foundations and install new cabinet foundations;
- Furnish and install new controllers;
- Remove existing control equipment, cabinets and foundations;
- Furnish and install local intersection detector loops, system detector loops, junction boxes, lead-ins and detector amplifiers;
- Upgrade the signal displays at several intersections, including adding pedestrian signal heads and pushbuttons, and replacing and adding signal heads;
- Furnish and install conduit, junction boxes, riser assemblies with heat shrink tubing, riser assemblies with weatherhead, and pole guys with guy guards.

1.2 DESCRIPTION

These Sections of the Project Special Provisions consist of the requirements for traffic signal system work and are generally written in the imperative mood. In sentences using the imperative mood, the subject, "the Contractor," is implied. Also, implied in such language is "shall," "shall be," or similar wording and phrases. In material specifications, the subject may also be the supplier, fabricator, or manufacturer supplying the material, products, or equipment for use on the project. The Engineer shall be as defined in the Standard Specifications for Roads and Structures (also referred to herein as "Standard Specifications").

Conform to these Project Special Provisions, the traffic signal system plans (referred to herein as "Plans"), the NCDOT Roadway Standard Drawings, and the 2006 Standard Specifications for Roads and Structures. The current edition of these "Specifications" and publications in effect on the date of advertisement shall apply.

Revisions have been made to the Standard Specifications. These revisions have been incorporated into the applicable sections of these Project Special Provisions.

Unless otherwise stated in these Sections, furnish, store, deliver, and install all equipment, material, tools, and incidental hardware necessary to complete the required traffic signal system work.

The intent of these Project Special Provisions is to prescribe the details of the construction and completion of the work, which you undertake to perform in accordance with the contract. It is understood that only the best general practice is to prevail where the Plans and Project Special Provisions describe portions of the work in general terms but not in complete detail.

In the event of conflict between these Project Special Provisions and the Standard Specifications, these Project Special Provisions shall govern.

All traffic signal displays shall conform to the requirements of the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) and the North Carolina Supplement to the Manual on Uniform Traffic Control Devices. In the event of a conflict between the two, the latter shall govern.

The Engineer is responsible for administration and construction observation of the work.

1.3 MATERIALS

A. Contractor Furnished Materials

Furnish new materials meeting the requirements of the Standard Specifications, the Plans, and these Project Special Provisions.

Section 1098-1, GENERAL REQUIREMENTS, of the 2006 Standard Specifications is revised as follows:

General Requirements (1098-1)

Page 10-268, Subarticle 1098-1(H)

In the second paragraph, add "Use 200 amp meter base for underground electrical service".

Furnish new equipment, materials, and hardware unless otherwise required. Inscribe manufacturer's name, model number, serial number, and any additional information needed for proper identification on each piece of equipment housed in a case or housing.

NCDOT has a signal equipment Qualified Products List (QPL) available for the Contractor's use. The QPL web site is:

http://www.ncdot.org/doh/preconstruct/traffic/tmssu/sms/qpl/

Certain signal and communications equipment, material, and hardware shall be pre-approved on the QPL by the date of installation. Equipment, material, and hardware not pre-approved when required will not be allowed for use on the project. Consult the QPL web site to obtain pre-approval procedures.

B. Submittal Requirements

Provide written certification to the Department that all contractor-furnished equipment is in accordance with the Plans and Specifications. When requested by the Department, provide additional certifications from independent testing laboratories and sufficient data to verify that the items meet applicable specifications. Ensure that the additional certification states that the testing laboratory is independent of the equipment manufacturer and that neither the laboratory nor the manufacturer has a vested interest in the other.

Identify all proprietary parts in contractor-furnished equipment. The Department reserves the right to reject equipment that uses proprietary components that are not commercially available through electronic supply houses.

For contractor–furnished equipment that is listed on the QPL, furnish submittals in the format defined by the QPL.

For contractor-furnished equipment that is not on the QPL, furnish three copies of a list of the equipment including three copies of catalog cuts. Identify the proposed equipment on the catalog cuts by reproducible means. Equipment lists must contain the material description, brand name, manufacturer's address and telephone number, stock number, size, identifying trademark or symbol, and other appropriate ratings.

Do not fabricate or order material until receipt of the Engineer's approval of the catalog cuts. See QPL web site for required catalog cut documentation.

All electrical equipment shall conform to the applicable standards of the National Electrical Manufacturers Association (NEMA), the Underwriters' Laboratories, Inc. (UL) or third party accreditation, the Electronic Industries Association (EIA), the International Municipal Signal Association (IMSA), and the Rural Electrification Administration (REA).

Furnish materials and workmanship conforming to the latest requirements of the Standards of the American Society for Testing and Materials (ASTM); American National Standards Institute (ANSI); and all local ordinances and regulations.

C. Department Furnished Information and Software

The Department will furnish the final timing parameters (cycle, split, and offset) in traffic engineering format. Perform any conversions necessary to implement the timing in the controllers and the field master. As necessary, the Department may modify the timings at an individual intersection. Install these modified timings. As directed by the Engineer, it may be necessary for the Contractor to install up to 5 such changes, per intersection. Inputting coordination timing will be considered incidental and will not be measured for separate payment.

Identify in the overall project schedule the date when the final timing parameters will be needed. Request these parameters from the Engineer in writing one hundred and twenty (120) days before they are needed.

Install and integrate Department-furnished information and Contractor-furnished materials into a complete and totally operational traffic signal system.

The Department will provide Master/Local and Closed Loop Traffic Management System software prior to the burning-in period. Contractor shall give 5 working days notice before needing software.

D. System Operational Test

All equipment and software provided in this project shall be fully installed and operational prior to the start of the system operational test. These test procedures shall demonstrate that all equipment is fully integrated and operational, and is properly controlling the system. Rewrite the proposed operational test at no additional cost to the project to correct deficiencies. Conduct the test, document the results of the test, and furnish the documented test results to the Engineer.

Submit a System Operational test plan a minimum of sixty (60) days prior to the scheduled start of the test. Within thirty (30) days of receipt, the test plan will be reviewed by the Engineer, and either approve it or indicate changes that are required for approval. The Contractor shall then submit the revised test plan. This process shall be repeated until the Engineer is able to approve the test plan.

Provide an operational test matrix at least four weeks prior to the scheduled beginning of the system operational test. The test matrix shall include columns for a description of the test, a summary of the test procedures, a column with sufficient space for comments and a status (pass/fail) column.

Repair or replace any component or software module that fails the System Operational Test. Retest repaired or replaced component(s) or software module.

The testing shall include, but not be limited to, the following:

- Uploading and downloading of controller
- Spread Spectrum Wireless Radio

E. Observation Period

Upon successful completion of the System Operational Test and the correction of all known deficiencies, including minor construction items and punch-list items developed by the Engineer, a sixty (60) day Observation Period shall commence. The purpose of this period is to determine that all components of the signal system function in accordance with the Plans and these Project Special Provisions over an extended length of time.

System or component failures that occur during the sixty (60) day Observation Period shall be responded to by the Contractor within two (2) hours, and corrected within twenty-four (24) hours. Failures that affect any of the major system components defined below for more than seventy-two (72) hours shall suspend the timing of the sixty (60) day Observation Period beginning at the time when the failure occurred. After the cause of such failures has been corrected, timing of the sixty (60) day observation period shall resume. System or component failures that necessitate a redesign of any component, and failures in any of the major system components exceeding a total of three (3) like major system components in any thirty (30) day period for the entire complement of major system components, shall terminate the sixty (60) day Observation Period and shall cause the sixty (60)day Observation Period to be restarted from zero

when the redesigned component has been installed and/or the failures corrected. The major system components are:

- Local controllers and cabinets
- Wireless Radios
- System hardware
- Local and closed loop 2070 traffic signal controller software [to be provided by NCDOT as described in Section 11 (Controllers with Cabinets) of these Project Special Provisions

The sixty (60) day Observation Period is considered to be a part of the work included in the total contract time and must be completed prior to acceptance of the Project.

Final acceptance will occur at the successful completion of the sixty (60) day Observation Period and after all documentation requirements have been fully satisfied.

F. As-Built Documentation

1. As-Built Drawings

Advise the Engineer of any change of measurement, layout, or component of the plans submitted to him. Upon completion of construction, within (10) days after the observation period begins, prior to acceptance of the project, furnish as-built plans on 22" x 34" standard plan sheets.

The Engineer will provide electronic copies of MicroStation design files for the original plans for your use in preparing electronic as-built drawings. Use CAD conventions that are consistent with the conventions used on the original plans.

Show, in detail, all construction changes, with the final location and depth of conduits, wiring external to the cabinet, location of junction boxes, system detector locations, coaxial cable and antenna, etc.

Correct any errors to the as-built plans upon review by the Engineer prior to the acceptance of the project. Submit final as-built plans in electronic and hard copy format. Provide electronic plans in MicroStation (latest release) format on CD-ROM.

2. Field Hardware

Furnish the following field hardware documentation:

- Operating instructions and maintenance manuals shall be bound, and consist of minimum size of 8.5"x 11" sheets with 11" x 17" minimum schematics. Provide operating instructions and maintenance manuals for each type of traffic signal equipment, including controllers, malfunction management units, and detector amplifiers. Provide one set of such manuals and instructions with each controller.

- Furnish two sets of operating instructions and two sets of maintenance manuals for each item of test equipment specified in these Project Special Provisions.

- Provide the controller cabinet wiring diagrams on 22" x 34" plan sheets, and include actual field hook-ups, system and local detectors, communications interface connections, preemption wiring, surge protection, and all auxiliary relays. Provide three (3) copies of the cabinet wiring diagrams for each controller assembly provided. Provide a digital file, in MicroStation (latest version) format on a CD-ROM, for each controller assembly type.

- Provide two (2) prints of the following diagrams applicable to the equipment, in a weatherproof holder and mounted within each cabinet or housing: 1) Intersection Drawing, 2) Phasing Diagram, 3) Loop Detector Locations, 4) "Input File – Typical Wiring Diagram," and 5) "Output File – Typical Wiring Diagram".

Submit five (5) copies of draft documentation to the Engineer for written approval no later than the delivery of the corresponding equipment. Upon written approval by the Engineer, submit final documentation for field hardware prior to the end of the 60-day Observation Period.

G. Warranty

All of the equipment, materials and workmanship supplied under this contract shall be fully warranted. The warranty period shall begin on the date of the final acceptance of all work. This warranty shall cover all parts and labor necessary or incidental to the repair of any defect in equipment or workmanship and malfunctions that arise during the warranty period. The warranty shall be provided to the Department in writing prior to final acceptance of the work or material. The warranty shall unconditionally cover all specified requirements. The wording of the warranty shall be subject to the approval of the Engineer.

The period of warranty coverage for equipment and materials shall be at least six (6) months for equipment, materials, and workmanship supplied on this project, and in no case shall be less than the manufacturer's usual and customary warranty. All warranties that are customarily issued by the equipment manufacturers shall be secured and provided to the Department. The warranties delivered by the manufacturer to you shall include the provision that they are subject to transfer to the Department or its designated maintaining agency, and shall be accompanied by proper validation by the manufacturer. Transfer of warranties to the Department shall occur at the time of acceptance of the work.

Fully warrant all workmanship supplied in the installation of equipment and materials under this contract for a minimum period of 30 days from the date of final acceptance of all work, except that the workmanship supplied in the installation of loop systems shall be fully warranted for a period of six months.

H. Timing of Signals

Implement timing values for signal controllers as shown on the Plans. Modify proposed phasing and timing of existing controllers.

Reinstall all existing time-based coordination. As directed, make modifications to existing coordination to account for changes in signal phasing.

The Department reserves the right to make, or have the Contractor make, field timing changes necessary for pattern optimization and to eliminate identifiable, potential hazards to the motoring public. The Engineer will notify the Contractor of timing changes made by the Department.

1.4 CONSTRUCTION METHODS

A. General

Construction methods shall comply with Section 1700 of the 2006 Standard Specifications.

B. Intersection Schedule

Construction shall begin at the intersections of Patton Ave/Pack Square at US 25/Biltmore Ave/Broadway (13-0271) and College Street at US 25/Broadway (13-0267) to coincide with additional work to be completed by the City. The intersection schedule can change at the Engineer's discretion.

C. Site Work

Jointly inventory and verify that the existing traffic signal equipment is in satisfactory working order before beginning work at a signalized intersection. Report all defective traffic signal equipment to the Engineer before beginning work at a signalized intersection so as not to be held responsible for existing defects.

Do not remove and replace more than one controller and cabinet per day, unless otherwise approved by the Engineer. Once controller and cabinet replacement has begun at a given location, complete the removal and replacement work at that location before beginning removal and replacement of a controller and cabinet at another location.

Determine the exact location of the existing conduit, cable runs, inductive detector loops, lead-in cables/wires, junction boxes, and detection equipment before installing or using equipment that may damage or interfere with such facilities. The location of existing inductive detection loops, associated junction boxes and conduits where shown on the Plans are approximate.

Utilize IMSA Level II Technicians to perform all cabinet placement, cabinet wiring and controller programming. Program the controllers and wire the cabinets so that the phasing, type of operation (time-based, volume density, or special sequences), loop to phase assignments, and phase numbering assignments match the existing assignments, unless otherwise directed by the Engineer.

At the end of each workday, clean and clear the work site of excess excavation, waste packing material, wire, and all other debris that results from traffic signal system work. Haul and dispose of all waste as required by Section 802 of the Standard Specifications.

D. Electrical License, Codes, and Inspections

Comply with Article 4, Chapter 87 of the North Carolina General Statues (Licensing of Electrical Contractors). The license must have been issued on or before the date of the scheduled bid opening and must be of a class to accomplish the total dollar value of the work.

Obtain all permits and licenses required by state and local government agencies having jurisdiction over the same. Install meter bases and circuit breakers as required by the local utility companies and ordinances. Furnish written certification of the authorized inspector's approval, if required, to the Engineer. Inspection by the authorized government electrical inspector shall neither eliminate nor replace inspections by the Engineer. Upon the Engineer's receipt of required written certification and your written request for a final inspection of the traffic signal system work, the Engineer will perform a final inspection.

E. System Integration

Integrate all components of the system. Compliance with the operational and technical specifications of these Project Special Provisions pertaining to individual elements of the system does not in itself meet the requirement to provide a complete, fully functional, and integrated traffic signal system.

F. Maintenance and Repair of Materials

Furnish the Engineer with the name, office telephone number, cellular (mobile) telephone number, and pager number of the supervisory employee who will be responsible for repair calls during all hours.

Once the controller and cabinet have been replaced at an intersection, maintain the new cabinet, controller and all other items furnished and installed with this contract. For these items, begin to make necessary repairs to failures, malfunctions, or damages within four (4) hours of notification and complete the necessary repairs within eight (8) hours of notification. Remove all material that fails and install replacement material. Replace failed material with new material at no additional cost to the Department.

Items reused (that are unmodified), such as signal heads, signal cable, local detector loops and lead-in cable, will be maintained by others. Maintain traffic signal system equipment until completion of the 60-day Observation Period and written notification of final acceptance of the project has been received from the Engineer.

Perform yearly maintenance on all Traffic Signal Conflict Monitors. The year shall be defined from the date of installation of the controller and cabinet at an intersection. Use the Signal Monitor Tester described in Section 20 (System Support Equipment) of these Project Special Provisions. Ensure that the Signal Monitor Tester is maintained and calibrated per the manufactures recommendation. Provide to the Engineer a copy of the manufacture's certification that the Signal Monitor Tester has been certified before testing any Traffic Signal Conflict Monitors. Perform the test on each Traffic Signal Conflict Monitor per the manufactures recommendation. Provide one (1) copy of the Traffic Signal Conflict Monitor test results to the Engineer. Place one (1) copy in the Traffic Signal Cabinet. Perform these yearly tests for the life of the project.

Maintain traffic flow according to Section 150 of the Standard Specifications during maintenance and repair operations.

Repair scratches, dents, or other damage to the cabinet that occur while the cabinet is under your responsibility.

Should you fail to make necessary repairs to the traffic signal installation within the specified time, the Department, the City or their agent may make the repairs and deduct the cost from any money due you. The inability to contact the supervisory employee or a prearranged alternate shall not extend the response time requirements.

G. Inspections

The Department and/or the City may access the Contractor's equipment to perform railroad, signal, and preventative maintenance inspections, or conflict monitor certification as necessary. The Contractor must be present for these inspections.

H. Listing of Intersection Ownership

The following list provides the ownership of existing traffic signal by intersection:

13-1029 (EB I-240 Exit Ramp at I-240/US 19/US 23 Ramps) ..... NCDOT
13-0263 (Patton Ave at Clingman Ave) ..... NCDOT
COA 1-11 (Patton Ave at French Broad Ave) ..... City of Asheville
COA 1-10 (Patton Ave at Otis St) ..... City of Asheville
COA 1-09 (Patton Ave at Asheland Ave) ..... City of Asheville
COA 1-08 (Patton Ave at Coxe Ave) ..... City of Asheville
COA 1-13 (Patton Ave at Haywood St) ..... City of Asheville
COA 1-14 (Patton Ave at Lexington Ave) ..... City of Asheville
13-0271 (Patton Ave/Pack Square at US 25/Biltmore Ave/Broadway) ..... NCDOT
COA 1-18 (Asheland Ave at Bus Depot) ..... City of Asheville
COA 1-19 (Coxe Ave at Bus Depot/Aston St) ..... City of Asheville
COA 1-07 (College St at Haywood St) ..... City of Asheville
COA 1-06 (College St at Lexington Ave) ..... City of Asheville
13-0267 (College St at US 25/Broadway) ..... NCDOT
COA 1-04 (College St at Market St) ..... City of Asheville
COA 1-03 (College St/Pack Square at Spruce St) ..... City of Asheville
13-0401 (US 70/74A/College St at SR 3284/So Charlotte St) ..... NCDOT
13-0264 (US 70/74A/College St at NC 694/Martin Luther King Jr Dr) ..... NCDOT

I. Removal of Traffic Signal Equipment

Remove all Department and City traffic signal equipment as shown in the Plans including, but not limited to signal heads, signs, controllers, cabinets, conflict monitors, cabinet foundations, and supporting hardware that will not be reused. Assume ownership of the removed signal cable, messenger cable, interconnect cable, cabinet foundations, wood poles, guy assemblies, and supporting hardware.

Return all other State-owned salvageable traffic signal equipment and material to the NCDOT Division 13 Traffic Services yard. Call (828) 298-0094 to arrange for delivery of State-owned equipment.

Return all other City-owned salvageable traffic signal equipment and material to the City's Traffic Signal Shop. To make arrangements for delivery of City-owned equipment, call (828) 259-5873.

Return the removed equipment and materials between the hours of 8:00 a.m. and 12:00 p.m., Monday through Thursday, or at a time mutually agreed upon by you and the Engineer. Replace or repair all material lost or damaged during its removal and transit. Label all returned equipment and material to indicate its original location.

Refer to the Listing of Intersection Ownership, section 1.4-G of these Project Special Provisions, to determine the appropriate owner of salvageable traffic signal equipment.

J. Acquisition of Electrical Service

Contact appropriate utility company and make application to ensure completion of the work. For existing installations, obtain authorization from the Engineer for power service in NCDOT's name or the City of Asheville's, as appropriate, and make application for service in that name. Pay the cost of acquiring the service.

The service owner (NCDOT or the City of Asheville) will be responsible for direct payment of the monthly use utility bills.

Acquisition of electrical service will be considered incidental and will not be measured for separate payment.

Refer to the Listing of Intersection Ownership, section 1.4-G of these Project Special Provisions, to determine the appropriate service owner.

K. Acquisition of Telephone Service

Contact the telephone company and make application to ensure completion of the work. Obtain authorization from the Engineer for telephone service in NCDOT's name and make application for service in NCDOT's name. Pay any cost associated with acquiring the service.

The Department will be responsible for direct payment of the monthly use telephone service bills.

Acquisition of telephone service will be considered incidental and will not be measured for separate payment.

L. Protection of Utilities and Other Existing Facilities

Protect all existing utilities. Contact the North Carolina One-Call Center (1-800-632-4949) at least 72 hours prior to beginning any underground work to request that underground utilities be located. Notify utility companies 48 hours prior to the beginning of any underground work. Do not begin drilling, digging, or trenching until all underground utilities have been located.

Protect existing traffic signals and their related equipment from damage caused by subcontractors and employees under this Contract. Ascertain the exact location of existing conduit and cable run and junction boxes before using equipment that may damage such facilities or interfere with any system.

Unless otherwise indicated, the existing intersection detection loops and associated lead-in cables will be re-used. Replace any loops or lead-in cables that you damage, at your expense. The locations of all existing loops are not shown on the Plans; however, determine the locations of all existing loops to prevent damage to loops. Prior to performing any work that might damage existing loops or other detector elements, verify to your own satisfaction that these elements are in good working order. Identify in writing any defective elements to the Engineer prior to beginning work in order that you will not be held responsible for such defects.

Maintain proper clearances from existing utilities as required by the NESC.

1.5 BASIS OF PAYMENT

There will be no direct payment for the work covered by this Section.

2. MOBILIZATION

2.1 DESCRIPTION

The work covered by this section consists of preparatory work and operations, including (but not limited to) those necessary for the movement of personnel, equipment, supplies, and incidentals to the project site; for the establishment of offices, buildings, and other facilities necessary for work on the project; removal and disbandment of those personnel, equipment, supplies, incidentals, or other facilities that were established for the prosecution of work on the project; and for all other work and operations that must be performed for costs incurred prior to beginning work on the various items on the project site.

2.2 MEASUREMENT AND PAYMENT

Compensation for Mobilization shall be made in accordance with Section 800 (Mobilization) of the Standard Specifications.

Payment will be made under:

Mobilization.....Lump Sum

3. ELECTRICAL SERVICE

3.1 DESCRIPTION

Comply with the Standard Specifications and these Special Provisions. At locations called out in the Plans, install new electrical service. All work involving electrical service shall be coordinated with the appropriate electrical utility company. Obtain all required local permits before beginning work.

3.2 MATERIALS

A. General

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of equipment installation.

Construct electrical service installations in accordance with the Standard Specifications. For locations shown on the Plans requiring new electrical service, provide a service that includes a new external service disconnect (breaker box) and meter base. Run service cable(s) separately in 1" rigid metallic conduit (RMC).

For pole mounted cabinets, mount the service on an existing pole as indicated on the Plans, and extend the service cables into the cabinet through a new 1" RMC.

Coordinate with utility company to ascertain the practicality of installing electrical service at each location before performing any work.

B. External Electrical Service Disconnect

Furnish external electrical service disconnects with single pole 50 ampere circuit breaker with a minimum of 10,000 RMS symmetrical amperes short circuit current rating in a lockable NEMA 3R enclosure. Ensure service disconnects are UL listed and marked as being suitable for use as service equipment. Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint finish, light gray in color, to yield a minimum thickness of 2.4 mils. Provide ground bus and neutral bus with a minimum of four terminals with minimum wire capacity range of number 14 through number 4.

Furnish NEMA Type 3R outdoor enclosure, 100 Ampere rated meter base. Furnish 4 terminal, 600 volt, single phase, 3 wire meter base that complies with the following:

- Line, Load, and Neutral Terminals accept #8 to 2/0 AWG Copper/Aluminum wire
- Ringless Type without bypass
- Made of galvanized steel
- Meets Standard UL-414
- Overhead or underground service entrance as specified

Provide meter bases with ampere rating of meter sockets based on sockets being wired with minimum of 167 degrees F insulated wire. Ensure meter bases have electrostatically applied dry powder paint finish, light gray in color, with minimum thickness of 2.4 mils.

Furnish 1-inch watertight hub for threaded rigid conduit with meter base.

If meter base and electrical service disconnect are supplied in the same enclosure, ensure assembly is UL listed and marked as being suitable for use as service equipment.

3.3 CONSTRUCTION METHODS

A. Electrical Service

At locations where new electrical service is to be installed on wood pole or service pedestal, furnish and install electrical service as called for in the Plans. After installation of the meter base, the utility company will transfer the existing meter or install a new meter if required and make any necessary connections to the power lines. Ground the new electrical service in accordance with the Standard Specifications and Standard Drawings.

See the Base Mounted Cabinet & Service Detail included in the plans for service pedestal

Provide Engineer with a copy of all permits and final inspections if required.

B. Modify Existing Electrical Service

At locations shown in the Plans, modify electrical service to provide complete electrical service with meter base and external service disconnect that complies with the Standard Specifications and Drawings. After all required modifications are complete, each cabinet shall have its own power meter and electrical disconnect that are located on a pedestal or pole and not attached to the signal cabinet. Ensure that all connections between the power source, meter, disconnect, and signal cabinet are complete and grounded in accordance with these Project Special Provisions, the Standard Specifications, and the Plans.

3.4 MEASUREMENT AND PAYMENT

New electrical services will be measured and paid as the actual number furnished, installed and tested. Riser assemblies (1 inch), meter bases, service disconnects, underground and exposed conduit runs to the cabinet, acquisition of service fees, electrical service conductors, ground rod, ground wire and any remaining hardware and conduit to connect the electrical service to the cabinet are considered incidental to installing a new electrical service.

Existing electrical service location will be measured and paid as the actual number of locations modified, integrated, and tested. Any electrical service conductors, remaining hardware and conduit to connect the electrical service to the cabinet or any other work to bring the electrical service into compliance with the Standard Specifications are considered incidental to the service modifications and will not be paid for separately. This includes, but is not limited to, furnishing new or relocating existing external service disconnects. No separate payment will be made for extending or replacing electrical service cable and conduits.

Payment will be made under:

New Electrical Service ..... **Each**

Modify Existing Electrical Service ..... **Each**

4. SIGNAL HEADS AND ACCESSORIES

4.1 DESCRIPTION

Furnish and install signal heads and signal cable for vehicle signal heads with all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

Furnish and install vehicle and pedestrian LED signal heads, visors, interconnecting brackets, wire entrance fittings, mounting assemblies, signal cable, lashing wire, pedestrian push buttons, pedestrian signal signs, grounding systems and all necessary hardware.

Modify existing traffic signal head sections in accordance with the plans and specifications.

4.2 MATERIALS

A. General

Fabricate vehicle signal head housings and end caps from die-cast aluminum. Fabricate 16-inch pedestrian signal head housings and end caps from die-cast aluminum. Provide visor mounting screws, door latches, and hinge pins fabricated from stainless steel. Provide interior screws, fasteners, and metal parts fabricated from stainless steel or corrosion resistant material.

Fabricate tunnel and traditional visors from sheet aluminum.

Paint all surfaces inside and outside of signal housings and doors. Paint outside surfaces of tunnel and traditional visors, messenger cable mounting assemblies, pole and pedestal mounting assemblies, and pedestrian pushbutton housings. Have electrostatically-applied, fused-polyester paint in Asheville Green a minimum of 2.5 to 3.5 mils thick. Do not apply paint to the latching hardware or rigid vehicle signal head mounting brackets.

Have the interior surfaces of tunnel and traditional visors painted an alkyd urea black synthetic baking enamel with a minimum gloss reflectance and meeting the requirements of MIL-E-10169, "Enamel Heat Resisting, Instrument Black."

For pole mounting, provide side of pole mounting assemblies with framework and all other hardware necessary to make complete, watertight connections of the signal heads to the poles and pedestals. Fabricate the mounting assemblies and frames from aluminum with all necessary hardware, screws, washers, etc. to be stainless steel. Provide mounting fittings that match the positive locking device on the signal head with the serrations integrally cast into the brackets. Provide upper and lower pole plates that have a 1 ¼-inch vertical conduit entrance hubs with the hubs capped on the lower plate and 1 ½-inch horizontal hubs. Ensure that the assemblies provide rigid attachments to poles and pedestals so as to allow no twisting or swaying of the signal heads. Ensure that all raceways are free of sharp edges and protrusions, and can accommodate a minimum of ten Number 14 AWG conductors.

For pedestal mounting, provide a post-top slipfitter mounting assembly that matches the positive locking device on the signal head with serrations integrally cast into the slipfitter. Provide stainless steel hardware, screws, washers, etc. Provide a minimum of six 3/8 X 3/4-inch long square head bolts for attachment to pedestal. Provide a center post for multi-way slipfitters.

B. Vehicle Signal Heads

Comply with the ITE standard "Vehicle Traffic Control Signal Heads".

Provide visors that are 8 inches in length for 8-inch vehicle signal head sections. Provide visors that are 10 inches in length for 12-inch vehicle signal heads.

Provide a termination block with one empty terminal for field wiring for each indication plus one empty terminal for the neutral conductor. Have all signal sections wired to the termination block. Provide barriers between the terminals that have terminal screws with a minimum Number 8 thread size and that will accommodate and secure spade lugs sized for a Number 10 terminal screw.

Mount termination blocks in the yellow signal head sections on all in-line vehicle signal heads. Mount the termination block in the red section on five-section vehicle signal heads.

Furnish vehicle signal head interconnecting brackets. Provide one-piece aluminum brackets less than 4.5 inches in height and with no threaded pipe connections. Provide hand holes on the bottom of the brackets to aid in installing wires to the signal heads. Lower brackets that carry no wires and are used only for connecting the bottom signal sections together may be flat in construction.

For mast-arm mounting, provide rigid vehicle signal head mounting brackets and all other hardware necessary to make complete, watertight connections of the vehicle signal heads to the mast arms and to provide a means for vertically adjusting the vehicle signal heads to proper alignment. Fabricate the mounting assemblies from malleable iron or aluminum, and provide serrated rings made of aluminum.

Provide light emitting diode (LED) vehicular traffic signal modules (hereafter referred to as modules) that consist of an assembly that uses LEDs as the light source in lieu of an incandescent lamp for use in traffic signal sections. Use LEDs that are aluminum indium gallium phosphorus (AlInGaP) technology for red and yellow indications and indium gallium nitride (InGaN) for green indications. Install the ultra bright type LEDs that are rated for 100,000 hours of continuous operation from -40°F to +165°F. Design modules to have a minimum useful life of 60 months and to meet all parameters of this specification during this period of useful life.

LED Circular Signal Modules

Provide modules in the following configurations: 12-inch circular sections, and 8-inch circular sections. All makes and models of LED modules purchased for use on the State Highway System shall appear on the current NCDOT Traffic Signal Qualified Products List (QPL).

Ensure, unless otherwise state in these specifications, that each module meets or exceeds the ITE "Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement" dated June 27, 2005 (hereafter referred to as VTCSH Circular Supplement).

Certify compliance with paragraphs 3.3.2, 3.3.3, 3.4.2, 4.1.1, 4.1.2, 4.1.3, 4.2.1, 4.2.2, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.3, 5.4, 5.5.1, 5.5.2, 5.6.2, 5.7 of the VTCSH Circular Supplement.

Provide quick connect Molex terminals (part # 19092026 female housing, part # 02091615 female pin, part # 19092027 male housing, and 02092101 male pin) or equivalent, and spade terminals appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard signal head. Ensure the replacement module provided has the Molex male connector 6 inches from the module.

Ensure the power supply is integral to the module assembly. On the back of the module, permanently mark the date of manufacture (month & year) or some other method of identifying date of manufacture.

Tint the red, yellow and green lenses to correspond with the wavelength (chromaticity) of the LED. Transparent tinting films are unacceptable.

Provide modules that meet the requirements of Tables 1098-1 and 1098-2.

In addition to meeting the performance requirements for the minimum period of 60 months, provide a written warranty against defects in materials and workmanship for the modules for a period of 60 months after installation of the modules. During the warranty period, the manufacturer must provide replacement modules within 45 days of receipt of modules that have failed at no cost to the Owner. Provide manufacturer's warranty documentation to Owner during evaluation of product for inclusion on Qualified Products List (QPL).

Table 1098-1
Maximum Power Consumption (in Watts) at 77°F

	Red	Yellow	Green
12-inch circular	12	22	15
8-inch circular	8	13	12

Table 1098-2
Minimum Maintained Luminous Intensity/Minimum Initial Luminous Intensity (in cd) at 77°F

Vertical Angle	Horizontal Angle	Red 8"		Yellow 8"		Green 8"		Red12"		Yellow 12"		Green 12"	
		Main.	Initial	Main.	Initial	Main.	Initial	Main.	Initial	Main.	Initial	Main.	Initial
+12.5	2.5	17	21	41	51	22	28	37	46	91	114	48	60
	7.5	13	16	33	41	17	21	29	36	73	91	38	48
+7.5	2.5	31	39	78	98	41	51	69	86	173	216	90	113
	7.5	25	31	62	78	32	40	55	69	137	171	71	89
	12.5	18	23	45	56	24	30	40	50	100	125	52	65
+2.5	2.5	68	85	168	210	88	110	150	188	373	466	195	244
	7.5	56	70	139	174	73	91	124	155	309	386	162	203
	12.5	38	48	94	118	49	61	84	105	209	261	109	136
	17.5	21	26	53	66	28	35	47	59	118	148	62	78
	22.5	12	15	29	36	15	19	26	33	64	80	33	41
-2.5	2.5	162	203	402	503	211	264	358	448	892	1115	466	583
	7.5	132	165	328	410	172	215	292	365	728	910	380	475
	12.5	91	114	226	283	118	148	201	251	501	626	261	326
	17.5	53	66	131	164	69	86	117	146	291	364	152	190
	22.5	28	35	70	88	37	46	62	78	155	194	81	101
	27.5	15	19	37	46	19	24	33	41	82	103	43	54
-7.5	2.5	127	159	316	395	166	208	281	351	701	876	366	458
	7.5	106	133	262	328	138	173	234	293	582	728	304	380
	12.5	71	89	176	220	92	115	157	196	391	489	204	255
	17.5	41	51	103	129	54	68	91	114	228	285	119	149
	22.5	21	26	53	66	28	35	47	59	118	148	62	78
	27.5	12	15	29	36	15	19	26	33	64	80	33	41
-12.5	2.5	50	63	123	154	65	81	110	138	273	341	143	179
	7.5	40	50	98	123	52	65	88	110	218	273	114	143
	12.5	28	35	70	88	37	46	62	78	155	194	81	101
	17.5	17	21	41	51	22	28	37	46	91	114	48	60
	22.5	8	10	21	26	11	14	18	23	46	58	24	30
	27.5	5	6	12	15	6	8	11	14	27	34	14	18
-17.5	2.5	23	29	57	71	30	38	51	64	127	159	67	84
	7.5	18	23	45	56	24	30	40	50	100	125	52	65
	12.5	13	16	33	41	17	21	29	36	73	91	38	48
	17.5	7	9	16	20	9	11	15	19	36	45	19	24
	22.5	3	4	8	10	4	5	7	9	18	23	10	13
-22.5	2.5	17	21	41	51	22	28	37	46	91	114	48	60
	7.5	13	16	33	41	17	21	29	36	73	91	38	48
	12.5	10	13	25	31	13	16	22	28	55	69	29	36
	17.5	5	6	12	15	6	8	11	14	27	34	14	18
-27.5	2.5	12	15	29	36	15	19	26	33	64	80	33	41
	7.5	8	10	21	26	11	14	18	23	46	58	24	30

Note 1: Luminous intensity values for equivalent left and right horizontal angles are the same.

Note 2: Tabulated values of luminous intensity are rounded to the nearest whole value.

LED Arrow Signal Modules

Ensure arrow modules meet or exceed the electrical and environmental operating requirements of sections 3 and 5 of the Interim Purchase Specification of the ITE VTCSH part 2 Light Emitting Diode (LED) Vehicular Traffic Signal Modules (hereafter referred to as VTCSH-2), the chromaticity requirements of Section 4.2, and the requirements of Sections 6.3 (except 6.3.2) and 6.4 (except 6.4.2).

Provide modules that meet the requirements of Table 1098-3. Ensure that fluctuations of line voltage have no visible effect on the luminous intensity of the indications. Design the module to have a normal operating voltage of 120 VAC rms, and measure all parameters at this voltage.

Table 1098-3
Maximum Power Consumption (in Watts) at 77°F

	Red	Yellow	Green
12-inch arrow	9	10	11

Certify that the module meets the requirements of VTCSH-2, Section 5.7. Ensure all wiring meets the requirements of Section 5.1 of the VTCSH-2. In addition, provide quick connect Molex terminals (part # 19092026 female housing, part # 02091615 female pin, part # 19092027 male housing, and 02092101 male pin) or equivalent, and spade terminals appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard signal head. Ensure the replacement module provided has the Molex male connector 6 inches from the module.

Ensure that the module is compatible with signal load switches and conflict monitors. Design the module to provide sufficient current draw to ensure proper load switch operation while the voltage is varied from a regulated 80 Vrms to 135 Vrms. Design off-state for green and yellow modules to be 30Vrms or less, and on-state to be 40 Vrms or greater. Design the voltage to decay to 10 Vrms or less in 100 milliseconds. Ensure that the control circuitry prevents current flow through the LEDs in the off state to avoid a false indication.

Design all modules to meet existing NCDOT monitor specifications for each of the following types of signal monitors: NEMA TS-1 conflict monitors (including so-called NEMA plus features such as dual indication detection and short yellow time detection); NEMA TS-2 Malfunction Management Units (MMU); and 170 cabinet Type 210ECL and 2010ECL conflict monitors (including red monitoring and so-called plus features such as dual indication detection and short yellow time detection).

Ensure that the modules and associated onboard circuitry meet Class A emission limits referred to in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.

Provide modules that meet the requirements of Table 1098-4. Design and certify the modules to meet or exceed the maintained minimum luminous intensity values throughout the warranty period based on normal use in a traffic signal operation over the operating temperature range. Test the Red and Green arrow modules for maintained luminous intensity at 165°F (ITE 6.4.2.2). Use LEDs that conform to the chromaticity requirements of VTCSH-2, Section 2 throughout the warranty period over the operating temperature range. Make chromaticity coordinate compliance measurements at 77°F.

Table 1098-4
Minimum Initial and Maintained Luminance for Arrow Indications (in cd/ft2)

	Red	Yellow	Green
Arrow Indication	511	1022	1022

Design the modules as retrofit replacements for installation into standard incandescent traffic sections that do not contain the incandescent lens, reflector assembly, lamp socket and lens gasket. Ensure that installation does not require special tools or physical modification for the

existing fixture other than the removal of the incandescent lens, reflector assembly, lamp socket, and lens gasket.

Provide modules that are rated for use in the operating temperature range of -40oF to +165oF. Ensure that the modules (except yellow) meet all specifications throughout this range. Fabricate the module to protect the onboard circuitry against dust and moisture intrusion per the requirements of NEMA Standard 250-1991 for Type 4 enclosures to protect all internal components.

Design the module to be a single, self-contained device with the circuit board and power supply for the module inside and integral to the unit.

Design the assembly and manufacturing process for the module to ensure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources. Group the individual LEDs such that a catastrophic loss or the failure of one LED will result in the loss of not more than 20 percent of the signal module light output. Solder the LEDs to the circuit board.

Fabricate the lens and signal module from material that conforms to ASTM specifications. Ensure enclosures containing either the power supply or electronic components of the module are made of UL94VO flame retardant materials. The lens of the signal module is excluded from this requirement.

Permanently mark the manufacturer's name, trademark, model number, serial number, date of manufacture (month & year), and lot number as identification on the back of the module.

Permanently mark the following operating characteristics on the back of the module: rated voltage and rated power in watts and volt-amperes.

If a specific mounting orientation is required, provide permanent markings consisting of an up arrow, or the word "UP" or "TOP" for correct indexing and orientation within the signal housing.

Provide a lens that is integral to the unit with a smooth outer surface and UV stabilized to withstand ultraviolet exposure for a minimum period of 60 months without exhibiting evidence of deterioration. Coat the front of a polycarbonate lens to make it more abrasion resistant. Seal the lens to the module to prevent moisture and dust from entering the module.

Tint the red, yellow, and green lens to match the wavelength (chromaticity) of the LED.

Ensure that the module meets specifications stated in Chapter 2, Section 9.01 of the ITE Equipment and Materials Standards for arrow indications. Design arrow displays to be solid LEDs (spread evenly across the illuminated portion of the arrow or other designs), not outlines. **Determine the luminous intensity using the CALTRANS 606 method or similar procedure.**

Burn In - Energize the sample module(s) for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of +165°F before performing any qualification testing. Any failure of the module, which renders the unit non-compliant with the specification after burn-in, is cause for rejection. All specifications will be measured including, but not limited to:

(a) **Photometric (Rated Initial Luminous Intensity)** - Measure at +77°F. Measure luminous intensity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage. **Measure luminous intensity for yellow modules immediately upon energizing at the rated voltage.**

(b) **Chromaticity (Color)** - Measure at +77°F. Measure chromaticity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage. **Measure chromaticity for yellow modules immediately upon energizing at the rated voltage.**

(c) **Electrical** - Measure all specified parameters for quality comparison of production quality assurance on production modules. (rated power, etc)

NCDOT evaluates and approves all LED Traffic Signal modules for the QPL by a standard visual inspection and blind operational survey, a compatibility test, current flow, and other random tests, in addition to reviewing the lab reports and documentation from the manufacturer. The tests are conducted at the Traffic Electronics Center in Raleigh. Ensure each 12-inch arrow module is visible at 300 feet during sway conditions (extended view) until obscured by the visor. Sufficient luminance during the extended views will be determined during this blind survey evaluation.

In addition to meeting the performance requirements for the minimum period of 60 months, provide a written warranty against defects in materials and workmanship for the modules for a period of 60 months after installation of the modules. During the warranty period, the manufacturer must provide replacement modules within 45 days of receipt of modules that have failed at no cost to the Owner. Provide manufacturer's warranty documentation to the Owner during evaluation of product for inclusion on Qualified Products List (QPL).

C. Pedestrian Signal Heads

Provide pedestrian signal heads with international symbols that meet the MUTCD. Do not provide letter indications.

Comply with the ITE standard for "Pedestrian Traffic Control Signal Indications" and the following sections of the ITE standard for "Vehicle Traffic Control Signal Heads" in effect on the date of advertisement:

- Section 3.00 - "Physical and Mechanical Requirements"
- Section 4.01 - "Housing, Door, and Visor: General"
- Section 4.04 - "Housing, Door, and Visor: Materials and Fabrication"
- Section 7.00 - "Exterior Finish"

Provide a double-row termination block with three empty terminals and number 10 screws for field wiring. Provide barriers between the terminals that accommodate a spade lug sized for number 10 terminal screws. Mount the termination block in the hand section. Wire all signal sections to the terminal block.

Where required by the plans, provide 16-inch pedestrian signal heads with traditional three-sided, rectangular visors, 6 inches long.

Design the LED pedestrian traffic signal modules for installation into standard pedestrian traffic signal sections that do not contain the incandescent signal section reflector, lens, eggcrate

visor, gasket, or socket. Provide a clear 0.25-inch, non-glare, mat finish lens with a smooth outer surface and UV stabilized to withstand ultraviolet exposure for a minimum period of 60 months without exhibiting evidence of deterioration. Coat the front surface of a polycarbonate lens to make it more abrasion resistant. Ensure that the lens has light transmission properties equal to or greater than 80%.

Ensure installation of all modules requires no physical modification of the existing fixture other than the removal of the incandescent signal section reflector, lens, eggcrate visor and socket where applicable.

Design the man and hand to be a solid display, which meets the minimum requirements of "The Equipment and Materials Standards" of the Institute of Transportation Engineers (ITE) Chapter 3, Table 1 Symbol Message. Group the LEDs such that a catastrophic loss or failure of one or more LEDs will result in the loss of not more than five percent of the signal module light output. Solder the LEDs to the circuit board.

Ensure that the power consumption for the modules is equal to or less than the following in watts, and that the modules have EPA Energy Star compliance ratings, if applicable to that shape, size and color:

Temperature	77°F	165°F
Hand	10	12
Man	9	12
Countdown	9	12

Provide 16-inch displays, where required by the plans, which have the hand/man overlay on the left and the countdown on the right. Ensure the hand/man symbols meet the dimension requirements cited in Chapter 3, Table 1 Symbol Message for Class 3 or Class 4 displays. Ensure that the countdown number display is at least 9 inches high by 6 inches wide. Configure the signal head with a sufficient number of LEDs to provide an average luminance of at least 342 candela per square foot of lighting surface for the "RAISED HAND" and "COUNTDOWN", and 483 candela per square foot of lighting surface for the "walking person". Ensure modules meet this average luminous intensity throughout the warranty period over the operating temperature range. Design the countdown display as a double row of LEDs, and ensure the countdown display blanks-out during the initial cycle while it records the countdown time. Ensure that the countdown display is operational only during the flashing don't walk, clearance interval. Blank-out the countdown indication after it reaches zero until the beginning of the next don't walk indication, and design the controlling circuitry to prevent the timer from being triggered during the solid hand indication.

Design all modules to operate using a standard 3 - wire field installation. Provide lead wires that are eighteen gauge (18AWG) minimum copper conductors with 221 degree F insulation. Ensure that lead wires are a minimum of 30 inches long with NEMA "spade" terminals that are appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in the signal head.

Ensure that modules are compatible with signal load switches and conflict monitors. Design the module to provide sufficient current draw to ensure proper load switch operation while the

voltage is varied from a regulated 80Vrms to 135Vrms. Provide control circuitry to prevent current flow through the LEDs in the off state to avoid a false indication. Design all modules to meet existing NCDOT monitor specifications for each of the following types of signal monitors: NEMA TS-1 conflict monitors (including so-called NEMA plus features such as dual indication detection and short yellow time detection); NEMA TS-2 Malfunction Management Units; and 170 cabinet 210ECL and 2010ECL conflict monitors (including red monitoring and so-called plus features such as dual indication detection and short yellow time detection).

Comply with the following sections: 3.3, 3.5, 3.6.1, 3.6.2, 5.2, 5.3, 5.7, 6.1, 6.3.1, 6.3.3, 6.3.4, 6.3.5, 6.4.4, 6.4.5, and 6.4.6 of VTCSH-2.

Furnish Portland Orange LEDs for the hand and countdown displays that are the latest AlInGaP technology or higher, and Lunar White LEDs for the man display that are the latest InGaN technology or higher.

Provide manufacturer's certification of compliance with the sections of the ITE specification identified above and this specification when product is submitted for evaluation. Provide test results showing that the signal modules meet or exceed the luminous intensity requirements.

Provide modules that include, but are not limited to the following items: lens, LED display mounted on a circuit board, wire leads with strain relief, rigid housing, electronics including a power supply integral to the LED module which is protected by the housing, and a neoprene one piece gasket. Ensure that the module is compatible with standard, existing, pedestrian head mounting hardware.

Warrant performance for a period of 60 months from the date of installation and include repair or replacement of an LED signal module that exhibits light output degradation, which in the judgment of the Owner, cannot be easily seen at 150 feet in bright sunlight with a visor on the housing or which drops below the luminous intensity output requirements. In addition to meeting the performance requirements for the minimum period of 60 months, provide a written warranty against defects in materials and workmanship for the modules for a period of 60 months after installation of the modules. During the warranty period, the manufacturer must provide replacement modules within 45 days of receipt of modules that have failed at no cost to the Owner. Provide manufacturer's warranty documentation to the Owner during evaluation of product for inclusion on Qualified Products List (QPL).

Provide 2-inch diameter pedestrian push-buttons with weather-tight housings fabricated from die-cast aluminum and threading in compliance with the NEC for rigid metal conduit. Provide a weep hole in the housing bottom and ensure that the unit is vandal resistant.

Provide push-button housings that are suitable for mounting on flat or curved surfaces and that will accept 1/2-inch conduit installed in the top. Provide units that have a heavy duty push-button assembly with a sturdy, momentary, normally-open switch. Have contacts that are electrically insulated from the housing and push-button. Ensure that the push-buttons are rated for a minimum of 5 mA at 24 volts DC and 250 mA at 12 volts AC.

Provide standard R10-3 signs with mounting hardware that comply with the MUTCD in effect on the date of advertisement. Provide R10-3E signs for countdown pedestrian heads and R10-3B for non-countdown pedestrian heads.

D. Signal Cable

Furnish 16-4 and 16-7 signal cable that complies with IMSA specification 20-1 except provide the following conductor insulation colors:

- For 16-4 cable: white, yellow, red, and green
- For 16-7 cable: white, yellow, red, green, yellow with black stripe tracer, red with black stripe tracer, and green with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.

Provide a ripcord to allow the cable jacket to be opened without using a cutter. IMSA specification 19-1 will not be acceptable. Provide a cable jacket labeled with the IMSA specification number and provide conductors constructed of stranded copper.

4.3 CONSTRUCTION METHODS

A. General

Bag new pedestrian and vehicle signal heads with burlap bags or bags made of nonripping material specifically designed for covering signal heads until the signal heads are placed in operation. Do not use trash bags of any type.

When new signal heads are placed into operation, immediately bag and remove signals heads that are not to be reused.

Vertically and horizontally adjust each signal head so that light output will be of maximum effectiveness for the traffic and pedestrians. Do not tilt signal heads forward.

Reposition signal heads as required for various construction phases.

B. Vehicle Signal Heads

Install vehicle signal heads at the heights required in the North Carolina Supplement to the MUTCD in effect on the date of advertisement.

Where vehicle signal heads are installed on messenger cable, install mounting hardware consisting of a messenger cable hanger, balance adjuster, bottom cap, wire entrance fitting bracket, and insulating bushings.

Where vehicle signal heads are installed on mast arms, install mounting hardware consisting of rigid vehicle signal head mounting brackets.

Install signal cable in continuous lengths between signal controller cabinets and signal heads. Route signal cable to minimize the length of cable installed, and the number of cables and conductors in each run. Pull 36 inches of additional signal cable into controller cabinets.

Wrap signal cable to messenger cable with at least four turns of wrapping tape spaced at intervals less than 15 inches or lash signal cable to messenger cable with one 360-degree spiral of lashing wire per 12 inches.

Make electrical connections inside each signal head, signal controller cabinet, and termination compartment in metal poles. Do not splice at any other point between signal heads and controller cabinet.

Coil sufficient signal cable beside each vehicle signal head to accommodate head shifts during various construction phases. For final signal head locations, coil 36 inches on each side of signal head if signal cable comes from both directions. If signal cable terminates at the signal head, coil 36 inches of signal cable on the same side as the cable run.

C. Pedestrian Signal Heads

Install signs with mounting hardware immediately above pedestrian push buttons.

Connect pushbutton to controller cabinet using lead-in cable. Bond pushbutton housing and all metal components to cabinet ground using cable ground.

D. Modify Existing Vehicle Signal Heads

Modify existing vehicle signal heads by removing incandescent lamp hardware and replacing with new LED modules with all necessary hardware.

4.4 MEASUREMENT AND PAYMENT

Vehicle signal head (_____) and Pedestrian signal head (_____) will be measured and paid for as the actual number of signal heads of each type, size, and number of sections furnished, installed, and accepted.

No measurement will be made of visors, wire entrance fittings, interconnecting brackets, mounting assemblies, pedestrian push buttons, and pedestrian signal signs as these will be considered incidental to furnishing and installing signal heads.

Signal cable will be measured and paid for as actual linear feet of signal cable furnished, installed, and accepted. Measurement will be point to point with no allowance for sag. Twenty-five feet will be allowed for vertical segments up or down poles.

No measurement will be made for drip loops, coiled sections, or lashing wire as these will be considered incidental to furnishing and installing signal cable.

Payment will be made under:

Vehicle Signal Head (_____) ..... **Each**

Pedestrian Signal Head (_____) ..... **Each**

Signal Cable ..... **Linear Foot**

Modify Existing Vehicle Signal Head ..... **Each**

5. INDUCTIVE DETECTION LOOPS AND ACCESSORIES

5.1 DESCRIPTION

Furnish and install inductive detection loops and loop lead-in cable with all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

Furnish inductive detection loops with loop slot sealant, loop wire, conduit with fittings, loop lead-in cable, and all necessary hardware.

5.2 MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the NCDOT's QPL.

Refer to Article 1098-7 "Inductive Detection Loops" of the Standard Specifications.

5.3 CONSTRUCTION METHODS

A. Inductive Loops

All work performed in this section must be done in the presence of the Engineer.

Notify the Engineer one week prior to installing inductive detection loops.

Coordinate sawcutting and loop placement with pavement markings. For new construction or for resurfacing, install inductive detection loops prior to placement of the final layer of surface course. On unmarked pavement, pre-mark locations of stop lines and lane lines prior to locating inductive detection loops.

Before sawcutting, pre-mark inductive detection loop locations and receive approval. Saw cut pavement at approved pre-marked locations. Do not allow vehicles to travel over unsealed loop slots.

Install conduit with bushings from edge of pavement to junction box. Do not saw cut through curb.

Remove all loose material and wash saw slots with a high-pressure method using an air and water mixture. Dry saw slots with compressed air. Clear saw slots of jagged edges and protrusions. Seat loop conductor at the bottom of the saw slot without damaging loop wire.

Before sealing loop conductors, test that impedance from the loop wire to ground is at least 100 megohms. For each location with inductive loops, submit a completed "Inductive Detection Loop & Grounding Test Results" form and place copy in controller cabinet. Ensure all loops are included on the following form (the form is also located on the Department's website (http://www.ncdot.org/doh/preconstruct/traffic/tmssu/ws/signal_data.xls):

Inductive Detection Loop & Grounding Test Results

U-4715

Location: _____ Sig. Inv. #: _____

Inspected By: _____ \Contractor's Name Date Tested: _____

Loop No.	Sealant Type	Distance from Stop Bar	Megger Reading @ Pull Box (> 100 megohms)		Megger Reading @ Signal Cabinet (> 50 megohms)		Ohm Reading @ Signal Cabinet Length of Loop Wire & Lead-in Wire _____feet/meter (<0.00885 ohms/foot) (< 0.0295 ohms/meter)		
			Reading	Date	Reading	Date	Reading	Feet / Meter	Date

Grounding

Number of Ground rods? _____
(*3 Rod Minimum*)

How are the ground rods installed? ☐ Individually ☐ Stacked

Ohm Reading? _____

Amount of ground wire? _____
(*From cabinet to closest ground rod*)

Ground Rod Location
(Draw in cabinet & locate ground rods)

SIDE STREET

NOTES:

ω Grounding of traffic signal controller cabinets should be in accordance to Section 1751 of the NCDOT Standard Specifications for Roads and Structures Manual and drawing number 1751.01 of the Highway Design Branch Roadway Standard Drawings manual

ω The installation and testing of inductive detection loop systems should be in accordance to Section 1725 and 1726 of the NCDOT Standard Specifications for Road and Structures manual.

Embed loop conductors in saw slot with loop sealant. Seal saw slot and dispose of excess sealant in an environmentally safe manner. Provide Engineer with Material Safety Data Sheet and manufacturer's test data.

Between corners of loops and junction boxes, twist loop conductor pairs a minimum of 5 turns per foot. Permanently label each twisted pair in the junction box with nylon cable tie using indelible ink. Indicate loop number and loop polarity on the tie.

B. Loop Lead-in Cable

For underground runs, install lead-in cable in 2-inch non-metallic conduit. For aerial installation, wrap lead-in cable to messenger cable with at least four turns of wrapping tape spaced at intervals less than 15 inches or lash lead-in cable to messenger cable with one 360-degree spiral of lashing wire per 12 inches.

Where railroad preemption is required, install lead-in cable from signal controller cabinet to railroad company furnished and installed lockable junction box.

Splicing of lead-in cable will be allowed only for runs in excess of 750 feet. Splice lead-in cable in junction boxes or condulets on poles.

Test each complete loop system from the controller cabinet by using a megger to verify that impedance from the loop system to the ground is at least 50 megohms. After successful completion of megger test, test loop system resistance using an electronic ohmmeter to verify loop system resistance is less than 0.00885 ohms per foot. Record the readings on the "Inductive Detection Loop & Grounding Test Results" form (see page 28 of these Project Special Provisions).

5.4 MEASUREMENT AND PAYMENT

Inductive loop sawcut will me measured and paid as the actual linear feet of inductive loop sawcut furnished, installed, and accepted.

No measurement will be made of loop slot sealant, loop wire, conduit, and conduit fittings as these will be considered incidental to furnishing and installing inductive detection loops.

Lead-in cable (_____) will be measured and paid as the actual linear feet of lead-in cable of either 18-2 pair or 18-4 pair furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all cables before determining length of cable run. Measurement will be determined on 2-pair/4-pair combination resulting in the least number of linear feet.

If markings are not visible, measurement will be point to point with no allowance for sag. Twenty-five feet will be allowed for vertical segments up or down poles.

Payment will be made under:

Inductive Loop Saw Cut .....Linear Foot

Lead-in Cable.....Linear Foot

6. SIGNS INSTALLED FOR SIGNALS

6.1 DESCRIPTION

Furnish and install signs for signals and all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

Furnish signs with cable hangers, rigid sign mounting brackets, U-channel post, and all necessary hardware.

6.2 MATERIALS

Comply with Article 901-2 "Sign Fabrication" of the Standard Specifications.

Use Type III retroreflective sheeting, except for black sheeting. Use non-reflective for black sheeting.

Conform to the message layout, size, and color as required in the MUTCD.

For mast-arm mounting, furnish rigid aluminum, galvanized steel or stainless steel sign mounting brackets.

6.3 CONSTRUCTION METHODS

Install signs with applicable mounting hardware. Comply with sign offsets and mounting heights as shown in the MUTCD and Standard Drawing numbered 904.50.

For messenger cable mounting, install signs a minimum of 6 inches from signal heads.

For ground mounting, comply with the following section of the Standard Specifications:

Ground Mounted Sign Supports ..... Article 903-3

For signs mounted on mast arms, install attachment brackets to signs to allow the positions to be adjusted so that signs:

- Are aimed in the required direction,
- Are plumb as viewed from their respective approaches,
- May be tilted forward or backward as required, and
- May be raised or lowered on the mast arm throughout the full length of the sign.

6.4 MEASUREMENT AND PAYMENT

Signs for signals will be measured and paid as the actual number of signs for signals, regardless of mounting method, furnished, installed, and accepted.

Payment will be made under:

Sign for Signals ..... Each

7. SIGNAL PEDESTALS

7.1 DESCRIPTION

Furnish and install signal pedestals with foundations and all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

Furnish signal pedestals with foundations, grounding systems, and all necessary hardware.

7.2 MATERIALS

Provide aluminum pedestals with foundations that conform to AASHTO. Furnish Class B minimum concrete that conforms to the applicable parts of Section 1000 "Portland Cement Concrete Production and Delivery."

Provide reinforcing steel that conforms to the applicable parts of Section 1070 "Reinforcing Steel."

Provide caps and bases as part of pedestal assemblies. Unless otherwise required, furnish pedestals that provide the following heights:

To support traffic signal equipment cabinets – 30 inches above foundation.

To support signal heads, see Section 1705 for required signal head height.

Provide drawings of templates for setting pedestal anchor bolts.

Provide shafts that are not welded and can accommodate 4 1/2 inch slip fitters for mounting signal heads or cabinets. Form shafts by spinning and cold-working a seamless tube of aluminum alloy. Fabricate shafts from aluminum that meets Aluminum Association 6061-T6 or 6063-T6 alloy or approved equivalent. Ensure shafts have minimum thickness of 0.125 inch and circular cross section with 4 inch inside diameter.

Provide pedestal caps fabricated from cast aluminum that meets Aluminum Association Alloy 356.0F. Provide stainless steel set screws as fasteners.

Provide either shoe-type or transformer-type pedestal bases made of aluminum that meets Aluminum Association Alloy 356.0 or equivalent, and designed to break upon impact in accordance with AASHTO requirements. For shoe-type bases, provide aluminum flange plate with four anchor boltholes, a hole to match the shaft, and a 4 x 8 inch hand hole with a reinforced frame located 8 inches above base. For transformer-type bases, provide overall dimensions of 15(l) x 13(w) x 13(d) inches and an 8 x 8-inch hand hole with removable cover. Ensure bases are continuously welded to shafts or threaded to receive shafts. For use in grounding, provide a 1/2 inch minimum diameter, coarse thread stud located inside base at the handhold and oriented for easy access.

For each pedestal, provide four bolts with outside diameter of 3/4 inches and length of 18 inches each with leveling nut and washer. Ensure anchor bolts are hot-dipped galvanized in accordance with ASTM A 153 with completely galvanized nuts and washers.

7.3 CONSTRUCTION METHODS

Locate foundations, determine elevation, and submit findings. Obtain the Engineer's approval of foundation locations and elevations before constructing foundations.

Excavate in accordance with Section 410 "Foundation Excavation" of the Standard Specifications. If encountered, remove rock or boulders to a depth sufficient to obtain stability necessary to support the structure for design loads. Ensure ground is level before installing foundations.

Construct foundations in accordance with Section 825 "Incidental Concrete Construction" of the Standard Specifications. Cast concrete for pole foundations against undisturbed soil unless otherwise permitted. Provide forms with chamfer strips that measure one inch along diagonal face at all corners above ground level. Do not install foundations over uncompacted fill or muck. Install conduit in foundations.

Securely place, position, and align anchor bolts symmetrically about the center of foundation.

Give exposed vertical concrete surfaces an ordinary surface finish. Give exposed horizontal surfaces a float finish.

Level tops of concrete foundations. Do not allow tops to exceed 6 inches above adjacent ground surface. Pour and finish foundation to a level flush with surrounding sidewalk when possible.

Do not erect pedestals until concrete has attained a minimum compressive strength of 2500 psi as determined by cylinder breaks.

7.4 MEASUREMENT AND PAYMENT

Signal pedestal with foundation will be measured and paid as the actual number of signal pedestals with foundations furnished, installed and accepted.

Payment will be made under:

Signal Pedestal with Foundation ..... Each

8. UNDERGROUND CONDUIT

8.1 DESCRIPTION

Furnish and install conduit for underground installation in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

Furnish and install conduit for underground installation with miscellaneous fittings, all necessary hardware, marker tape, backfill, graded stone, paving materials, and seeding and mulching.

8.2 MATERIALS

A. General

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of advertisement.

Refer to Divisions 5 and 10 of the Standard Specifications except as noted herein:

Metallic Conduit ..... Article 1097-5

Backfill..... Article 1018-2

Graded Stone.....Articles 545-2 and 545-3

B. High Density Polyethylene Conduit (HDPE)

Provide HDPE conduit with an outer diameter to minimum wall thickness ratio that complies with ASTM D 3035, Standard Dimension Ratio (SDR) 13.6. Provide conduit that meets UL Standard 651B "Continuous Length HDPE Conduit."

Provide conduit that meets or exceeds the following:

ASTM D 638 Tensile Strength – 3,000 psi, min; Elongation – 400 percent, min

ASTM D 1238 Melt Index – 0.4 maximum

ASTM D 1505 Density – (0.941-0.955g/cc)

ASTM D 1693 Condition B – 20 percent failure, maximum

ASTM D 2444 Impact – NEMA Standards Publication Number TC7

ASTM D 3350 Cell Classification – 334420 or 344420

Ensure HDPE conduit is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate, and transformer oil, and is protected against degradation due to oxidation and general corrosion. Furnish conduit with a coefficient of friction of 0.09 or less in accordance with Telcordia GR-356.

Furnish factory lubricated, low friction, coilable, conduit constructed of HDPE. Furnish conduit with nominal diameter as required. Provide conduit with smooth outer wall and ribbed inner wall. Ensure conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

8.3 CONSTRUCTION METHODS

A. General

Ensure conduit is free of moisture and debris before pulling cables.

Following installation of conduit where cable is not immediately installed, or conduit is for future use (spare), seal the ends of the conduit with a duct plug. Secure a pull line to the duct plug in such a manner that it will not interfere with installation of the duct plug and provides a watertight seal.

Extend ends of conduit 2 to 4 inches above concrete surfaces and 4 inches above crushed stone bases. For metallic conduit, install metallic bushings and bond conduits.

1. Conduit Entering Junction Boxes

Terminate conduits installed for communications cables in oversized junction boxes. Do not install other conduits in the oversized junction box unless otherwise specified.

Terminate conduits installed for signal wiring, including loop lead-in cable, in standard size junction boxes unless otherwise specified.

For all conduits entering junction boxes, seal spare conduits with approved duct plugs. Seal conduits containing coaxial communications cable with mechanical sealing devices. Seal conduits containing new and existing signal cable and loop lead-in wire with moldable duct seal.

2. Plan of Record Drawings

Upon completion of the conduit system for communications, furnish the Engineer with a plan of record drawing detailing the locations of the conduit system.

B. Trenching

In certain cases the Contractor may use an alternate material and method of installation between trenching and plowing based on existing field conduits and preferences. Obtain approval from the Engineer before proceeding.

1. General

Install PVC, HDPE, or rigid metallic conduit for all underground runs. Install metallic conduit at all locations where conduits cross beneath railroad tracks. Clean existing underground conduit to be incorporated into a new system. Bond all metallic conduits.

If more than one conduit is required between the same points, install conduit in one common trench. Install non-detectable marker tape.

Install longitudinal runs of conduit a minimum of 1 foot from back of curb or 6 feet from edge of pavement in the absence of curb.

Upon completion, restore surface to like-original condition within seven calendar days of occurrence of damage. Remove all rock and debris from backfill material. Remove excess material from site and compact area according to Article 300-7 of the Standard Specifications. Backfill with excavated material and compact to 95% of original density.

Backfill trench at locations along the trench path where non-movable objects, such as rocks and boulders, cannot be avoided. The purpose of the backfill is to provide a gradual change in elevation of the trench, so that excessive bending and stress will not be transferred to conduits once underground conduit system is installed.

After installation of conduits and upon completion of tamping and backfilling, perform a mandrel test on each conduit to ensure no conduit has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit. Ensure pull line is re-installed.

2. Unpaved Trenching

Install conduit in all unpaved areas. Rake smooth the top 1 1/2 inches and seed with same type of grass as surrounding area. Finish unpaved areas flush with surrounding natural ground.

3. Paved Trenching

On concrete surfaces, replace the entire joint of concrete unless otherwise specified. On all other surfaces, neatly cut and replace the width of trench with like material.

Finish paved areas with materials matching damaged areas. For conduit installed under roadways, cut neatly and replace the width of paved area damaged by trenching. For conduit installed under sidewalks and walkways, remove entire section of slab from joint to joint and replace. Place graded stone material temporarily to maintain traffic where repairs cannot be performed immediately. Comply with Article 545-4 of the Standard Specifications.

C. Directional Drilling

1. Pre-Approvals and Minimum Depth Requirements

Obtain approval before beginning drilling operations.

At all points where HDPE conduit will traverse under roadways, driveways, sidewalks, or "Controlled Access Areas" including entrance/exit ramps, maintain a minimum depth of 4 feet or 8 times the back reamer's diameter, whichever is deeper. For an installation that runs parallel to a controlled access area or entrance/exit ramps maintain a minimum depth of 30 inches below finished grade. Maintain a minimum clearance of 30 inches below finished grade when crossing ditch lines. For the following structures, the minimum clearance requirements are:

Man-made Structure	Minimum Clearance Requirement
Bridge foundation	5' horizontal & 4' vertical (clearances greater than minimum horizontal should continue to use the 4V:5H ratio, i.e., 10' horizontal should be no deeper than 8')
Drainage pipes less than 60"	1' above or below [while maintaining a minimum depth of 30" below grade]
Drainage pipes greater than 60"	1' above or 4' below [while maintaining a minimum depth of 30" below grade]
Box Culverts	1' above or 4' below [while maintaining a minimum depth of 30" below grade]
Slope protection	2' below
Slope protection foundation footing	5' below

Guarantee the drill rig operator and digital walkover locating system operator are factory-trained to operate the make and model of equipment provided and have a minimum of one year experience operating the make and model of drill rig. Submit documentation of the operators' training and experience for review at least two weeks before start of directional drilling operations.

Provide a means of collecting and containing drilling fluid/slurry that returns to the surface such as a slurry pit. Provide measures to prevent drilling fluids from entering drainage ditches and storm sewer systems. Prevent drilling fluid/slurry from accumulating on or flowing onto pedestrian walkways, driveways, and streets. Immediately remove all drilling fluids/slurry that are accidentally spilled.

2. Directional Drill Operations

Provide grounding for the drill rig in accordance with the manufacturer's recommendations.

Place excavated material near the top of the working pit and dispose of properly. Backfill pits and trenches to facilitate drilling operations immediately after drilling is completed.

Use drill head suitable for type of material being drilled and sized no more than 2 inches larger than the outer diameter of the conduit. Direct drill to obtain proper depth and desired destination. Pressure grout with an approved bentonite/polymer slurry mixture to fill all voids. Do not jet alone or wet bore with water.

During drilling operation, locate drill head every 10 feet along drill path and before traversing underground utilities or structures. Use digital walkover locating system to track drill head during directional drilling operation. Ensure locating system is capable of determining pitch, roll, heading, depth, and horizontal position of the drill head at any point.

Once drill head has reached final location, remove head, and install back reamer of appropriate size (no more than 2 inches larger than outer diameter of conduits) to simultaneously

facilitate back reaming of drill hole and installation of conduit. Back reamer is sized larger than actual conduits to ensure conduits are not adversely subjected to deviations caused by the original drill operation and are as straight as practical in their final position.

The intent of these specifications is to limit the diameter of the actual drill shaft/hole so that it is no more than 2 inches larger than the conduit outer diameter. The 2-inch larger diameter may be accomplished during the original bore or during the back reaming/conduit installation process.

Once installation of conduit has started, continue installation without interruption so as to prevent conduit from becoming firmly set. Apply bentonite/polymer slurry mixture during conduit installation.

Upon completion of conduit installation, perform a mandrel test on conduit system to ensure conduit has not been damaged. Furnish non-metallic mandrel with a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit and ensure that pull line is re-installed.

3. Drilling Fluids

Use lubrication for subsequent removal of material and immediate installation of the conduit. The use of water and other fluids in connection with directional drilling operations will be permitted only to the extent necessary to lubricate cuttings. Do not jet alone or wet bore with water. Use drilling fluid/slurry consisting of at least 10 percent high-grade bentonite/polymer slurry to consolidate excavated material and seal drill hole walls.

Transport waste drilling fluid/slurry from site and dispose of in a method that complies with local, state and federal laws and regulations.

4. Conduit Splicing

With prior approval, install a junction box at locations where splicing or coupling of conduit is necessary. Otherwise, splicing or joining of HDPE conduit is prohibited.

8.4 MEASUREMENT AND PAYMENT

Unpaved trenching will be measured horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

Paved trenching will be measured horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

Directional drill will be measured horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

No measurement will be made of vertical segments, non-metallic conduit, metallic conduit, sealing devices, backfill, graded stone, paved materials, miscellaneous fittings, pull lines, and seeding and mulching as these will be considered incidental to conduit installation.

Conduit will be paid for per linear foot based on quantity and size of conduits. As examples, an installation of a single 2" conduit would be paid as:

Trenching Unpaved (1, 2").....Linear Foot

An installation of two 1" and four 2" conduits would be paid as:

Trenching Unpaved (2, 1") & (4, 2").....Linear Foot

Payment will be made under:

Trenching Unpaved (qty, size) & (qty, size).....Linear Foot

Trenching Paved (qty, size) & (qty, size).....Linear Foot

Directional Drill (qty, size) & (qty, size).....Linear Foot

9. JUNCTION BOXES

9.1 DESCRIPTION

Furnish and install junction boxes (pull boxes) with all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

Furnish junction boxes with covers, graded stone, grounding systems, and all necessary hardware.

9.2 MATERIALS

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of advertisement.

Refer to Divisions 5 and 10 of the Standard Specifications:

Junction Boxes ..... Article 1098-5

Graded Stone ..... Articles 545-2 and 545-3

9.3 CONSTRUCTION METHODS

Comply with the following except as noted herein:

Junction boxes ..... Article 1411-3

Install the junction boxes flush with finished grade. Do not install sealant compound between junction boxes and covers.

Install junction boxes where underground splicing of cable is necessary and where transitioning from below ground to above ground installation or vice-versa.

9.4 MEASUREMENT AND PAYMENT

Junction box (_____) will be measured and paid in actual number of junction boxes of each size and type furnished, installed, and accepted.

No measurement will be made of covers, graded stone, and required grounding systems as these will be considered incidental to furnishing and installing junction boxes.

Payment will be made under:

Junction Box (_____) ..... Each

10. RISERS

10.1 DESCRIPTION

Furnish riser assemblies with clamp-on, aluminum weatherheads or heat shrink tubing, galvanized pole attachment fittings, and all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

10.2 MATERIALS

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of advertisement.

Provide metallic conduit for risers.

Refer to Division 10 of the Standard Specifications:

Metallic Conduit..... Article 1097-5

Provide Tyco™ (Raychem™) part number 066193-000 or equal heat shrink tubing for the installation of fiber optic cable. Obtain pre-approval for any heat shrink tubing retrofit or expansion kits.

10.3 CONSTRUCTION METHODS

Install risers with required weatherheads or heat shrink tubing on poles using pole attachment fittings.

Install heat shrink tubing retrofit kits in existing risers as specified.

Use separate 1/2-inch riser with weatherhead for pedestrian pushbutton.

Use separate 1-inch riser with weatherhead for electrical service.

Use separate 2-inch riser with weatherhead for signal cables (bundled). Use separate 2-inch riser with weatherhead for the combination of all lead-in and twisted-pair communications cable. Install condulet on all risers for lead-in cable.

Use separate 1-inch riser with heat shrink tubing for coaxial cable. Install risers with heat shrink tubing so that cable can be installed without violating its minimum bending radius. Install cable so it does not share a riser with any other cable.

Install heat shrink tubing in accordance with manufacturer's recommendations. Provide tubing a minimum of 5 inches in length with a minimum of 2.5 inches extended over cables and 2.5 inches extended over risers after heat has been applied. Use nylon filler rods with UV protection or equivalent, and sealing spacer clips to separate cables where multiple cables enter a riser. Ensure sealing spacer clips have a heat activated sealing compound with the sealing compound fully encapsulating the space between cables. Ensure heat shrink tubing provides a watertight fit around individual cables and outer walls of risers. Do not use cut sections of cable or any other devices in lieu of filler rods. Use aluminum tape around cables to prevent damage from sealing chemicals. Use

a heat source that will provide even heat distribution around tubing. Ensure no damage occurs to any cables.

10.4 MEASUREMENT AND PAYMENT

__" Riser with _____ will be measured and paid as the actual number of riser of each type and size furnished, installed, and accepted. No measurement will be made of weatherheads, heat shrink tubing, or pole attachment fittings as these will be considered incidental to furnishing and installing risers.

Payment will be made under:

__-Inch Riser with _____ ..... Each

11. CONTROLLERS WITH CABINETS

11.1 DESCRIPTION.

Furnish and install controllers with cabinets and all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

As specified on the Plans, furnish either Type 170E, Type 2070L, or NEMA TS-2, Type 2 controllers with cabinets. Furnish all pole or foundation mounting hardware, detector sensor cards, one Corbin Number 2 cabinet key, one police panel key, conflict monitors or malfunction management units, surge protection, grounding systems, AC/DC isolator cards, and all necessary hardware. Permanently inscribe cabinet identification information on the interior of the door.

11.2 MATERIALS.

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of advertisement.

A. Materials – Type 170E Cabinets

1. Type 170 E Cabinets General:

Conform to CALTRANS Traffic Signal Control Equipment Specifications except as required herein.

For pole mounted applications, furnish CALTRANS Model 336S cabinets configured for 8 vehicle phases with power distribution assemblies (PDAs) number 2, and 4 pedestrian phases or overlaps.

At the intersection of US 70/74A (College St.) at SR 3284 (So. College St.) & US 70/74A (Charlotte St.) (Sig. Inv. No. 13-0401), furnish aCALTRANS Model 332A base mounted cabinet with PDAs #2 and configured for 8 vehicle phases, 4 pedestrian phases, and 4 overlaps. When overlaps are required, provide auxiliary output files for the overlaps. Do not reassign load switches to accommodate overlaps unless shown on electrical details.

At all other locations, furnish CALTRANS Model 336S base mounted cabinets configured for 8 vehicle phases with PDAs #2, and 4 pedestrian phases or overlaps.

2. Type 170 E Cabinet Electrical Requirements:

Provide a cabinet assembly designed to ensure that upon leaving any cabinet switch or conflict monitor initiated flashing operation, the controller starts up in the programmed start up phases and start up interval.

Furnish two sets of non-fading cabinet wiring diagrams and schematics in a paper envelope or container and placed in the cabinet drawer.

Provide surge suppression in the cabinet for each type of cabinet device. Provide surge protection for the full capacity of the cabinet input file.

All AC+ power is subject to radio frequency signal suppression.

If additional surge protected power outlets are needed to accommodate fiber transceivers, modems, etc.; install a UL listed, industrial, heavy-duty type power outlet strip with a maximum rating of 15 A / 125 VAC, 60 Hz. Provide a strip that has a minimum of 3 grounded outlets. Ensure the power outlet strip plugs into one of the controller unit receptacles located on the rear of the PDA. Ensure power outlet strip is mounted securely; provide strain relief if necessary.

Connect detector test switches for cabinets as follows:

336S Cabinet		332A Cabinet	
Detector Call Switches	**Terminals**	**Detector Call Switches**	**Terminals**
Phase 1	I1-F	Phase 1	I1-W
Phase 2	I2-F	Phase 2	I4-W
Phase 3	I3-F	Phase 3	I5-W
Phase 4	I4-F	Phase 4	I8-W
Phase 5	I5-F	Phase 5	J1-W
Phase 6	I6-F	Phase 6	J4-W
Phase 7	I7-F	Phase 7	J5-W
Phase 8	I8-F	Phase 8	J8-W

Provide a terminal mounted loop surge suppresser device for each set of loop terminals in the cabinet. For a 10x700 microsecond waveform, ensure that the device can withstand a minimum of 25 peak surge current occurrences at 100A, in both differential and common modes. Ensure that the maximum breakover voltage is 170V and the maximum on-state clamping voltage is 30V. Provide a maximum response time less than 5 nanoseconds. Ensure that off-state leakage current is less than 10 μA. Provide a nominal capacitance less than 220pf for both differential and common modes.

Provide surge suppression on each communications line entering or leaving a cabinet. Ensure that the communications surge suppresser can withstand at least 80 occurrences of an 8x20 microsecond wave form at 2000A and a 10x700 microsecond waveform at 400A. Ensure that the maximum clamping voltage is suited to the protected equipment. Provide a maximum response time less than 1 nanosecond. Provide a nominal capacitance less than 1500pf and a series resistance less than 15 Ω.

Provide surge suppression on each DC input channel in the cabinet. Ensure that the DC input channel surge suppresser can withstand a peak surge current of at least 10,000 amperes in the form of an 8x20 microsecond waveform and at least 100 occurrences of an 8x20 microsecond wave form at 2000 A. Ensure that the maximum clamping voltage is 30V. Provide a maximum response time less than 1 nanosecond and a series resistance less than 15 Ω per line.

Provide protection for each preemption or 120 Vrms single phase signal input by an external stud mounted surge protector. Ensure that a minimum stud size of 1/3 inch, and Number 14 AWG minimum sized wire leads with 1 foot minimum lengths. Ensure that a peak surge trip point less than 890 volts nominal for a 600 volt rise per microsecond impulse, and 950 volts nominal for a 3000 volt per microsecond rise impulse. Provide a maximum surge response time less than 200 nanoseconds at 10 kV per microsecond. Ensure that the AC isolation channel surge suppresser can withstand at least 25 occurrences of a 8x20 waveform of 10,000 amperes and a peak single pulse 8x20 microsecond wave form of 20,000 amperes. Provide a maximum clamping voltage of 30V. Provide a maximum response time less than 1 nanosecond. Ensure that the discharge voltage is under 200 volts at 1000 amperes and the insulation resistance is 100 megaohms. Provide an absolute maximum operating line current of one ampere at 120 Vrms.

Provide conductors for surge protection wiring that are of sufficient size (ampacity) to withstand maximum overcurrents which could occur before protective device thresholds are attained and current flow is interrupted.

Furnish a fluorescent fixture in the rear across the top of the cabinet and another fluorescent fixture in the front across the top of the cabinet at a minimum. Ensure that the fixtures provide sufficient light to illuminate all terminals, labels, switches, and devices in the cabinet. Conveniently locate the fixtures so as not to interfere with a technician's ability to perform work on any devices or terminals in the cabinet. Provide a protective diffuser to cover exposed bulbs. Furnish all bulbs with the cabinet. Provide door switch actuation for the fixtures.

Furnish a police panel with a police panel door. Ensure that the police panel door permits access to the police panel when the main door is closed. Ensure that no rainwater can enter the cabinet even with the police panel door open. Provide a police panel door hinged on the right side as viewed from the front. Provide a police panel door lock that is keyed to a standard police/fire call box key. In addition to CALTRANS Specifications, provide the police panel with a toggle switch connected to switch the intersection operation between normal stop-and-go operation (AUTO) and manual operation (MANUAL). Ensure that manual control can be implemented using inputs and software such that the controller provides full programmed clearance times for the yellow clearance and red clearance for each phase while under manual control.

Provide a 1/4-inch locking phone jack in the police panel for a hand control to manually control the intersection. Provide sufficient room in the police panel for storage of a hand control and cord.

Provide detector test switches inside the cabinet on the door or other convenient location which may be used to place a call on each of eight phases based on standard CALTRANS input file designation for detector racks. Provide three positions for each switch: On (place call), Off (normal detector operation), and Momentary On (place momentary call and return to normal detector operation after switch is released). Ensure that the switches are located such that the technician can read the controller display and observe the intersection.

Provide a shorting jack inside cabinet that functions exclusively to call the controller and cabinet assembly into the automatic diagnostics functions. Ensure shorting jack will mate with a Switchcraft Model 190 plug or equivalent. Place jack in a convenient, unobstructed location inside cabinet. When the mating plug is inserted into the jack, ensure controller enters the diagnostic test mode and a controller generated monitor reset signal is placed on Pin C1-102 (monitor external reset) of the model 210 conflict monitor which causes the monitor to automatically reset.

Equip cabinet with a connector and terminal assembly designated as P20 (Magnum P/N 722120 or equivalent) for monitoring the absence of any valid AC+ signal display (defined here as red, yellow, or green) input on any channel of the conflict monitor. Connect the terminal through a 3 1/2 feet 20 wire ribbon cable which mates on the other end to a connector (3M-3428-5302 or equivalent) installed in the front of the Type 210 enhanced conflict monitor. Ensure that the female connector which mates with the connector on the conflict monitor has keys to ensure that proper connection. Ensure that the cabinet enters the flash mode if the ribbon cable is not properly connected. Provide a P20 connector and terminal assembly that conforms to Los Angeles City DOT "Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02".

Terminate ribbon cable at the P20 connector and terminal assembly. Ensure the P20 connector and mating ribbon cable connector is keyed to prevent cable from being improperly installed. Wire the P20 connector to the traffic signal red displays to provide inputs to conflict monitor as shown:

Pin #	Function	Pin #	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel 14 Red	13	Channel 7 Red
4	GND	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function 2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function 1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red
10	Channel 11 Red	20	Red Enable

Provide a convenient means to jumper 120 VAC from the signal load switch AC+ supply bus to any channel Red input to the P20 connector in order to tie unused red inputs high. Ensure that easy access is provided to the jumper connecting terminals on the back side of cabinet. Locate the jumper terminals connecting to all 16 channel Red inputs in the same terminal block. For each channel Red input terminal, provide a companion terminal supplying AC+ from the signal bus. Provide one of the following two methods for providing Signal AC+ to the channel red input:

- Place a commercially available jumper plug between the channel Red input and its companion Signal Bus AC+ terminal.
- Place a jumper wire between a channel red input screw terminal and its companion Signal Bus AC+ screw terminal.

Connection between channel Red input terminal and its companion Signal Bus AC+ terminal must not require a wire greater than 1/2 inch in length.

Conform to the following Department wiring requirements:

- Wire the Red Enable monitor input to the Signal Bus AC+ terminal TB01-1.
- Do not connect either the special function 1 or the special function 2 monitor input to the red monitor card.
- Ensure that removal of the P-20 ribbon cable will cause the monitor to recognize a latching fault condition and place the cabinet into flashing operation and that this is implemented in the conflict monitor software.

Ensure that removal of the conflict monitor from the cabinet will cause the cabinet to revert to flashing operation.

Provide Model 200 load switches and Model 204 flashers.

3. Type 170 E Cabinet Physical Requirements:

Provide a surge protection panel with 16 loop protection devices and designed to allow sufficient free space for wire connection/disconnection and surge protection device replacement. Provide an additional three slots protected with six AC+ interconnect surge devices and two protected by four DC surge protection devices. Provide no protection devices on slot 14. Attach flash sense and stop time to the upper and lower slot as required.

i) For pole mounted cabinets, mount surge protection devices for the AC+ interconnect cable inputs, inductive loop detector inputs, and low voltage DC inputs on a fold down panel assembly on the rear side of the input files. Fabricate the surge protection devices from sturdy aluminum and incorporate a swing down back panel to which the surge protection devices are attached. Attach the swing down panel to the assembly using thumb screws. Have the surge protection devices mounted horizontally on the panel and soldered to the feed through terminals of four 14 position terminal blocks with #8 screws mounted on the other side.

ii) For base mounted cabinets, attach separate surge protection termination panels to each side of the cabinet rack assembly. Mount the surge protection termination panel for AC isolation devices on the same side of the cabinet as the AC service inputs. Install the surge protection termination panel for DC terminals and loop detector terminals on the opposite side of the cabinet from the AC service inputs. Attach each panel to the rack assembly using bolts and make it easily removable. Mount the surge protection devices in horizontal rows on each panel and solder to the feed through terminals of 14 position terminal blocks with #8 screws mounted on the other side. Wire the terminals to the rear of a standard input file using spade lugs for input file protection.

Provide permanent labels that indicate the slot and the pins connected to each terminal that may be viewed from the rear cabinet door. Label and orient terminals so that each pair of inputs is next to each other. Ensure the top row of terminals is connected to the upper slots and the bottom row of terminals is connected to the bottom slots. Indicate on the labeling the slot number (1-14) and the terminal pins of the input slots (either D & E for upper or J & K for lower). Terminate all grounds from the surge protection on a 15 position copper equipment ground bus attached to the rear swing down panel. Ensure that a Number 4 AWG green wire connects the surge protection panel assembly ground bus to the main cabinet equipment ground. Provide a standard input file and surge protection panel assembly that fits outside and behind the input file. Ensure the fold down panel allows for easy removal of the input file without removing the surge protection panel assembly or its parts.

Provide a minimum 14 x 16 inch pull out, hinged top shelf located immediately below controller mounting section of the cabinet. Ensure the shelf is designed to fully expose the table surface outside the controller at a height approximately even with the bottom of the controller. Ensure the shelf has a storage bin interior which is a minimum of 1 inch deep and approximately the same dimensions as the shelf. Provide an access to the storage area by lifting the hinged top of the shelf. Fabricate the shelf and slide from aluminum or stainless steel and ensure the assembly can support the 170E controller plus 15 pounds of additional weight. Ensure shelf has a locking mechanism to secure it in the fully extended position and does not inhibit the removal of the 170E

controller or removal of cards inside the controller when fully extended. Provide a locking mechanism that is easily released when the shelf is to be returned to its non-use position directly under the controller.

4. Type 170 E Model 2010 Enhanced Conflict Monitor:

Furnish Model 2010 Enhanced Conflict Monitors with 16 channels. In addition to CALTRANS requirements, ensure the conflict monitor monitors for the absence of a valid voltage level on at least one channel output of each load switch. Ensure that the absence of the programming card will cause the conflict monitor to trigger, and remain in the triggered state until reset.

Provide a conflict monitor that recognizes the faults specified by CALTRANS and the following additional per channel faults that apply for monitor inputs to each channel:

- consider a Red input greater than 70 Vrms as an "on" condition;
- consider a Red input less than 50 Vrms as an "off" condition (no valid signal);
- consider a Red input between 50 Vrms and 70 Vrms to be undefined by these specifications;
- consider a Yellow or Green input greater than 25 Vrms as an "on" condition;
- consider a Green or Yellow input less than 15 Vrms as an "off" condition; and
- consider a Green or Yellow input between 15 Vrms and 25 Vrms to be undefined by these specifications.

Ensure monitor will trigger upon detection of a fault and will remain in the triggered (failure detected) state until unit is reset at the front panel or through the remote reset input for the following failures:

a. **Red Monitoring or Absence of Any Indication (Red Failure):** A condition in which no "on" voltage signal is detected on any of the green, yellow, or red inputs to a given monitor channel. If a signal is not detected on at least one input (R, Y, or G) of a conflict monitor channel for a period greater than 1000 ms when used with a 170 controller and 1500 ms when used with a 2070L controller, ensure monitor will trigger and put the intersection into flash. If the absence of any indication condition lasts less that 750 ms when used with a 170 controller and 1200 ms when used with a 2070L controller, ensure conflict monitor will not trigger. Have red monitoring occur when the P20 Connector is installed and both the following input conditions are in effect: a) Red Enable input to monitor is active (Red Enable voltages are "on" at greater than 70 Vrms, off at less than 50 Vrms, undefined between 50 and 70 Vrms), and b) neither Special Function 1 nor Special Function 2 inputs are active.

b. **Yellow Indication Sequence Error:** Yellow indication following a green is missing or shorter than 2.7 seconds (with ± 0.1-second accuracy). If a channel fails to detect an "on" signal at the Yellow input following the detection of an "on" signal at a Green input for that channel, ensure that the monitor triggers and generates a sequence error fault indication.

c. **Dual Indications on the Same Channel:** In this condition, more than one indication (R,Y,G) is detected as "on" at the same time on the same channel. If dual indications are detected for a period greater than 500 ms, ensure that the conflict monitor triggers and displays the proper failure indication (Dual Ind fault). If this condition is detected for less than 250 ms, ensure that the monitor does not trigger.

Enable the monitor function for short/missing yellows and for dual indications on a per channel basis.

Provide Special Function 1 and Special Function 2 that comply with the Los Angeles City DOT Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02 to eliminate red failure monitoring while allowing other additional enhanced fault monitoring functions to continue.

Ensure that the removal of the P-20 ribbon cable will cause the monitor to recognize a latching fault condition and place the cabinet into flashing operation.

Ensure that when the Conflict Monitor is triggered due to a fault, it provides an LED indication identifying the type of failure detected by the monitor except for the P20 ribbon cable removal fault. Ensure that the monitor indicates which channels were active during a conflict condition and which channels experienced a failure for all other per channel fault conditions detected, and that these indications and the status of each channel are retained until the Conflict Monitor is reset.

Ensure that the conflict monitor will store at least nine of the most recent malfunctions detected by the monitor in EEPROM memory. For each malfunction, record at a minimum the time, date, type of malfunction, relevant field signal indications, and specific channels involved with the malfunction.

Provide communications from the monitor to the 170/2070L controller via an RS-232C/D port on the monitor in order to upload all event log information from the monitor to the controller or to a Department-furnished system computer via the controller. Ensure that the controller can receive the data through a controller Asynchronous Communications Interface Adapter (Type 170E) or Async Serial Comm Module (2070L) determined by the controller software. Provide software capable of communicating directly through the same monitor RS-232C/D to retrieve all event log information to a Department-furnished laptop computer.

In addition to the connectors required by the CALTRANS Specifications, provide the conflict monitor with a connector mounted on the front of the monitor (3M-3428-5302 with two polarizing keys or equal) which mates with a 20 pin ribbon cable connector that conducts the signals from the P20 connector on the cabinet assembly. Provide a P20 connector and terminal assembly that complies with the Los Angeles City DOT "Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02". Provide connector pins on the monitor with the following functions:

Pin #	Function	Pin #	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel 14 Red	13	Channel 7 Red
4	Chassis Ground	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function 2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function 1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red
10	Channel 11 Red	20	Red Enable

Provide a DB-9 female connector for the purpose of data communication with the controller. Electrically isolate the port interface electronics from all monitor electronics, excluding Chassis Ground. Furnish a communications connecting cable with pin connections as follows:

170		Conflict Monitor DB-9
RX pin L	Connect to	TX pin 2
TX pin K	Connect to	RX pin 3
+5 pin D	Connect to	DTR pin 4
GND pin N	Connect to	GND pin 5

2070L		Conflict Monitor DB-9
DCD pin 1	Connect to	DCD pin 1
RX pin 2	Connect to	TX pin 2
TX pin 3	Connect to	RX pin 3
GND pin 5	Connect to	GND pin 5
RTS pin 7	Connect to	CTS pin 7
CTS pin 8	Connect to	RTS pin 8

B. Type 2070L Controllers

Conform to CALTRANS TEES (Transportation Electrical Equipment Specifications) August 2002, TEES 2002 Errata 1 and TEES 2002 Errata 2 except as required herein.

Furnish Model 2070L controllers. Ensure that removal of the CPU module from the controller will place the intersection into flash.

The Department will provide Master/Local software prior to the burning-in period. Contractor shall give 5 working days notice before needing software. Program software provided by the Department.

Provide model 2070L controllers with the latest version of OS9 operating software and device drivers, composed of the unit chassis and at a minimum the following modules and assemblies:

- MODEL 2070 1B, CPU Module, Single Board
- MODEL 2070-2A, Field I/O Module (FI/O)
- MODEL 2070-3B, Front Panel Module (FP), Display B (8x40)
- MODEL 2070-4A, Power Supply Module, 10 AMP
- MODEL 2070-7A, Async Serial Com Module (9-pin RS-232)

Furnish one additional MODEL 2070-7A, Async Serial Com Module (9-pin RS-232) for all master controller locations.

For each master location and central control center, furnish a U.S. Robotics V.92 or approved equivalent auto-dial/auto-answer external modem to accomplish the interface to the Department-furnished microcomputers. Include all necessary hardware to ensure telecommunications.

11.3 CONSTRUCTION METHODS

A. General

Remove existing controllers and cabinets where required. Remove maintenance diary from cabinet and place in new cabinet or deliver to the Engineer. Take existing equipment out of service only at the time directed.

Locate new cabinets so as not to obstruct sight distance of vehicles turning on red.

Install controllers, cabinets, detector sensor units, and hardware that provide required phasing, color sequence, flash sequence, interconnection, railroad clearance and preemption, and emergency vehicle clearance and preemption.

Stencil signal inventory number on cabinet side facing roadway. Use 3 inch black characters.

Provide external electrical service disconnect at all new and existing cabinet locations unless otherwise specified.

Do not program controller for late night flashing operation at railroad preemption installations. For all other installations, do not program controller for late night flashing operation unless otherwise directed. Ensure all signal heads for same approach flash concurrently during flashing operation.

Provide serial number and cabinet model number for each new controller and controller cabinet installed.

Install pole mounted cabinets so height to cabinet middle is 4 feet.

Activate controllers with proposed phasing and timing.

B. System Interconnection

When interconnection of signals is required, install interface equipment and hardware for signals. Demonstrate proper operation of interconnection using manual commands after interconnection is complete.

Program telemetry command sequences and enable devices necessary for testing of communication between local controllers and field master controllers, and between field master controllers and Department-furnished central computer.

C. Workshop

Provide enclosed workshop to set up and test new controllers and cabinets before installation. Locate workshop within Division responsible for project administration. Ensure workshop provides protection from weather and sufficient space to house two test observers, all necessary test equipment and material, controllers and cabinets.

Configure and test each controller and cabinet to match the proposed signal design. Ensure all equipment furnished and installed or modified by the Contractor at each location operates in full compliance with the plans and project special provisions. Test each controller and cabinet for proper color sequence, flashing operation, phase timings, preemption, coordination, and conflict monitor programming or malfunction management unit programming. Ensure that simultaneous conflicting phase outputs will cause the cabinet to revert to flashing operation. For intersections with any type of preemption, submit a completed "Preemption Test Procedure Checklist". The checklist is located on the Department's website.

Test the cabinet and controller for eight hours minimum. Following this test, and before installation, the Engineer will inspect the equipment in operation. The Engineer may require other tests to ensure proper operation. These tests shall be at no additional cost to the Department.

11.4 MEASUREMENT AND PAYMENT

Controllers with cabinets (_____) will be measured and paid as the actual number of each type of controllers with cabinets furnished, installed, and accepted.

Detector cards will be measured and paid as the actual number furnished, installed, and accepted.

No measurement will be made of conflict monitors, malfunction management units, external electrical service disconnect, grounding systems, modems, meter bases, and workshop as these will be considered incidental to furnishing and installing controllers with cabinets.

Payment will be made under:

Controller with Cabinet (_____)..... Each

Detector Card (_____)..... Each

12. DIAL-UP COMMUNICATIONS

12.1 DESCRIPTION

At the master controller locations shown in the Plans, furnish and install an external, dial-up modem and apply for and install dial-up telephone service.

12.2 MATERIALS

A. Modem

Controller dial-up modem shall be an external unit having a raw data-transfer speed of 56 kbps and shall conform to the Microcom Networking Protocol (MNP) classes 2 through 5, and the International Telecommunications Union (ITU) V.34, V.42, V.42bis, V.90, and V.92 standards. The modem shall be capable of communicating with 28,800, 14,400, 9600, 2400 and 1200 bps modems and shall automatically adjust the data rate and modulation to accomplish this. The modem shall have auto dial/auto answer features. Modem shall support the Hayes AT Command set and have at least the following function indicators for identifying modem operation:

- Carrier detect
- Auto answer on
- Modem ready
- Terminal ready
- Modem has taken phone off hook
- Received data is being sent to the computer or received transmission from phone line.
- Data sent from the computer was received by the modem or transmission made to phone line.

Modem shall be US Robotics Model 5686E or approved equivalent.

B. Telephone Demarcation

At locations shown in the Plans, provide a telephone demarcation assembly for dial-up modem communications. Each assembly shall consist of a 1" riser with weatherhead installed on a designated existing pole and a telephone demarcation box attached at the base of the riser approximately 3 feet above ground level.

12.3 CONSTRUCTION METHODS

A. Modem

At locations shown in the Plans, furnish and install a dial-up modem for signal controller communications. Fully integrate with signal controller and telephone demarcation assembly.

B. Telephone Demarcation

Install telephone service on an existing pole as noted on the Plans and as approved by the Engineer. Run telephone service into the controller cabinet through a dedicated conduit.

12.4 MEASUREMENT AND PAYMENT

Dial-up modems will be measured and paid for as the actual number furnished, installed, and accepted.

Telephone demarcation assemblies will be measured and paid for as the actual number furnished, installed, and accepted.

Payment will be made under:

Dial-Up Modem ..... Each

Telephone Demarcation Assembly..... Each

13. SIGNAL CABLE SPLICE CABINETS

13.1 DESCRIPTION

Furnish and install splice cabinets including all necessary hardware, and relocate messenger cable, signal cable, and lead-in cable in accordance with the Plans and Specifications for the purpose of splicing and terminating signal cable and lead-in cable. Comply with the provisions of Section 1700 of the Standard Specifications.

13.2 MATERIALS

Furnish signal cable splice cabinet to splice and extend signal conductors and loop lead-in cables. Provide signal cable splice cabinet as described below. Furnish binder type terminal strips. Separate binder strips shall be furnished for signal wire and loop lead-in cable. Provide sufficient size so that the equipment installed will not occupy more than 60 percent of the total cabinet volume.

Additional signal conductors and loop lead-in shall be of the same size and type of the existing wires. Provide permanent labels prior to construction on all incoming and out going conductors using a naming convention such as Phase One Green, Phase Two Yellow, Loops 2A, etc.

Furnish signal cable splice cabinet that is fabricated of steel or aluminum and satisfies the requirements of a NEMA 4X enclosure.

Furnish signal cable splice cabinet with a minimum size of 12 inches wide by 20 inches high by 8 inches deep. Each signal cable splice cabinet shall have a terminal block having at least 20 terminals with each terminal having 2 terminal screws. The terminal screws shall be nickel-plated brass screws and have a minimum outside diameter of 4.3 mm. A removable shorting bar shall be provided between the screws of each terminal. The terminal block shall be of electrical grade thermoplastic or thermosetting plastic and shall have the terminals recessed between molded barriers. The terminal block shall be mounted on the back wall of the signal cable splice cabinet in such a manner that no mounting screws, nuts, etc. protrude through the box. The terminal block shall be centered on the back wall in line with the long dimension of the box. Install additional terminal blocks as necessary.

The signal cable splice cabinet shall be furnished with weatherproof caps for all holes. Holes shall be provided with suitable cable entrance fittings which will both clamp the entering cables in place and protect their insulation from damage. These holes and their fittings shall be located so that the conduit hole between them can be fitted with a conduit hub without difficulty.

Furnish signal cable splice cabinet with brackets suitable for attaching the box to wood poles using nails or screws. The brackets shall facilitate a firm attachment to the pole. The design of the brackets shall be such that the conduit hubs and cable fittings shall not make mounting of the box difficult.

The signal cable splice cabinet shall have a hinged cover which shall open to the side.

13.3 CONSTRUCTION METHODS

Install pole-mounted splice cabinets. Install cabinets approximately five feet from the ground line to the top of the cabinet. Locate cabinets so as not to obstruct sight distance of vehicles turning on red.

Bond signal cable splice cabinet to equipment ground in cabinet using a 14 AWG stranded THHN. Do not put loop grounds and other grounds with neutral conductors.

13.4 MEASUREMENT AND PAYMENT

Signal cable splice cabinets will be measured and paid as the actual number furnished, installed, and accepted.

No measurement will be made for relocating messenger cable, grounding messenger cable, relocating signal cable, relocating lead-in cable, additional signal cable, additional lead-in cable, splicing of all existing signal conductors and loop lead-ins in the splice cabinet, extending them through new risers and conduits, and connecting them to the new controller cabinet as this will be considered incidental to the installation of the signal cable splice cabinet.

Payment will be made under:

Signal Cable Splice Cabinet..... Each

14. SIGNAL CABINET FOUNDATIONS

14.1 DESCRIPTION

Furnish and install signal cabinet foundations and all necessary hardware in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

Furnish either poured concrete foundations or preformed cabinet pad foundations and all necessary hardware. Selection of the type of foundation will be your option.

14.2 MATERIALS

Preformed cabinet pad foundation material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of advertisement.

Provide foundations with a minimum pad area that extends 24 inches from front and back of cabinet, and 3 inches from sides of cabinet.

Furnish cabinet foundations with chamfered top edges. Provide minimum Class B concrete.

Refer to Division 10 of the Standard Specifications:

Portland Cement Concrete ..... Article 1000-4

Provide preformed cabinet pad foundations with 7 (l) x 18 (w) inch minimum opening for the entrance of conduits. Ensure that no more than four 3/4-inch holes are cast or drilled in each pad.

14.3 CONSTRUCTION METHODS

Comply with the following section of the Standard Specifications:

Incidental Concrete Construction.....Section 825

Obtain approval for final cabinet foundation locations before pouring the concrete base. Do not install foundations over uncompacted fill or muck.

Use procedures, equipment, and hardware as follows:

- Hand tamp the soil on which the concrete is to be placed before placing the concrete.
- Maintain a minimum distance of 12 inches from the service pole to the closest point on the cabinet foundation unless approved.
- Use a minimum of four 1/2-inch diameter expanding type anchor bolts to secure the cabinet.
- Install foundations a minimum of 4 inches above the finished grade.
- Install conduits no more than 4 inches above the foundation. Locate external stubbed out conduit at the cabinet foundation so that the conduit is in the middle of the cabinet. Provide a service conduit as the rightmost conduit coming into the cabinet. Provide two spare conduits stubbed out; one pointed toward the service pole and the other toward the direction of the lead-in cable. Inscribe an identification arrow in the cabinet foundation indicating the direction of spare conduits.

- Give the cabinet foundation a broom finish.
- Seal the space between the base of the cabinet and the foundation with a permanent, flexible, waterproof sealing material.

14.4 MEASUREMENT AND PAYMENT

Signal cabinet foundation will be measured and paid as the actual number furnished, installed, and accepted.

Payment will be made under:

Signal Cabinet Foundation ..... Each

15. MODIFY CABINET FOUNDATIONS

15.1 DESCRIPTION

Where approved by the Engineer, install conduit entrances into existing foundations in accordance with the Plans and Specifications. Comply with the provisions of Sections 1700 and 1750 of the Standard Specifications.

Modify existing foundations in accordance with the Plans and Specifications.

15.2 MATERIALS

Comply with the provisions of section 1750-2.

15.3 CONSTRUCTION METHODS

A. Install Conduit Entrance into Existing Foundation

Install Conduit Entrances into existing cabinet foundations by core drilling foundations to install additional conduit.

Maintain a minimum of 3 inches of cover between new conduit and edge of foundation. Maintain minimum clearances of 1 inch from the flange of the base adapter and 2 inches from existing conduits. Avoid damaging existing conduit, conductors, and anchor bolts. Repair all such damages. Where approved by the Engineer, the foundation may be chipped instead of drilled for conduit entrance. When possible, maintain traffic signal operations while drilling is performed.

Bond new metallic conduit to the cabinet grounding system.

After installation of conduit, place grout to seal around conduit, and return the foundation to normal appearance.

B. Modify Foundation

Enlarge existing cabinet foundations to accommodate the new cabinet and/or to provide a maintenance technician pad.

Excavate the ground around the existing foundation to a depth sufficient to expose a minimum of 4 inches of the foundation below existing grade.

Rough the sides of the existing foundation from the top to a point 4 inches below grade by means of a chisel or other method approved by the Engineer.

Wash the sides of the foundation with water pressurized at 50 psi and thoroughly dry with compressed air.

Drill holes approximately 12 inches deep on 12-inch centers into the existing foundation. Install #4 dowels and epoxy into place. Provide dowels of the following lengths:

Foundation Extension	Length of Dowel
>16"	24"
>6" and <16"	17"
=6"	14"

Use concrete to install the maintenance technician pad.

Form the sides of the modified foundation to a minimum depth of 4 inches below grade.

Position forms so that all existing exposed foundation surfaces at or above grade level will be matched.

Apply a coating of approved epoxy bonding agent to all exposed roughened concrete surfaces as recommended by the manufacturer.

Enlarge the foundation to the distance specified for new cabinet foundations. Provide a 1-inch chamfer on all new outside edges.

Maintenance technician pads should be added to the foundation to provide a minimum work area of 24 inches [length] x 30 inches [width] from both the front and rear doors of the cabinet.

15.4 MEASUREMENT AND PAYMENT

Conduit entrances drilled into existing cabinet foundations will be measured and paid as the actual number furnished, installed and accepted.

Existing cabinet foundations modified will be measured and paid as the actual number modified and accepted.

Payment will be made under:

Conduit Entrance into Existing Foundation ..... Each

Modify Foundation for Controller Cabinet... ..... Each

16. CABINET BASE ADAPTER/EXTENDER

16.1 DESCRIPTION

Furnish and install cabinet base adapters and extenders in accordance with the Plans and Specifications. Comply with the provisions of Section 1700 of the Standard Specifications.

16.2 MATERIALS

Fabricate base adapters and extenders from the same materials and with the same finish as cabinet housing. Fabricate base adapter and extender in the same manner as controller cabinets, meeting all applicable specifications called for in Section 7.5 of CALTRANS TEES (11/19/99). Provide base adapters and extenders a minimum height of 12 inches.

16.3 CONSTRUCTION METHODS

Install a cabinet base adapter at every location requiring a new Model 332 or 336 cabinet on an existing/modified foundation. Install a cabinet base extender at every location requiring a new Model 332 or 336 cabinet on a new foundation.

Use a permanent, flexible waterproof sealing material to:

- Seal between the base of the cabinet and the cabinet base adapter/extender,
- Seal the seams of a two-piece cabinet base adapter/extender, and
- Seal the space between the cabinet base adapter/extender and the foundation.

16.4 MEASUREMENT AND PAYMENT

Cabinet base adapters will be measured and paid as actual number furnished, installed, and accepted.

Cabinet base extenders will be measured and paid as the actual number furnished, installed, and accepted.

Payment will be made under:

Cabinet Base Adapter ..... **Each**

Cabinet Base Extender ..... **Each**

17. SPREAD SPECTRUM WIRELESS RADIO

17.1 DESCRIPTION

Furnish and install a spread spectrum wireless radio system with all necessary hardware and signage in accordance with the plans and specifications to provide a data link between field devices (i.e. Traffic Signal Controllers, Dynamic Message Signs, etc.). Provide a radio system with a bi-directional, full duplex communications channel between two "line-of-sight" antennas using license free, spread spectrum technology operating in the 902-928 MHz frequency band.

Furnish material and workmanship conforming to the National Electrical Code (NEC), the National Electrical Safety Code (NESC), Underwriter's Laboratories (UL) or a third-party listing agency accredited by the North Carolina Department of Insurance, and all local safety codes in effect on the date of advertisement. Comply with all regulations and codes imposed by the owner of affected utility poles.

17.2 MATERIALS

A. 900MHz Wireless Radio Systems

Furnish license free 902 – 928 MHz radio modems with antennas, coaxial cable and mounting hardware, and configuration software. Design radio modems to work in "point-to-point", "point-to-multipoint", "multipoint-to-point", and "multipoint-to-multipoint" configurations. Ensure the spread spectrum wireless radio meets the following minimum requirements:

- License free (ISM) Spread Spectrum radio band (902 – 928 MHz)
- Frequency Hopping Technology (Direct Sequence Spread Spectrum Technology is not acceptable)
- Bi-Directional, Full Duplex
- Programmable Radio Frequency (RF) output levels of 1mW, 10mW, 100mW, or 1 Watt
- A minimum of 139 user-selectable radio frequency channels, with 62 available hopping sequences (2 non-overlapping)
- RS-232 interface capable of operating from 1200 bps to 115.2 Kbps, with 8 or 9 bit format or 1200 bps Bell 202 and supports FSK (2 or 4-wire) systems configurations (provide appropriate FSK module as needed when working with copper backbone systems)
- DB9-F connector for RS-232 port
- RJ 22 connector for FSK port
- Maximum of 8 mSec. end-to-end latency
- 16 bit Cyclic Redundancy Check (CRC) error checking with auto re-transmit
- Built-in store-and-forward (single radio repeater – back to back radio set-ups are not allowed to accomplish this function)
- 32 Bit encryption
- Receiver Sensitivity of –110dBm @ 10^-6 BER
- Antenna port: Reverse Polarity - Threaded Normalized Connector-Female (RP TNC-F) antenna connector
- Front panel LED indicators:
  - Power
  - Transmit Data

  - Receive Data
  - Data Port Indicator
- Operating temperature of –40 to +176 degrees F at 0 to 95% Humidity
- Power supply requirements:
  - Wall Adapter: 120 VAC UL/CSA wall cube plug-in module with 12 VDC, 1 Amp, nominal output.
  - Typical current draw of no greater than 355 mA when powered with 12 VDC input, and transmitting 1 Watt of RF output power.
  - Radio Sleep mode with a maximum current draw of <1μA.
- Shelf mounted design not to exceed 9" long x 2" wide x 5" high

Furnish a Radio Frequency Signal Jumper constructed of an RG-58 Coaxial Cable with Reverse Polarity - Threaded Normalized Connector-Male (RP TNC-M) on one end for connection to a radio unit and a Standard N-Type Male Connector on the other end for connection to the lightning arrestor. Provide the jumper in 6 foot lengths.

Furnish an RS-232 data interface cable to be installed between the radio modem and the field device's RS-232 interface. Ensure cable is a minimum of 6 feet long.

Ensure that installing the wireless radio system with a fully functional field device (i.e. controller) does not require any field device modifications with regards to hardware or software.

Furnish an ENCOM Model # EP-5100 Spread Spectrum Wireless Radio or an approved equivalent.

B. Software

Furnish units with a Window Based™ software program that uses a GUI (Graphical User Interface) to provide "remote programming, radio configuration, remote maintenance, diagnostics and spectrum analyzer" features. For compatibility with the ENCOM wireless radio or an approved equivalent wireless radio, provide ENCOM ControlPAK software or an approved equivalent software that is designed to function with the approved wireless radio. Provide configuration software that can be upgraded in the future at no additional charge.

Ensure the radio modem is configurable from a single location (i.e. master radio location) via supplied software (no extra cost). Furnish software supplied with drivers to allow easy set-up with all industry standard traffic signal controllers, including 2070 controllers containing custom software written specifically for the North Carolina Department of Transportation. Ensure the supplied software contains pre-written drivers for industry standard radar and video detection packages and Dynamic Message Sign controllers.

C. Directional Antenna (Yagi)

Furnish a directional antenna that will allow the system to function as designed. Furnish Cushcraft Model # PC906N (8.5 dB Gain) or Cushcraft Model # PC9013N (13 dB Gain) antenna or an approved equivalent antenna that meets the following minimum specifications:

Cushcraft Model # PC906N (8.5 dB Gain)

Frequency Range	896 – 940 MHz
Nominal Gain	8.5 dB
Front to Back Ratio	18 dB
Horizontal Beamwidth (at half power points)	65 degree
Vertical Beamwidth (at half power points)	55 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Length	24" (612 mm)
Rated Wind Velocity	125 mph (200 kph)
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph (161 kph)
Projected Wind Surface Area (flat plane equivalent)	0.26 ftsq. (0.024 msq)
Number Elements	6
Allows for Vertical or Horizontal polarization	
Wrap all connections with self sealing tape for weatherproofing and moisture seal	
Minimum separation distance from persons installing and using an active device	9" (230 mm)
Minimum separation distance from other RF sources including radios and antennas	6.5' (2 m)
Welded construction	

Cushcraft Model # PC9013N (13 dB Gain)

Frequency Range	902 – 928 MHz
Nominal Gain	13 dB
Front to Back Ratio	20 dB
Horizontal Beamwidth (at half power points)	40 degree
Vertical Beamwidth (at half power points)	35 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Length	53" (1346 mm)
Rated Wind Velocity	125 mph (200 kph)
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph (161 kph)
Projected Wind Surface Area (flat plane equivalent)	0.46 ftsq. (0.043 msq)
Number Elements	13
Allows for Vertical or Horizontal polarization	
Wrap all connections with self sealing tape for weatherproofing and moisture seal	
Minimum separation distance from persons installing and using an active device	9" (230 mm)
Minimum separation distance from other RF sources including radios and antennas	6.5' (2 m)
Welded construction	

Furnish mounting hardware to secure the antenna to the metal pole or wood pole, as recommended by the manufacturer of the antenna and as approved by the Engineer.

D. Omni Directional Antenna

Furnish an omni directional antenna that will allow the system to function as designed. Furnish 3dB Antenex Model # FG9023 or 6dB Antenex Model # FG9026 antenna or approved equivalent antennas that meet the following minimum specifications:

Frequency Range	902 – 928 MHz
Nominal Gain	Typical gains of 3 or 6 dB (dependent upon gain needed for application)
Termination	Standard N-Type Female Connector
Impedance	50 ohms
VSWR	1.5:1
Vertical Beam Width	3 dB – 33 degrees; 6 dB – 17 degrees
Lightening Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Length	3dB – 25" (635 mm) 6dB – 65" (1.65 m)
Rated Wind Velocity	125 mph (200 kph)
Solid, single piece construction	
Wrap all connections with self sealing tape for weatherproofing and moisture seal	
Minimum separation distance from persons installing and using an active device	9" (23 cm)
Minimum separation distance from other RF sources including radios and antennas	6.5' (2 meters)
Mount in a vertical direction and limit to vertically polarized RF systems	

Furnish mounting hardware to secure the antenna to the metal pole or wood pole, as recommended by the manufacturer of the antenna and as approved by the Engineer.

E. Coaxial Cable

Furnish a Times Microwave Systems™ LMR 400 Cable or ANDREW CNT-400 Cinta Braided Cable, or equivalent antenna coaxial cable to provide a link between the antenna and the lightning arrestor that meets the following minimum specifications:

Attenuation (dB per 100 feet) @ 900 MHz	3.9 dB
Power Rating @ 900 Mhz	0.58 kW
Center Conductor	0.109" Copper Clad Aluminum
Dielectric: Cellular PE	0.285"
Shield	Aluminum Tape – 0.291" Tinned Copper Braid – 0.320"
Jacket	Black UV protected polyethylene
Bend Radius	1" with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance per foot	23.9 pf/ft
Wrap all connections with self sealing tape for weatherproofing and moisture seal	
End Connectors	Standard N-Type Male Connectors on both ends

F. Lightning Arrestor

Furnish a lightning arrestor installed in line between each antenna and its designated radio modem inside the equipment cabinet. Furnish a Polyphaser Model # IS-B50LN-C2 lightning arrestor or an approved equivalent that meets the following minimum specifications:

- Surge: 50kA IEC 1000-4-5 8/20us waveform 500 Joules
- Turn-on: 600 VDC ±20% 2.5 ns for 2kV/ns
- Insertion Loss: ≤0.1 dB over frequency range
- Temperature: -49 to 185° F (-45 to 85° C) Storage/Operating 122° F (50° C)
- Vibration: 1G up to 100Hz
- Uses UL497B listed gas tube
- Throughput energy: ≤ 200 µJ for 3kA @ 8/20 µs Waveform
- Throughput voltage: ≤150 Vpk
- VSWR: 1.1:1
- Frequency Range: 125 MHz to 1000 MHz
- Max Power: VHF 375W, UHF (low) 250W, 800MHz to 1GHz, 125W
- Multistrike capability
- Low strike throughput energy
- Flange mount and bulkhead mount options
- Standard N-Type Female Connector on both the surge side and protected side connectors

17.3 CONSTRUCTION METHODS

A. General

Perform a radio path Site Survey test before installing any equipment. Ensure the test evaluates the Signal Strength (dBm), Fade Margin (dB), Signal-to-Noise Ratio, Data Integrity (poll test), and a complete frequency spectrum scan. Ensure the radio path site survey test is performed using the supplied brand of radio equipment to be deployed. During the initial radio path signal strength test it may be determined that a repeater station may be necessary to complete the intended link. Provide the test results to the Engineer for review and approval. Submit copies of the test results and colored copies of the frequency spectrum scan along with an electronic copy of this information. The Engineer will approve final locations of antennas and any necessary repeater stations. Install an antenna splitter cable at locations where it is determined that a dual antenna configuration is necessary to accommodate communications in multiple directions.

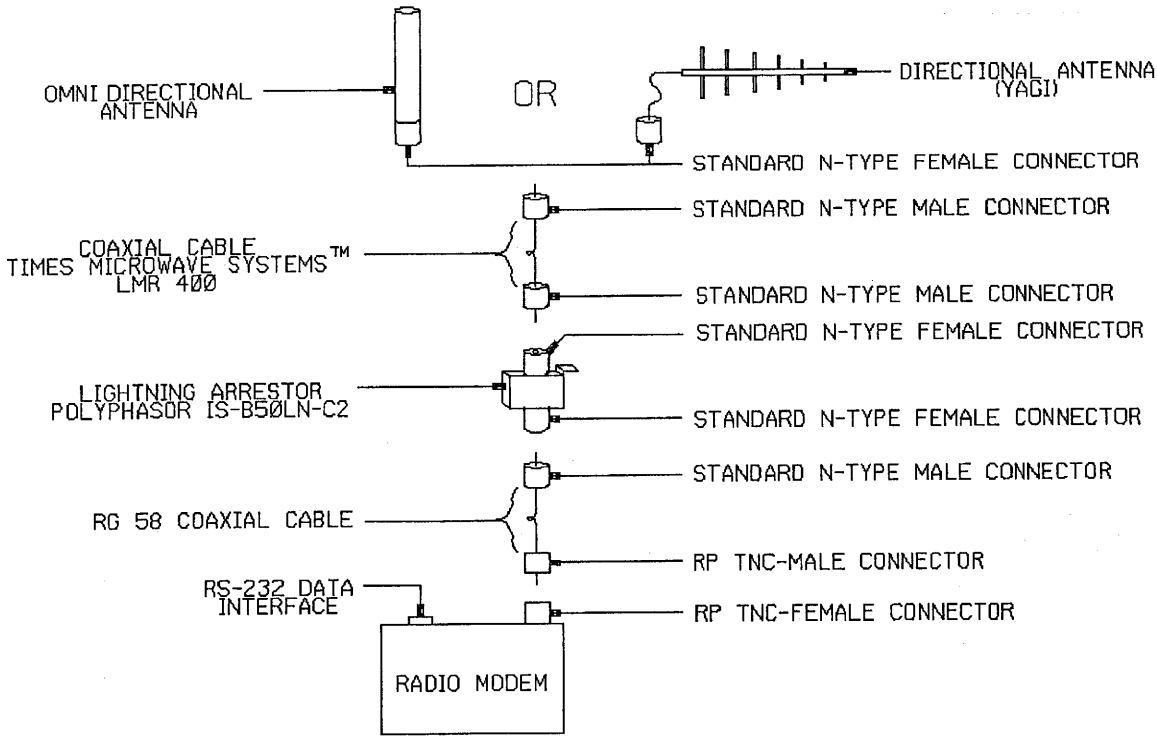
Install the antenna in such a manner that avoids conflicts with other utilities (separation distances in accordance with the guidelines of the National Electrical Safety Code) and as specified in the antenna manufacturer's recommendations. Secure the antenna mounting hardware to the pole and route the coaxial cable such that no strain is placed on the coaxial connectors.

On wood pole installations, bond the antenna mounting hardware to the pole ground using # 6 AWG bare copper wire using split bolt or compression type fitting.

On metal pole installations, mount the antenna on the mastarm or above the arm on the pole. Drill a hole in the pole six 6-inches below the arm and run the coaxial cable inside pole. Seal the hole with a water tight grommet.

Do not exceed the 1-inch (25-mm) bend radius of the coaxial cable as it transverses from the cabinet to the antenna assembly. Connect the lightning arrestor to the coaxial cable in the equipment cabinet. Properly ground and secure the arrestor in the cabinet. Permanently label all cables entering the cabinet. Ensure that the power supply for the radio system is NOT connected to the GFCI receptacle circuitry located in the cabinet. Place a copy of all manufacturer equipment specifications and instruction and maintenance manuals in the equipment cabinet.

B. Antenna and Coaxial Cable Schematic



C. Luminaire arm for antenna

Install luminaire arm on wood pole at location shown on plans. Provide all hardware necessary to attach the arm to the pole and the antenna to the arm including but not limited to anchors, bolts, nuts, washers, and end cap.

D. RF decal and sign

Install RF antenna warning sign and decal as shown in the plans.

17.4 WARRANTY

Provide a minimum two-year warranty with each radio and antenna assembly to ensure that the products are free of manufacturing defects in material and workmanship. The warranty commences on the date that the radio system is accepted by the Engineer.

17.5 MEASUREMENT AND PAYMENT

900 MHz wireless radio sites will be measured and paid as the actual number furnished, installed and accepted. This item includes the appropriate antenna, coaxial cable, lightning arrestor, labeling and any integration between the wireless radio system and a fiber optic network if necessary. The quantity of 900 MHz wireless radio systems, measured as provided above, will be paid for at the contract unit price each for "900 MHz Wireless Radio System" in accord with the following conditions: 75% of the payment will be made upon acceptance of each system; 25% of the payment

will be made following final acceptance of the integrated system (including completion of the 60 day observation period).

Luminaire arms for antennas will be measured and paid for as the actual number of furnished, installed, and accepted.

RF decal and sign sets will be measured and paid for as the actual number furnished, installed, and accepted.

All power supplies, power cords, adapters, antenna mounting hardware, connectors, serial cables, repeaters, installation materials and configuration software necessary to complete this work, including the radio path Site Survey test and warranties, will be incidental. Final payment will be made when work is accepted by the Engineer.

Payment will be made under:

900MHz Wireless Radio System ..... Each

Luminaire Arm for Antenna ..... Each

RF Decal and Sign ..... Each

18. CONCRETE SIDEWALKS

18.1 DESCRIPTION

Construct portland cement concrete sidewalks in accordance with the requirements shown on the plans and the provisions of these specifications. The work includes but is not limited to excavating and backfilling; sawing the existing sidewalk; furnishing and placing concrete; and constructing and sealing joints. Comply with the provisions of Sections 1000, 1026 and 1028 of the Standard Specifications.

18.2 MATERIALS

Refer to Division 10:

Portland cement concrete .....Section 1000

Curing agents .....Section 1026

Joint fillers..... Article 1028-1

Joint sealers .....Article 1028-2, Article 1028-4

18.3 CONSTRUCTION REQUIREMENTS

Where it is necessary to remove a portion of existing sidewalks, saw a neat edge along the pavement to be retained approximately 2 inches (50 mm) deep with a concrete saw before breaking the adjacent pavement away.

Construct concrete in accordance with Section 825 and give a sidewalk finish. Use Class B concrete.

Broom the concrete surface in a transverse direction to traffic. Make joint spacing no less than 5 feet (1.5 m). Seal expansion joints where sidewalk is placed adjacent to concrete curb and/or gutter. Do not seal grooved joints.

Do not place backfill adjacent to the sidewalk until at least 3 curing days, as defined in Article 825-9, have elapsed. Complete backfill within 4 calendar days after the completion of the 3 day curing period unless otherwise approved. Compact the backfill to a degree comparable to the adjacent undisturbed material.

Do not place vehicles on the completed work until 7 curing days, as defined in Article 825-9, have elapsed. When high early strength concrete is used, vehicles will be permitted on the completed work after 3 curing days have elapsed.

18.4 MEASUREMENT AND PAYMENT

The quantities of sidewalk to be paid for will be the actual number of square yards of sidewalks measured along the surface of the completed and accepted work.

The quantity of sidewalk, measured as provided above, will be paid for at the contract unit price per square yard for "4" Concrete Sidewalk."

Payment will be made under:

4" Concrete Sidewalk ..... Square Yard

19. BOND EXISTING JUNCTION BOX

19.1 DESCRIPTION

Bond the lids and the rings of the existing cast iron, water meter type, junction boxes containing either signal cable or signal cabinet electrical service in accordance with the requirements shown on the plans and the provisions of these specifications.

19.2 MATERIALS

Furnish Landis & Gyr H56734, H57606 pressure lug connectors, or approved equivalent, with brass mounting hardware and 14 AWG stranded THHN with green insulation.

19.3 CONSTRUCTION REQUIREMENTS

Mount pressure lug connectors on existing cast iron, water meter type, junction box lid and ring as shown on the plans. Use a compression connection to mount the lug to the lid and ring. Countersink the bolt through the ring to allow the lid to fit flush. Countersink the bolt through the lid to maintain a smooth lid top and prevent a tripping obstacle

Bond the lid to the ring using 14 AWG stranded THHN. Provide a minimum of 18 inches of wire between the lid and the ring. Bond the ring to the signal cabinet ground bus using 14 AWG stranded THHN.

19.4 MEASUREMENT AND PAYMENT

The quantities for the bonding of existing junction boxes to be paid for will be the actual number of junction boxes bonded and accepted.

The quantity for the bonding of existing junction boxes, measured as provided above, will be paid for at the contract unit price each for "Bond Existing Junction Box."

Payment will be made under:

Bond Existing Junction Box ..... Each

20. SYSTEM SUPPORT EQUIPMENT

20.1 DESCRIPTION

Furnish system support equipment with all necessary hardware in accordance with the plans and specifications.

20.2 MATERIALS

A. General

All system support equipment will be furnished only and delivered to the City of Asheville Traffic Signal Shop. To make arrangements for delivery call (828) 259-5873.

B. Controller with Cabinet

Furnish two "Controller with Cabinet" as specified in chapter 11 (Controller with Cabinet) of these project special provisions. Cabinets furnished shall be base mounted 336 cabinets.

C. 900 MHz Wireless Radio System

Furnish two "900 MHz Wireless Radio System" as specified in chapter 17 (Spread Spectrum Wireless Radio) of these project special provisions.

D. Traffic Signal Monitor Tester

Furnish an ATSI PCMT-2600 Traffic Signal Monitor Tester or approved equivalent with notebook computer intended for use on work-bench. The Tester shall be capable of automated testing of Conflict Monitor Units (CMU) as defined by ODOT/TXDOT 2070 Standards. The Tester shall include all required hardware, cables and software to perform testing of 2070 CMUs. The Tester shall use/control an Intel-based notebook computer for input/output. The Tester shall test Signal Monitor displays, timing and voltage functions, and input/output combinations of either true or false conflicts. Any software provided with the tester shall be modular, menu driven, and offer a "help" screen. A video "setup/usage" training tape shall be provided with each unit. All input/outputs shall be in plain English. It shall be possible to generate a hardcopy printout, or to store the results to a disk file. A "No Faults Detected" indication shall be displayed as appropriate.

20.3 MEASUREMENT AND PAYMENT

Controller with cabinet will be measured and paid for as the actual number furnished and accepted.

900 MHz Wireless Radio Systems will be measured and paid for as the actual number furnished and accepted.

Traffic Signal Monitor Testers will be measured and paid for as the actual number furnished and accepted.

Payment will be made under:

Controller with Cabinet (Furnished Only) ..... **Each**

900MHz Wireless Radio System (Furnished Only) ..... **Each**

Traffic Signal Monitor Tester (Furnished Only) ..... **Each**

21. SYSTEM TRAINING

21.1 DESCRIPTION

Provide system training for the operation and maintenance of the 2070 Traffic Signal Controllers, the Traffic Signal Monitor Tester, and the 900 MHz Spread Spectrum Wireless Radio Systems to be provided as part of this project.

21.2 MATERIALS

Provide system training to properly operate, and maintain 2070 Traffic Signal Controllers, the Traffic Signal Monitor Tester, and a 900 MHz Wireless Radio Systems. Provide approved manufacturer's representatives or other qualified personnel to conduct training courses. Provide training for a minimum of fifteen Department and City personnel.

Before beginning the training course, submit detailed course curricula, draft manuals, and handouts, and resumes of the instructors for review and approval. The Engineer may request modification of the material and request courses desired by the Department and/or the City.

Conduct all training courses at a location provided by the City and at a time mutually agreed upon, but not later than the start of system testing. Provide training material, manuals, and other handouts to serve not only as subject guidance, but also as quick reference for use by the students. Deliver course material to in reproducible form immediately following the course.

Provide instruction on basic 2070 Traffic Signal Controller, Traffic Signal Monitor Tester, and a 900 MHz Wireless Radio System theories and principals as well as the installation, operation, maintenance, identification, detection, and correction of malfunctions in the controller, radio system and related hardware. Include field level troubleshooting as an integral part of the training.

Provide system training for the 2070 Traffic Signal Controller, the Traffic Signal Monitor Tester, and the 900 MHz Wireless Radio System for the following categories and for the minimum number of hours shown:

COURSE OUTLINES (L = Lecture; D = Demonstration; H = Hands-on by Student)

DAY 1 (4 Hours)

2070 TRAFFIC SIGNAL CONTROLLER

Safety - (L)

Introduction to 2070 Traffic Signal Controller - (L, D)

Review of Maintenance Manual - (L)

Review of Operations Manual - (L)

Demonstration of Controller Operation – (L, D, H)

Menu Structure and Navigation – (L, D, H)

Trouble Shooting – (L, D)

Question and answer session

DAY 1 (4 Hours)

TYPE 170E CABINET (332A & 336S)

Safety - (L)

Introduction to Type 170E Cabinet (332A & 336S) - (L, D)

Review of Cabinet Wiring Diagram (L, D)

Review of Maintenance Manual - (L)

Review of Operations Manual - (L)

Demonstration of Cabinet Wiring and Operation – (L, D, H)

Trouble Shooting – (L, D)

Question and answer session

DAY 2 (4 Hours)

TRAFFIC SIGNAL MONITOR TESTER

Safety - (L)

Introduction to the Traffic Signal Monitor Tester - (L, D)

Review of Maintenance Manual - (L)

Review of Operations Manual - (L)

Demonstration of Tester Operation – (L, D, H)

Question and answer session

DAY 2 (4 Hours)

900 MHz WIRELESS RADIO SYSTEM

Safety - (L)

Introduction to 900 MHz Wireless Radio System - (L)

Review of Maintenance Manual - (L)

Review of Operations Manual - (L)

Demonstration of Radio System – (L, D, H)

Trouble Shooting – (L)

Question and answer session

NCDOT will provide training for the City on the Master/Local and Closed Loop Traffic Management System software provided by the Department.

21.3 MEASUREMENT AND PAYMENT

The system training for the operation and maintenance of the 2070 Traffic Signal Controllers, the Traffic Signal Monitor Tester, and the 900 MHz Spread Spectrum Wireless Radio System will be paid on a lump sum basis.

Training packages, handouts, demonstration equipment, and other training materials will be incidental.

NCDOT will provide training for the City on the Master/Local and Closed Loop Traffic Management System software provided by the Department. Therefore, no measurement will be made for the Master/Local and Closed Loop Traffic Management System software training.

Payment will be made under:

System Training.....Lump Sum

22. SYSTEM COMPUTER EQUIPMENT

22.1 DESCRIPTION

Furnish and install central and notebook computers with software and all necessary hardware in accordance with the plans and specifications.

22.2 MATERIALS

A. Central Computers

Provide workstation computer with the following minimum features:

- Tower chassis,
- Intel Pentium 4, 3.0 GHz processor, or approved equivalent,
- Windows XP Professional (with Service Pack 2) operating system, or approved equivalent,
- Software: Microsoft Office 2007 Edition or approved equivalent,
- NTFS file system,
- Hyper-threading enabled,
- 1.0 GB of RAM (DDR2 Non-ECC SDRAM, 533MHz, 2DIMM), expandable to 2.0 GB,
- Standard 104-key USB keyboard (no hot keys),
- USB 2-button optical mouse with scroll,
- 160GB SATA hard drive with 8 MB cache,
- 16X DVD+/-RW CD/DVD reader/burner with read/write software,
- 1.44MB 3.5 Inch Floppy Drive,
- 19-inch flat panel LCD monitor (VGA/DVI) with adjustable stand, 1280 x 1024 at 60Hz,
- PCIe 128MB ATI Radeon X600SE (1 DVI/1 TV-out), or approved equivalent,
- Integrated AC97 audio, or approved equivalent, and two external stereo speakers,

Provide Network Ethernet Interface 100BaseTX (100 Mb/s Ethernet) RJ-45 connection and all software and hardware required for interface with the Division's computer network.

Provide internal PCI modem with 56,000 bps for data and 14,400 bps for fax with RJ-11 connector.

Provide modems that comply with the following:

1. Data Compatibility:

- V.34, V.FC, V.32, V.32bis, V.22, V.22bis, V.90

2. Fax Compatibility:

- V.17, V.29, V.27ter

3. Error Control and Data Compression:

- V.42/MNP 2-4 error control (hardware based)

- V.42bis/MNP 5 data compression (hardware based)

4. Ethernet:

- IEEE 802.3

B. Notebook Computers

Furnish notebook computer that complies with the following minimum features:

- Intel Pentium M, 2.33 GHz minimum processor, or approved equivalent,
- Windows XP Professional operating system (with Service Pack 2),
- 1.0 GB DDR2 533MHz SDRAM, 1 DIMM, expandable to 2.0 GB,
- 15 inch TFT display,
- 120 GB Hard Drive, 9.5 MM, 7200 RPM,
- NTFS file system,
- one internal 24X CD-RW/DVD with software,
- one internal diskette drive that will accept 3.5-inch, 1.44 MB diskettes,
- one parallel port,
- one RS-232 serial port,
- One USB port,
- Software: Microsoft Office 2007 Edition or approved equivalent,
- Smart lithium ion battery pack, fully charged battery capable of a minimum of 3 hours of continuous operation, AC adapter/charger, and a car cigarette lighter adapter cable,
- one spare battery pack,
- integrated 32-bit 3D, surround sound with built in speakers,
- full function keyboard,
- pointing device that is integral to the case (clip on devices will not be acceptable),
- one cable 10 feet (3 meters) long for connection to a controller port,
- one cable 10 feet (3 meters) long for connection to network port on the workstation computer,
- video capture card capable of digitizing and displaying full motion composite (NTSC/PAL) video in real time, or external device capable of digitizing.
- full screen source editing features,
- Wireless 802.11a/b/g WLAN miniPCI card,
- one on board modem that provides 56,600 bps for data and 14,400 bps for fax with RJ11 connector,
- 100Base TX (100 Mb/s Ethernet) with RJ-45 connector on board,
- IEEE 802.11g wireless network adapter card,
- cushioned, soft-side carrying case.

Provide modems that comply with the following:

1. Data Compatibility:

- V.34, V.FC, V.32, V.32bis, V.22, V.22bis, V.90

2. Fax Compatibility:

- V.17, V.29, V.27ter

3. Error Control and Data Compression:

- V.42/MNP 2-4 error control (hardware based)

- V.42bis/MNP 5 data compression (hardware based)

4. Ethernet:

- IEEE 802.3

C. Printer

Furnish color laser printer with the following minimum features:

- Utilizes the PCL 6 printer language featuring commands for fully integrated HP-GL/2 vector graphics and advanced imagery/special effects printing with a minimum of 80 internal, scaleable fonts,
- Utilizes the latest version of Windows print typefaces,
- Provides a minimum of 16 MB of RAM,
- Provides modular input/output (I/O) and Ethernet 10/100 Base-T network communications protocols,
- Comes equipped with an Ethernet 10/100 Base-T network interface card and an RS-232 serial (9-pin) interface, bi-directional IEEE 1284 ECP-compliant parallel interface, and one (1) open EIO expansion slot,
- Prints a minimum 17 pages per minute (ppm) for both color and black and white prints.

Provides 1,100 sheet capacity and 3 input trays supporting 8.5 x 11 inch, 8.5 x 14 inch, and 11 x 17 inch media.

D. Surge Suppression Strips

Provide surge suppression power strips with an illuminating on/off switch, isolating filter banks, and a minimum of six 120 VAC, 60 HZ outlets. Furnish power strips with isolation filter banks that attenuate high frequency noise as follows:

- Greater than 20 dB @ 50 kHz
- Greater than 40 dB @ 150 kHz
- Greater than 80 dB @ 1 MHz

22.3 CONSTRUCTION METHODS

Perform all work to furnish a fully functional central computer. Install all connecting cables and hardware as necessary to develop a complete and operational system.

Install the Closed Loop Traffic Management System software provided by the NCDOT on the central computer and the notebook computer.

Install surge suppression strips as necessary for all components and equipment.

After delivery and installation of the central hardware and software, perform detailed tests on each system component. Upon the successful completion of all component tests, provide a system acceptance test procedure for approval by the Engineer. These test procedures will demonstrate that all equipment, central and field, are fully integrated and operational, and are properly controlling the closed loop system.

22.4 MEASUREMENT AND PAYMENT

Central computers with operating software and surge suppression strip will be measured and paid for as the actual number furnished, installed, and accepted.

Notebook computers with operating software and surge suppression strip will be measured and paid for as the actual number furnished, installed, and accepted.

Printer with surge suppression strip will be measured and paid for as the actual number furnished, installed, and accepted.

Payment will be made under:

Central Computer ..... Each

Notebook Computer ..... Each

Printer ..... Each