PROJECT SPECIAL PROVISIONS

CITY OF WILMINGTON
TRAFFIC SIGNAL SYSTEM UPGRADE/EXPANSION PROJECT
PHASE 3 – NORTHWESTERN & EASTERN SECTIONS

N.C. Project No. U-5017C (WBS #41439)
F.A. Project No. STP-0332 (28)
New Hanover County

Prepared for:

North Carolina Department of Transportation
ITS and Signals Unit

NORTH CAROLINA PROFESSIONAL SEAL 17586 ENGINEER J. TODD BROOKS

9/9/08

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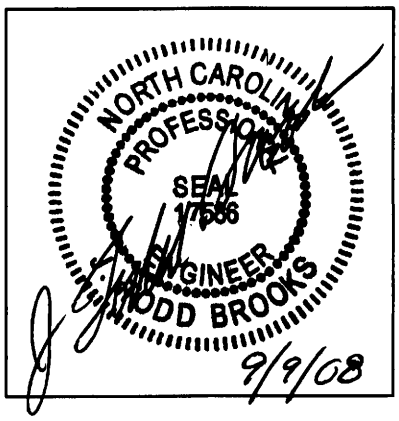

Project Special Provisions

Based On

NCDOT ITSS Project Special Provisions

Version 06.5

Prepared By: HAB/JTB/JS/DJ
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Contents

1. GENERAL REQUIREMENTS

1.1. DESCRIPTION

(A) Summary of Work

This project is the third phase of a three-phase construction project to rehabilitate and expand the City of Wilmington, North Carolina's existing computerized traffic signal system. Overall project work will be primarily comprised of communications system replacement and expansion, field equipment upgrades, replacement of the existing Traconex® closed-loop signal system with a new distributed processing traffic control system, enhancement of the Traffic Management Center, and expansion of the video monitoring system; however, not all of this work is included in Phase 3. In its entirety, the overall multiphase project includes:

- Signal display upgrades at selected locations and replacement of existing controllers and cabinets with new Model 2070L controllers housed in Model 332A or 336S cabinets for the approximately 215 signalized intersections that will comprise the expanded system;
- Replacement of an existing copper-wire communications system with a new, predominantly fiber-optic communications system comprised of approximately 60 roadway miles of fiber-optic cable along with several wireless communications links;
- Expanding the existing video surveillance system from 11 existing CCTV cameras to 25 CCTV cameras and replacing the central video equipment.

This Phase 3 project encompasses the northwestern and eastern geographic areas of the city designated Phase 3A and Phase 3B respectively. Phase 3A is generally bounded on the west by the Cape Fear River, on the north by Castle Hayne Road (NC 133), on the east by 23rd Street, and on the south by Market Street, Dock Street and Princess Place Drive. Phase 3A includes downtown Wilmington (i.e., the central business district, or CBD). Phase 3B is generally bounded on the west by College Road (US 117/NC 132), on the north by Market Street, on the east by Military Cutoff Road and on the south by Oleander Drive. Phase 3B includes the radial extensions of Market Street and Eastwood Road northeast and southeast of that general boundary.

Phase 3 will be comprised of 74 signalized intersections, 8 video surveillance cameras (install 7 new and replace 1 existing) and approximately 20 miles of fiber-optic communications cable. The Phase 3 contractor will be responsible for integrating the Phase 3 traffic signals and video surveillance cameras into the portion of the new fiber-optic communications system constructed in Phase 3 but not for integrating the signals into the central control system. The Contractor will integrate the cameras into the central video surveillance system. Integration of the Phase 3 traffic signal controllers, as well as those in previous Phase 1 and 2, will be performed by City of Wilmington.

Many existing signals in Phase 3 have NEMA controllers and cabinets that are to be replaced with Model 2070L controllers in Model 332A or 336S cabinets under this Phase 3 project. However, there are several existing Model 2070L controllers in Model 332A controller cabinets that will be retained. Most of these existing Model 2070L controllers

in Model 332A cabinets are located in Phase 3B within an existing closed-loop signal system along Military Cutoff Road and Market Street, but a few are located within Phase 3A in Downtown Wilmington.

New fiber-optic communications cable will be installed primarily by overlashing to existing aerial twisted-pair copper wire communications cable but also by lashing to new messenger cable, installing in existing underground conduit/duct systems, and installing in new underground conduit/duct systems. An existing 96-strand fiber-optic trunk cable originating at the City of Wilmington TMC located at 265 Operation Center Drive off of River Road in Wilmington will be retained to provide a homerun communications link between the TMC and the new fiber-optic communications network being constructed in Phase 1 and subsequent phases. To migrate from the existing to the new communications system while minimizing disruptions to signal system operations, the existing twisted-pair communications system in Phase 3 will be progressively decommissioned as the new fiber-optic communications is progressively built-out and brought online.

Perform the following major tasks under this contract, as shown in the Plans:

- Furnish and install a new fiber-optic communications system comprised of fiber-optic cable, fiber-optic splice/termination centers, fiber-optic transceivers (video and data), and related electronics;
- Furnish and install underground conduit/duct, junction boxes, risers with heat shrink tubing, risers with weatherheads, messenger cable, fiber-optic cable storage guides, wood poles, and pole guy assemblies with guy guards;
- Furnish and install new cabinets and ancillary equipment, extending existing field wiring as and if necessary;
- Modify existing cabinet bases and install new cabinet bases;
- Furnish and install new traffic signal controllers;
- Upgrade existing vehicle traffic signal displays at selected locations only;
- Remove existing control equipment and cabinets;
- Furnish and install detector loops, junction boxes, lead-in cables and digital detector units;
- Furnish and install signal cable and lead-in cable;
- Furnish and install CCTV camera assemblies and cabinets;
- Modify existing electrical services and install new electrical services;
- Integrate all components into a fully-functioning fiber-optic and wireless communications system.

The Department will stagger the start of each of the three construction phases beginning with the Phase 1 project, but there will be concurrent construction on one or more of the phases while Phase 3 is being constructed. In addition, Phase 3 construction work may overlap construction work in Phases 1 or 2 where the geographic boundaries of phases meet. In some cases, the work on adjoining phases may be interrelated to the Phase 3 work. For example, an adjacent phase's fiber-optic communications cable may be required to splice into fiber-optic cable being installed in Phase 3 and vice versa. Contractors for different phases who are working within the same area shall coordinate and cooperate with each other. Each contractor shall conduct his work so as not to

interfere with or hinder the progress of the work being performed by the other contractors.

The City of Wilmington has joint use permits for the proposed new attachments of aerial fiber-optic communications cable. Joint use permits issued by the utility pole owners expire 120 days from the date of issuance. The Contactor shall commence installation of messenger cables and guy assemblies at the outset of construction and work continuously and expeditiously to complete this work prior to the joint use permit expiration date. In the event that this work cannot be completed within 120 days, notify the Engineer 20 calendar days in advance to allow the City to request an extension of the permit.

(B) Standard Specifications

Conform to these Project Special Provisions and the North Carolina Department of Transportation (NCDOT) *Standard Specifications for Roads and Structures*, July 2006, herein after referred to as the "*Standard Specifications*". Conform to the Codes and Regulations described in Section 1700 of the *Standard Specifications*.

Within these Project Special Provisions, the "Department" refers to the North Carolina Department of Transportation (NCDOT), and the "City" refers to the City of Wilmington, Development Services Department, Traffic Engineering Division.

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

1.2. MATERIAL

(A) Qualified Products

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.

The Signal Equipment Qualified Products List (QPL) is available on the Department's Web site. 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 material is in accordance with the contract. When requested by the Department, provide additional certifications from independent testing laboratories and sufficient data to verify item meets applicable Specifications. Ensure additional certification states the testing laboratory is independent of the material manufacturer and neither the laboratory nor the manufacturer has a vested interest in the other.

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

For Contractor-furnished material listed on the QPL, furnish submittals in the format defined by the QPL.

For Contractor-furnished material not on the QPL, furnish three copies of the equipment list including three copies of catalog cuts. Identify proposed material on catalog cuts by a reproducible means (highlighter pen does not transfer to copies). Ensure material lists contain 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.

(C) Observation Period

Warrant workmanship and Contractor-furnished equipment for a thirty (30) Day Observation Period.

The thirty (30) Day Observation Period is considered to be a part of 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 thirty (30) Day Observation Period and after all documentation requirements have been fully satisfied.

(D) Warranties

Unless otherwise required herein, provide manufacturer's warranties on Contractor-furnished equipment for material and workmanship that are customarily issued by the equipment manufacturer or that are at least one year in length, whichever is greater, from successful completion of the 30-day observation period. The transient voltage and surge suppression (TVSS) device for the CCTV camera assembly power source shall carry a manufacturer's warranty of 10 years from the date of final acceptance by the Department. Include unconditional coverage for all parts and labor necessary or incidental to repair of defective equipment or workmanship and malfunctions that arise during warranty period.

Ensure all Contractor-furnished equipment, including pieces and components of equipment, hardware, firmware, software, middleware, internal components, and subroutines which perform any date or time data recognition function, calculation, or sequencing will support a four-digit year format for a period of at least 50 years and will support user-definable parameters for setting the start and end dates for daylight savings time.

Upon successful completion of the 30-day observation period, transfer manufacturer's warranties with proper validation by the manufacturer to the Department of its designated maintaining agency.

(E) Firmware Licensing and Upgrades

Provide the Department with a license to duplicate all programmable devices in equipment for maintenance and software upgrades. Provide binary or hexadecimal format files for each device that may be programmed by the Department. Ensure files are provided on PC compatible compact disks or other approved media.

Ensure firmware performance upgrades that occur during the contract period up through final acceptance of the project are furnished to the Department at no additional cost.

Make firmware upgrades that are developed to correct operating characteristics available to the Department at no additional cost until the warranty period expires.

(F) Wire and Cable

Furnish wire and cable on reels. When requested by the Department, furnish samples of wire and cable to the Department at no additional cost.

Provide either 0.05" x 0.30" aluminum wrapping tape or 0.06" stainless steel lashing wire for lashing cables to messenger cable. Use 0.045" stainless steel lashing wire to lash fiber-optic communications cable to messenger cable and existing self-supporting communications cable.

(G) Painting

Where painting of signal heads is required, apply paint at the factory. No field painting will be allowed except when paint has been scratched or marred. In such cases, apply two field coats of the same color and grade enamel as the original paint to the scratched or marred portions.

1.3. CONSTRUCTION STAGING/MIGRATION

(A) Introduction

This section addresses the general flow of construction in regards to communications throughout the life of the project. It is essential that the Contractor make every effort to minimize communications downtime to the traffic signals. Follow the outline of construction described below. Deviations from this sequence must be approved by the Engineer. The Contractor will furnish and install all CCTV equipment.

The first item of work on this project shall be the installation of messenger cable and guy assemblies. Commence installation of guys and messenger cable immediately to secure attachment locations joint use poles. Permits for attachment to joint use poles expire 120 days after issuance. In the event that this work cannot be completed within 120 days, notify the Engineer at 20 calendar days in advance to allow the City to request an extension of the permit.

(B) TMC Migration

The central block diagram for the new signal system is shown in the Plans as Sheet 7. It depicts the existing equipment to be retained and the new equipment to be installed. The block diagram depicts equipment that will have been furnished and installed by the City of Wilmington or the construction contractors for Phases 1 and 2. The proposed sequence is described below.

1) Step 1

Update the Protronix video management software database and maps with information regarding the new camera locations on the new analog video matrix switch. Complete migration of the CCTV system control equipment before adding any new cameras.

Continue the existing signal system operations by maintaining dial-up communications to the on-street masters for each closed loop control section.

2) Step 2

Construct the field communications as described in the plan set and move traffic signals from the closed loop signal systems and various isolated signals to the new communications system.

Coordinate with the City of Wilmington for the City to modify the communications addresses and other communications parameters in the new ATMS database to migrate from the existing closed loop system and isolated traffic signal operations over twisted-pair copper communications to the new ATMS software over fiber communications.

Add or relocate CCTV cameras to the GUI and database as shown in the Plans.

3) Step 3

Upon transferring signals to the new fiber-optic cable, disconnect the dial-up modems to the closed-loop masters.

(C) Field Infrastructure

The approach to maximizing communications to all signals throughout the long construction process requires that a new fiber communication route be established separate from the existing twisted-pair network, allowing both to function simultaneously. This network is comprised of:

1) New aerial cable over-lashed to existing twisted-pair copper cable while the copper cable remains in use. This means that the abandoned copper cable remains in place after construction. Certain aerial routes are on new pole lines or deviate from the course of the existed twisted-pair.
2) New underground cable in a new trenched, drilled or bored conduit. In certain situations, as shown in the Plans, the fiber cable will be run through the existing conduit with the existing twisted-pair cable.

(D) Field Migration

Follow the outline of construction described below. Deviations from this sequence must be approved by the Engineer.

1) Step 1

Install new messenger cable and new guy assemblies within 120 days of notice to proceed.

2) Step 2

Extend new communications cable to the major arterials as follows with 24-fiber cables as shown on the Plans:

<u>Phase 3A</u>

- Dock Street,
- Princess Street,
- Chestnut Street
- 3rd Street,
- 5th Street,
- 2nd Street, and
- Red Cross Street.

Phase 3B

- Market Street,
- Racine Drive, and
- Eastwood Road.

For Phases 3A and 3B, all fiber can be installed while maintaining communications to these signals via the copper cable network and existing fiber-optic cable. If necessary, establish new temporary on-street masters to allow central monitoring within each of the signal control channels. Coordinate closely with the City Traffic Engineer to ensure a smooth transition during this process.

During this process, remove only the copper communications cable if the following conditions exist:

1) The copper cable is not being used for traffic signals in Phase 3 and,
2) No other cables, such as fiber-optic cable belonging New Hanover County's IT Department, are lashed to the copper cable.

3) Step 3

Once the communications in Steps 1 and 2 are established and successfully tested, and continuous communications paths are established with outlying signals, begin the process of transferring communications from the old twisted-pair copper network to the new fiber network. Start at the outer edge of the local signal channels and work in the direction toward the TMC. Make every effort to group the work by the existing copper communications channel configurations, allowing channels to be taken offline and disconnected in discrete packages. When the existing copper communications are disconnected, complete the work at the intersection and initiate the fiber communications in a time period no greater than two days per traffic signal in that channel. Exceptions to this requirement must be approved by the Engineer. Notify the City of Wilmington Traffic Engineer at (910) 341-4696 at least two weeks prior to the commencement of work on a particular communications channel to ensure that TBC will be operating and effective during the time of communications interruption. As each signal channel is completed and lit, test intersection communications as per the requirements of "Testing and Acceptance" section of these Project Special Provisions.

In one instance, the new fiber-optic network will be connected to existing fiber-optic cable for a newly-installed NCDOT closed-loop signal system, the US 17 (Market Street)/Military Cutoff Road Closed-Loop System. The existing splicing and terminations are to be reused to the greatest extent possible. However, some modifications to the terminations and jumpers are required, as noted in the Plans. In addition, the transceivers will be replaced. Notify the NCDOT Division 3 Traffic Engineer at (910) 251-2693 at least two weeks prior to the commencement of connecting into this network to ensure that time-base coordination will be operating and effective during the time of interruption of communications. Complete the work at these intersections and initiate the modified fiber communications in a time period no greater than 72 hours.

(E) Intersection Parameters and Database

The City will provide, both in paper and electronic format, all intersection parameters, database and timing plans in OASIS format. The Contractor shall be responsible for loading OASIS-formatted data into the Model 2070L controllers. The City shall be responsible for graphics for these new intersections.

1.4. CONSTRUCTION METHODS

(A) General

Before beginning signal work, verify all existing signal equipment is in satisfactory working order. Report all defective signal equipment to the Engineer so as not to be held responsible for 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.

Locate existing conduit, cable runs, inductive detection loops, lead-in, junction boxes, and detection equipment before installing or using equipment that can damage or interfere with such facilities. The locations of existing inductive detection loops, junction boxes and conduits shown on the Plans are approximate.

Locate all underground utilities before beginning drilling, digging and trenching operations.

Immediately cease work and notify the Engineer and affected owners if damage to existing utilities, cables, or equipment occurs. Make all required repairs and replacements at no additional cost to the Department.

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.

(B) Work within Historic Districts

Several signalized intersections, some proposed CCTV cameras and several fiber-optic communications cable routes lie within or adjacent to historic districts. The Department has coordinated with the agencies that have jurisdiction over these historic districts and has applied for appropriate permits and certificates for the work called for in the Plans in these historic districts. Do not deviate from the work called for in the Plans within a historic district without the prior approval of the Engineer and the agency/agencies that have jurisdiction over the historic district. Where construction work must deviate from the Plans, notify the Engineer in advance so that the Department can request/apply for the appropriate approvals for such changes prior to the Contractor performing work at that location.

Avoid damaging or removing sidewalks and curbs within designated historic districts. Do not damage any existing granite curbs. Where granite curbs conflict with the installation of underground conduit and cable and subject to the Engineer's approval, carefully remove and subsequently reinstall the existing granite curb using methods approved by the Engineer. The Contractor shall be responsible for replacing any granite curb damaged by the Contractor or his/her subcontractor(s) at no cost to the Department.

Where removal and replacement of concrete sidewalk and concrete curb is unavoidable, replace them with concrete materials that match the finish, appearance and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. Finishes may include but are not limited to water-washed, broom and trowel. The dimensions and the profile (i.e., shape) of the new curbing shall match that of the adjacent existing curbing.

Where removal and replacement of sidewalk constructed of materials other than concrete is unavoidable, replace the sidewalk with in-kind materials that match the finish, appearance and color of the adjacent existing sidewalk as close as technically feasible as determined by the Engineer. If the sidewalk is constructed of materials such as brick, stone or pavers, carefully remove and subsequently reinstall the bricks, stones or pavers using methods approved by the Engineer. Take photographs and make sketches to record the pattern of the existing materials prior to removal. The Contractor shall be responsible for replacing any bricks, stones or pavers damaged by the Contractor or his/her subcontractor(s) with approved in-kind, matching materials at no cost to the Department.

Do not trim, remove or damage tree limbs within historic districts. Hand-lashing of aerial cables to messenger cable may be required in some areas due to overhanging and protruding tree limbs along the cable route.

(C) Regulations and Codes

Furnish material and workmanship conforming to the *National Electric Code* (NEC), *National Electric Safety Code* (NESC), Underwriters Laboratories (UL), or other listing agencies approved by the North Carolina Department of Insurance, and all local safety codes in effect on the date of advertisement. Comply with Article 4, Chapter 87 of the *North Carolina General Statutes* (Licensing of Electrical Contractors). Comply with the Plans, all previously referenced specifications, and all applicable local ordinances and regulations before and during all stages of the electrical work.

When required by the local ordinances and governmental agencies, upon completion of the work, have all systems inspected and approved in writing by the authorized governmental electrical inspector for the area. Furnish written certification of the authorized inspector's approval to the Engineer. Inspection by the authorized governmental electrical inspector must neither eliminate nor take the place of the inspections by the Engineer. Upon the Engineer's receipt of written certification band the Contractor's written request for a final inspection of the installations, the Engineer will perform a final inspection.

Where required, conform to ITE, AASHTO, and ASTM standards in effect on the date of advertisement.

Notify the Engineer, local traffic enforcement agency, local utility company, and affected railroad companies seven business days before operational shutdowns to coordinate connection or disconnection to an existing utility or system.

Install meter bases and service disconnects as required by the NESC, NEC, local utility companies, and local ordinances. Install standoffs only when required and approved by the local utility companies. Where a standoff must be used, obtain the local utility company's approval prior to installing the standoff.

(D) Utility Services

Coordinate all work to ensure electrical power of proper voltage, phase, frequency, and ampacity is available to complete the work. Use electrical services cables with THW insulation.

When electrical, telephone, and telecommunication service is not furnished by the Department or the City and is required, contact the utility company and make application to ensure all work can be completed. Obtain authorization and make application for service in the Department's name for Department-owned locations and in the City's name for City-owned locations.

The Department and the City will be responsible for direct payment of monthly utility company usage charges. The Contractor will be responsible for all expenses associated with utility installation costs, hookups, etc.

(E) Maintenance and Repair of Material

Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

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 maintenance and repair of equipment during all hours.

Maintain and repair all signal and communications related equipment within the project construction limits until completion of the observation period and receipt of written notification of final acceptance of the project. This requirement for maintaining and repairing such equipment shall remain in effect in the event of a natural disaster such as a tropical storm or hurricane.

For all failures, malfunctions, or damages to equipment, begin necessary repairs within four hours of notification. Complete repairs within eight hours of notification. Comply with Section 150 of the *Standard Specifications* for maintenance of traffic flow. The inability to contact the supervisory employee or prearranged alternate will not extend repair time requirements.

Remove and replace all signal and communications related equipment that fails. The Department will furnish the Contractor replacement equipment for Department-furnished equipment that fails.

Except for damages and malfunctions caused by the Contractor's work activities, the Contractor will not be held responsible for pre-existing conditions reported to the Engineer before starting traffic signal work at the specific intersection. The Contractor will assume responsibility for all maintenance and emergency services necessary once traffic signal work has begun at the specific intersection and for all damages and malfunctions caused either directly or indirectly by the Contractor's work activities.

In the event the Contractor fails to perform in accordance with the Plans and Specifications within the time frame specified, the Department reserves the right to perform maintenance and emergency service necessary to ensure continuous traffic signal operation. Further, all expenses incurred by the Department in implementing this option will be deducted from payment due the Contractor, plus $2,500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

Perform yearly maintenance on all traffic signal conflict monitors. The year shall be defined as beginning on the date of installation of the controller and cabinet at the intersection. Use a signal conflict monitor tester that is capable of interfacing with Intel®-based notebook computer for input/output. The tester shall test signal conflict monitor displays, timing and voltage functions and input/output combinations of either true or false conflicts. All outputs shall be in plain English. It shall be possible to generate a hardcopy printout or to store the results to a file on computer disc. A "No Faults Detected" indication shall be displayed as appropriate.

Ensure that the signal conflict monitor tester is maintained and calibrated per the manufacturer's recommendation. Provide to the Engineer a copy of the manufacturer's certification that the signal conflict monitor tester has been certified before testing any traffic signal conflict monitors. Perform test on each traffic signal conflict monitor per the manufacturer's recommendation. Provide one copy of the traffic signal conflict monitor test results to the Engineer. Place one copy in the traffic signal controller cabinet. Perform these yearly tests for the life of the project.

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 the completion of the 30-day observation period and the receipt of written notification from the Engineer of final acceptance of the project.

(F) Inspections

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

(G) Removal of Existing Equipment and Material

Remove all Department-owned and City-owned signal, CCTV and communications related equipment and material that will not be used unless the Plans indicate otherwise. Signal, CCTV and communications equipment and materials to be removed under this project include, but are not limited to: signal controllers and cabinets and the equipment housed therein; signal and lead-in cables; CCTV cameras and mounting brackets; CCTV cabinets and equipment housed therein; poles; splice cabinets; cabinet foundations; messenger cable; communications cable; and guy assemblies. Assume ownership of

removed poles, messenger cable, interconnect cable, communications cable, and supporting hardware. Return all other Department-owned equipment and material, except for CCTV equipment and material, between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the Division 3 Traffic Services Office located at 5504 Barbados Boulevard in Castle Hayne, North Carolina, 28429. Return all City-owned equipment and material as well as all CCTV equipment and materials between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the City Signal Shop located at 206 Operation Center Drive off of River Road in southwest Wilmington (28412). The Department will deduct the cost of Department-owned and City-owned equipment damaged by the Contractor from money due to the Contractor.

(H) Railroad Preemption

Where railroad preemption is required, coordinate all work with the railroad. Do not place signals into operation until signal and railroad company equipment has been interconnected with required railroad-highway crossing devices and railroad preemption is working properly. Ensure preemption sequences begin immediately after activation of train detection.

Contact and coordinate with the railroad company to schedule interconnection of the signal to the railroad controller cabinet. Install lead-in cable from the signal controller cabinet to a railroad company furnished and installed lockable junction box. Interconnection will be made by the railroad company.

Provide fail-safe operation such that removal of voltage from the railroad side of the isolation relay will initiate the railroad preemption sequence.

Conduct a railroad-highway interconnection preemption inspection for each intersection prior to placing new signal equipment into steady operation. The inspection shall be performed with all appropriate Division, City and Railroad personnel in attendance. The signal shall pass all requirements of the preemption inspection before it can be accepted under the project by the Engineer. The railroad preemption inspection form is available on ITS & Signals Unit website:

www.ncdot.org/doh/preconstruct/traffic/itss/

The Contractor shall conduct additional preempt inspections annually as long as the signal is in operation under the Contractor's jurisdiction until the signal is accepted by the Engineer.

(I) Vehicle Preemption Systems

Where required, implement and install vehicle preemption systems. Coordinate vehicle preemption work with the proper operating authority. Contact the proper operating authority and schedule installation of preemption equipment.

(J) Timing of Signals

Implement timing values for signal controllers. 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.

(K) Wire and Cable

For installation in a conduit system, lubricate cable and wires before installing in conduit. Use lubricant that will not physically or chemically harm cable jacket, wire insulation, and conduit.

Splice all electrical wire and cable at recessed-screw, barrier type terminal blocks, in junction boxes, in cabinets or in condulets. Unless specifically allowed, connect no more than two conductors to the same terminal screw.

Maintain color coding of wires through splices.

Protect ends of wire and cable from water and moisture.

Install all wire and cable with necessary hardware including, but not limited to shoulder eyebolts, washers, nuts, thimbleyelets, three-bolt clamps, J-hooks, split bolt connectors, grounding clamps, and lashing material.

(L) Grounding

Provide a grounding system at all new and revised electrical service points unless otherwise specified. Where existing cabinet foundations are to be reused, existing ground rods installed through the foundations are to be disconnected and cut off flush with the foundation surface. Install new ground rod(s) and grounding conductor(s) according to the Department's *Roadway Standard Drawings*.

In addition to NEC requirements, test grounding electrode resistance at connection point to electrical service ground bus for a maximum of 20 ohms. Furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements. Submit a completed Inductive Detection Loop & Grounding Test Results form. The form is located on the Department's Web site.

Provide a length of marker tape 6 to 12 inches below finished grade directly over grounding electrodes and conductors.

(M) Electrical Bonding

Using an approved termination means, connect a # 14 AWG minimum 19-strand copper conductor (Type THW) with green insulation to serve as an equipment grounding conductor to metal poles, vehicular and pedestrian signal pedestals, and other metallic components which are not otherwise bonded through means approved by the Engineer.

(N) Traffic Signal Activation

Do not place signal in steady (stop-and-go) mode until inspected and authorized by the Engineer.

(O) Requirements for Cables Crossing Railroads

Copies of all executed railroad agreements and related correspondence may be obtained from the Resident Engineer upon request.

1) Railroad Crossings

Application has been made with CSX Transportation, Inc., herein called the Railroad Company, for the encroachment agreements necessary under this Contract. Do not commence cable routings over or under railroad-owned facilities until notification and coordination with Engineer and the appropriate Railroad Company has occurred. Install fiber optic communications cable as shown on the Plans. All work associated with the crossing is to conform to the Railroad Company's specifications.

Cable crossings include the following locations:

Plan Sheet	Location	Railroad Company
CL 3-15	N. 3rd Street/Martin Luther King, Jr. Boulevard at Parsley Street (Isabel Holmes Bridge) / Crossing # Unknown	CSX
CL 3-18	N. 23rd Street between Shirley Road and Federal Express Boulevard / Crossing # 629 286M	CSX
CL 3-24	N. 23rd Street between Division Drive and Blue Clay Road / Crossing # 628 721N	CSX

2) Insurance Requirements

Provide any required railroad liability insurance in the amount specified prior to commencing any work. If required by the railroad, pay for railroad personnel to be present when work is performed.

In addition to any other forms of insurance or bonds required under the terms of the Contract and the Standard Specifications, take out and keep in force from the commencement of all construction on railroad right-of-way until the final inspection and acceptance of the project by the Engineer, insurance of the following kinds and amount. It is understood that the amounts specified are minimum amounts and that larger amounts may be carried if so desired. Any insurance taken out due to these requirements shall be subject to the approval of the Engineer, and the Railroad Companies as to form and amount. Furnish satisfactory policies prior to beginning of the work on railroad right-of-way.

a) Public Liability and Property Damage Liability Insurance

Furnish evidence to the Engineer that with respect to the operations performed on the railroad right-of-way, regular Contractor's Public Liability and Property Damage Liability Insurance is carried providing for bodily injury, death, and property damage in the amount of $3,000,000 combined single limit per occurrence. If any part of the work is sublet, similar insurance in the same amounts and evidence thereof as required of the Prime Contractor shall be provided by or on behalf of the Subcontractor to cover his operations on the railroad right-of-way.

Endorse the Contractor's and Subcontractor's Public Liability and Property Damage Liability Insurance policies to provide Contractual Liability Coverage only in respect to obligations assumed for Contractor/Subcontractor's construction machinery left unattended at the project site, such insurance being without an exclusion denying

coverage for operations conducted within 50 feet of any railroad hazard. Type the following information on the Contractual Liability Coverage endorsement:

NCDOT Project No. U-5017 New Hanover County

Construction on the right-of-way of the CSX Transportation, Inc.
in Wilmington and New Hanover County, North Carolina

Keep such insurance in force until final inspection of the project, or that portion or portions within the railroad right-of-way, by the Engineer or, in the case of Subcontractors, until a letter is furnished to the Engineer stating that the Subcontractor has completed his subcontracted work within the railroad right-of-way to your satisfaction, and that you will accomplish any additional work necessary on the railroad right-of-way with your own forces.

b) Protective Public Liability and Property Damage Liability Insurance

If any part of the work is sublet, furnish evidence satisfactory to the Engineer that, with respect to the operations performed for the Contractor by Subcontractors on railroad right-of-way, that the Contractor also carries, in the Contractor's behalf, regular Contractor's Protective Public Liability and Property Damage Liability Insurance providing for bodily injury, death, and property damage in the amount of $3,000,000 combined single limit per occurrence.

c) Bodily Injury Liability, Property Damage and Physical Damage to Property Liability Insurance

In addition to the above insurance, furnish evidence to the Engineer that, with respect to the operations the Contractor or any of the Contractor's Subcontractors performs, the Contractor has provided for, and on behalf of the Railroad Company as their respective interest may occur, the limits of liability for the Railroad Protective Liability Policy, Coverage A. Protective Bodily Injury Liability, B. Protective Property Damage Liability, C. Physical Damage to Property Liability Insurance, shall provide for a combined single limit of $5,000,000 for all damages arising out of bodily injury, death, property damage liability, and physical damage to property liability per occurrence with an aggregate limit of $10,000,000 for the term of the policy. The Railroad Protective Liability Policy is to be prepared in accordance with the requirement of the U.S. Department of Transportation on Federal Highway Administration Federal Aid Highway Program Manual, Volume 6, Chapter 6, Section 2, Subsection 2, and any subsequent supplement thereto or revisions thereof.

d) Termination of Insurance and Policies to be Submitted

Any insurance policies given hereunder shall cover all work performed by the Contractor in connection with the work in the introductory paragraph within railroad right-of-way, but shall not be liable for accidents occurring after acceptance of the completed project by the City. Such policies shall contain a clause requiring thirty (30) days written notice be given to the Engineer and to the appropriate Railroad Company, prior to cancellation or change.

Submit to the Engineer the original and one copy of the Railroad Company's Railroad Protective Liability Policy, one certified duplicate copy of all other policies, and certificates of insurance in an original and two copies as required by these Project Special Provisions.

No extra allowance will be made for the insurance required hereunder. The entire cost shall be included in the contract unit price bids for other pay items.

The named insured under the Railroad Protective Liability Policy is the respective Railroad Company, and the designation of the job site description of work is as follows: All construction on the CSX Transportation, Inc. right-of-way on NCDOT Project No. U-5017 in Wilmington and New Hanover County, North Carolina.

3) Flagging Protection or Watchman Service

Provide 72 hours advance notice to the Railroad Company in order that flagging service can be arranged and provided. Do not undertake any work within the Railroad Company right of way until the flagman is at the job site.

4) Delays Caused by Operations of Others

Neither the Department nor the Railroad Company assumes any responsibility for any work performed by others in connection with the construction of the project, and the Contractor shall have no claim whatsoever against the Department or the Railroad Company for any inconvenience, delay, or additional cost incurred by him on account of such operations by others.

5) Time Extensions

No time extensions related to railroad encroachments will be allowed until the related work becomes the controlling factor relative to overall project completion.

6) Cooperation with Others

Cooperate with others participating in the construction of the project to the end that all work may be carried on to the best advantage.

7) Authority of Railroad Engineer

The authorized representative of the Railroad Company, hereinafter referred to as the Railroad Engineer, will have the final authority in all matters affecting the safe maintenance of railroad traffic of his company.

8) Interference with Railroad Operations

Arrange and conduct work so that there will be no interference with railroad operations, including train, signal, telephone and telegraphic services, or damage to the property of the Railroad Company or to the poles, wire, and other facilities of tenants on the rights-of-way of the Railroad Company. Wherever work is liable to affect the operations or safety of trains, first submit the method of doing such work to the Railroad Engineer for approval. However, such approval will not relieve the Contractor from liability.

Should conditions arising from or in connection with the work, require that immediate and unusual provisions be made to protect train operations and property of the Railroad Company, it shall be a part of the required services by the Contractor to make

such provisions and if, in the judgment of the Railroad Engineer such provisions is insufficient, the Railroad Engineer or the Department may, at the expense of the Contractor, require or provide such provisions as may be deemed necessary.

9) Storage of Materials

Do not store materials and equipment where they will interfere with railroad operations, nor on the rights-of-way of the Railroad Company without first having obtained permission from the Railroad Engineer. Such permission will be with the understanding that the Railroad Company will not be liable or damage to such material and equipment from any cause, and that the Railroad Engineer may move or require the Contractor to move, at the Contractor's expense, such material and equipment.

10) Completion and Acceptance of Work

Upon completion of the work, remove from within the limits of the railroad right-of-way all machinery, equipment, surplus materials, or rubbish and leave such rights-of-way in a neat and orderly condition. After the final inspection has been made and work found to be completed in a satisfactory manner acceptable to the Department and the Railroad Company, the Department will be notified of the Railroad Company's acceptance in writing by the Railroad Company.

1.5. DOCUMENTATION

(A) General

Provide all as-built documentation. All as-built plans and documentation shall be reviewed and accepted by the Engineer prior to final acceptance of the project. All documentation, except as otherwise specifically approved by the Engineer, must meet the following requirements:

1. Provide any documentation that exceeds the size of 11"x 17" paper in a reproducible format 22"x 34" in size.
2. No documentation for as-built plans smaller than 8.5"x 11" will be accepted.
3. Do not fold or crease reproducibles.

As a minimum, provide the documentation described in the paragraphs below.

(B) Plan of Record Documentation

Provide as-built drawings that depict any changes of components, measurement or layout of the Plans. Show all construction changes, with the final location and depth of conduits, wiring external to the cabinet, locations of splice closures, system detector locations, and SMFO cable terminations, etc., in detail in reproducible format. Submit as-built construction changes as soon as a change is complete. Note and date each change on the drawings. Failure to revise as-built documentation to reflect current work may result withholding of payments until the as-built documentation is brought current. The submitted as-built may be field-checked by the Engineer at his discretion. If the as-built documentation is found to have an unacceptable number of inaccuracies, the Engineer may withhold payment until the as-built plans are corrected. Include all field installation including the SMFO cable network installed on the drawings.

For underground conduit systems that house communications cable, furnish the Engineer with a plan of record drawing detailing the locations of the conduit system. For Directionally-drilled underground conduit systems, identify the vertical location (i.e., depth) of the conduits along the run.

Store documentation for signal installations in a manila envelope placed in a weatherproof holder mounted within each cabinet or housing for easy access.

Provide a manual, electrical schematic diagram, and cabinet wiring diagram for each control equipment cabinet and piece of equipment in each cabinet. Place a marked-up "redline" copy of the cabinet wiring diagram inside the cabinet immediately upon installation of the cabinet and provide an electronic copy upon final acceptance. Place all manuals and cabinet prints in a weatherproof holder. For any wiring diagrams and electrical schematic diagrams not bound into printed manuals, provide copies in a reproducible format 22"x 34" in size.

For CCTV camera assemblies, provide two copies of a parts list(s) that includes serial and model numbers of all Contractor-furnished equipment furnished prior to final acceptance. All equipment and appurtenances shall be identified by name, model number, serial number, technical support and warranty telephone numbers, and any other pertinent information required to facilitate equipment maintenance. Include a factory test procedure sheet for each type CCTV cabinet used on a project.

The Department will provide the Contractor one reproducible and one electronic copy of the Plans for his use in developing the as-built drawings. Modify the original electronic file such that all changes are marked with callout boxes or other method approved by the Engineer. Any other base maps that may be necessary for the Contractor to prepare the as-built drawings in accordance with these Project Special Provisions will be the Contractor's responsibility. Use CADD conventions that are consistent with those used on the original plans.

Within 10 days after the observation period begins, furnish one reproducible copy of the draft as-built plans in hard copy format for review. Provide draft hard copy as-built drawings on 22"x 34" bond plan sheets.

Upon receipt of review comments from the Engineer, correct any errors on and make all necessary revisions to the draft as-built plans prior to final acceptance of the project. Submit final as-built plans in electronic and hard copy format. Provide electronic plans in MicroStation (latest release in use by the Department) format on CD.

(C) Manuals

Provide at least five hard copies along with one electronic copy (on CD or DVD) of the following manuals:

- Operator's manuals containing detailed operating instructions for each different type of model of equipment. Ensure that manuals contain instructions for possible modification to equipment.
- Maintenance procedures manuals containing detailed preventative and corrective maintenance procedures and troubleshooting procedures for each different type of model of equipment.

– Installation, operations and training manuals for all Contractor-provided software.

The manuals provided above shall be in addition to manuals provided with and stored inside each control equipment cabinet.

Manuals provided for CCTV camera assemblies shall include weight and dimension information, the operating temperature and relative humidity requirements and the system's general maintenance procedures. The CCTV manuals shall also include:

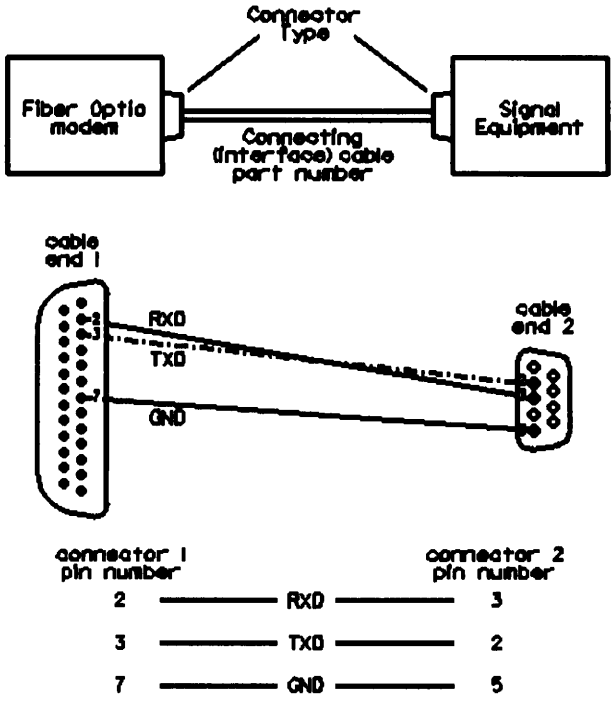
- Signal-to-noise ratios (see note below);
- Resolution;
- Sensitivity;
- Power consumption;
- Optical zoom range;
- Digital zoom range;
- Zoom and focus presets;
- Pan and tilt presets;
- Ethernet connection specifications; and
- EIA 232/422/485 camera control interface.

Note: Include a factory test procedure sheet for all CCTV cameras used on the project.

(D) Wiring Diagrams

Provide detailed wiring diagrams that include interconnection (wired and wireless) of equipment with pin-out configurations, pin functions, and cable parts numbers. This includes configuration at each field equipment cabinet or equipment cabinet at central locations. Provide two copies of system connection diagrams showing system interconnection cables and associated terminations. Use naming convention approved by the Engineer and conforming to Belcore standards. Provide one electronic copy of the wiring diagrams in MicroStation format.

Example:



(E) Splice Diagrams

Prepare as-built splice diagrams that depict the communications cable plant as constructed. Depict the splices made at each splice enclosure by identifying fiber spliced and buffer tube. Ensure the splice diagram is in a similar format to those provided with the project plans. Identify all expressed fibers, spare fibers, used fibers and capped fibers.

Original splice diagrams will be provided in electronic format in MicroStation format. Designate any changes to these diagrams by using a method approved by the Engineer. Furnish as-built splice diagrams in MicroStation format on CD and in hard copy.

1.6. MEASUREMENT AND PAYMENT

There will be no direct payment for work covered in this section. Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this section.

2. MOBILIZATION

2.1. DESCRIPTION

This work consists of preparatory work and operations, including but not limited to 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, the 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 which must be performed for costs incurred prior to the beginning of work on the various items on the project site.

2.2. COMPENSATION

All work covered by this section will be paid for at the lump sum price for "Mobilization."

Partial payments for the item of "Mobilization" will be made with the first and second partial pay estimates paid on the contract, and will be made at the rate of 50% lump sum price for "Mobilization" on each of these partial pay estimates, less than the retainage provided in Article 109-4 of the *Standard Specifications*, provided the amount bid for "Mobilization" does not exceed 5 percent of the total amount bid for the contract. Where the amount bid for the item of "Mobilization" exceeds 5 percent of the total amount bid for the contract, 2-1/2 percent of the total amount bid will be paid on each of the first two partial pay estimates, and the portion exceeding 5 percent will be paid on the last partial pay estimate. All such payments will be made less the retainage provided in Article 109-4 of the *Standard Specifications*.

Payment will be made under:

Pay Item	**Pay Unit**
Mobilization	Lump Sum

3. TEMPORARY TRAFFIC CONTROL

3.1. DESCRIPTION

Furnish, install, maintain, relocate, and remove traffic control devices in accordance with these Project Special Provisions, the Temporary Traffic Control Plan, the MUTCD, and Roadway Standard Drawings to maintain and control vehicular and pedestrian traffic in a safe and efficient manner during signal system construction. Traffic control devices required for this project include work zones signs, flashing arrow panels, changeable message signs, drums, cones, barricades, use of flaggers, truck mounted impact attenuators (TMIA), skinny drums and the use of police.

3.2. GENERAL REQUIREMENTS

(A) Maintenance of Traffic

The Contractor will be required to maintain traffic, both vehicular and pedestrian, within the limits of the project, including roadways that cross or intersect the project, unless otherwise provided for in the contract or approved by the Engineer.

(B) Temporary Traffic Control Plan

1) General

Maintain vehicular and pedestrian traffic through work zones in accordance with these Project Special Provisions, the Temporary Traffic Control Plan, the MUTCD, and Roadway Standard Drawings.

If a conflict arises, Phasing and Drawings govern over project notes, and local notes govern over general notes.

2) Phasing

Complete the requirements of each Step before proceeding to the next Step, unless the Plans permit work to be performed concurrently.

3) Project Notes

General Notes included in the Traffic Control Plan apply at all times during the project.

4) Alternate to Traffic Control Plan

If desired, submit an alternate traffic control plan a minimum of 30 calendar days in advance of the anticipated implementation to allow for adequate review time. Do not implement alternate plans for traffic control until approved in writing and properly sealed. No adjustment in compensation or extension of the completion date(s) will be allowed due to the review time of the alternate. If an alternate traffic control plan is implemented, the Contractor shall be responsible for any unanticipated changes to subsequent Steps.

5) Traffic Control Plan not fully covered in the Contract

When the Traffic Control Plan does not cover a particular work function, notify the Engineer to allow for the development or modification of a sealed set of the Traffic Control Plans.

(C) Temporary Lane Closures

1) General

Operate all equipment and personnel within the designated work area during lane closures. Do not impede or stop traffic for the purpose of performing construction related work on the traffic side of the lane closure, except when called for in the Temporary Traffic Control Plan.

Install lane closures with the traffic flow, beginning with devices on the upstream side of traffic. Remove lane closures against the traffic flow, beginning with devices on the downstream side of traffic.

Vehicles used to install or remove lane closures shall have flashing or rotating beacons.

2) Intersections

When construction proceeds through an intersection, provide flagger(s) and all other necessary Traffic Control as required by the Plans to direct the traffic through the intersection. When an intersection is signalized, have authorized personnel place the signal in flash mode prior to beginning work in the intersection.

When it is necessary to close a lane of traffic for construction on the departure (downstream) side of an intersection, implement the lane closure on the approach (upstream) side of the intersection. Close the appropriate lane of dual turn lanes that would otherwise turn into the lane that is closed on the departure side of the intersection.

(D) Temporary Road Closures

1) Traffic Pattern Alterations

Notify the Engineer 21 calendar days, or as specified, prior to altering the existing traffic pattern.

Pre-plan all traffic pattern alterations. Meet with the Engineer to discuss the implementation strategy before altering traffic. The Engineer will then notify the proper authorities and other affected parties as necessary.

2) Traffic Stoppage

Limit the stoppage of traffic to times specified in the Plans. Provide enough time between consecutive stoppages to allow the traffic queue to dissipate.

(E) Traffic Control Supervision

Designate a Traffic Control Supervisor for the project who is knowledgeable of Temporary Traffic Control Plan design, devices and application, and has full authority to ensure traffic is maintained in accordance with the contract. Coordinate with Department's project traffic control representative on all details concerning the Contractor's traffic control program.

Provide a Traffic Control Supervisor or designated representative to be on call at all times to make any necessary changes in the traffic control operations in a timely manner.

Coordinate with and cooperate with traffic control supervisors of adjacent or overlapping construction projects to insure safe and adequate traffic control is maintained throughout the projects at all times including periods of construction inactivity.

(F) Vehicular Access

Maintain continuous and safe vehicular access, including but not limited to, all residences, businesses, schools, police and fire stations, hydrants, other emergency services, hospitals and mailboxes. Conduct operations in such a manner as to limit the inconvenience to property owners.

(G) Pedestrian Access

Maintain continuous and safe pedestrian access, including but not limited to, all residences, businesses, schools and mailboxes. Conduct operations in such a manner as to limit the inconvenience to pedestrians. Pay special attention to pedestrian areas used by visually-impaired pedestrians. Coordinate with local Orientation and Mobility Specialists to make appropriate provisions for visually impaired pedestrians when construction activities will disrupt pedestrian paths that they normally use.

Protect open excavations within or adjacent to areas subject to pedestrian traffic from pedestrian intrusion by surrounding the excavation/hazard with orange plastic mesh construction fencing (also referred to as safety fence, tree protection barricade, warning fence, etc.) or other method approved by the Engineer. Do not use tape, flagging, rope or plastic chain strung between barricades, cones or stakes.

3.3. WORK ZONE TRAFFIC CONTROL DEVICES

(A) General

Furnish, install, maintain, relocate, and remove traffic control devices in accordance with the Plans and Project Special Provisions. All traffic control devices furnished by the Contractor will remain the property of the Contractor, unless otherwise specified in the contract.

(B) Work Zone Signs

Furnish, install, maintain, temporarily cover and uncover signs, relocate and remove work zone signs (barricade mounted) in accordance with the contract.

Furnish, install, maintain and relocate portable work zone signs and portable work zone sign stands in accordance with the contract. When portable work zone signs and portable work zone sign stands are not in use for periods longer than 30 minutes, collapse or remove sign stands and reinstall once work begins again.

Use portable work zone signs only with portable work zone sign stands specifically designed for one another. Portable work zone signs may be roll up or approved composite signs.

(C) Flashing Arrow Panels, Type C

Furnish, install, place, operate, maintain, relocate, and remove flashing arrow panels in accordance with the contract.

(D) Changeable Message Signs

Furnish, install, maintain, relocate and remove changeable message signs in accordance with the contract.

(E) Cones

Furnish, install, relocate, maintain, and remove cones and reflective cone collars in accordance with the contract.

(F) Barricades

Furnish, erect, maintain, relocate, ballast, and remove barricades in accordance with the contract.

(G) Flaggers

Furnish, relocate, and maintain the flaggers, hats, vests and STOP/SLOW Paddles and any other incidentals necessary to complete the work in accordance with the contract.

(H) Truck Mounted Impact Attenuators

Furnish, install, operate, maintain, and relocate truck mounted impact attenuators (TMIA) in accordance with the contract.

(I) Skinny Drums

Furnish, install, maintain, relocate, and remove Skinny Drums with ballast in accordance with the contract.

(J) Police

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

3.4. MATERIALS

(A) Work Zone Traffic Control Devices

Refer to Division 10 of the *Standard Specifications*.

Supply certifications that meet the requirements of *Standard Specifications* Article 106-3, at least 72 hours prior to use for all used traffic control devices.

Provide traffic control devices that are listed on the Department's Approved Product List or accepted as traffic-qualified by the Work Zone Traffic Control Unit.

(B) Work Zone Signs

1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Work Zone Signs	1089-1
Work Zone Sign Supports	1089-2
Barricade Mounted Signs	1089-3

2) Material Qualifications

Provide portable work zone sign stands, portable signs and sheeting that meet the requirements of NCHRP 350 for Category II traffic control devices and are listed on the Department's Approved Products List and accepted as traffic-qualified by the Work Zone Traffic Control Unit.

Provide portable work zone signs and stands that are crash tested by the manufacturer. The portable work zone sign and the portable work zone sign stand shall be crash tested together as a system.

(C) Flashing Arrow Panels, Type C

1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Flashing Arrow Panels	1089-6

2) Material Qualifications:

Use Flashing Arrow Panels that have been evaluated by NTPEP.

Use Flashing Arrow Panels that are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(D) Changeable Message Signs

1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Changeable Message Signs	1089-7

2) Material Qualifications:

Use Changeable Message Signs that have been evaluated by NTPEP.

Use Changeable Message Signs that are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(E) Drums

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Drums	1089-5

Provide drums that are on the Department's Approved Products List or are traffic-qualified by the Work Zone Traffic Control Unit.

(F) Cones

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Cones	1089-5

Provide cones that are on the Department's Approved Products List or are traffic-qualified by the Work Zone Traffic Control Unit.

(G) Barricades

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Barricades	1089-3

Provide barricades that meet the requirements of NCHRP 350 for Category II traffic control devices and are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(H) Flaggers

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Flaggers	1089-12

(I) Truck Mounted Impact Attenuators

1) General:

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Truck Mounted Impact Attenuators	1089-9

2) Material Qualifications:

Use TMIAs that meet the requirements of NCHRP 350 Test Level II or III for work zone traffic control devices and are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

(J) Skinny Drums

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Skinny Drums	1089-5

Provide Skinny Drums that are on the Department's Approved Products List and are traffic-qualified by the Work Zone Traffic Control Unit.

3.5. CONSTRUCTION METHODS

(A) Work Zone Traffic Control Devices

Have all traffic control devices inspected and approved prior to using them on the project.

Install traffic control devices before construction operations begin and during the proper phase of construction. Maintain and relocate traffic control devices during the time they are in use. Keep these devices in place as long as they are needed and immediately remove thereafter. When operations are performed in stages, install only those devices that apply to the present conditions.

(B) Work Zone Signs

1) Work Zone Signs (Barricade Mounted)

Mount approved composite or roll up signs to barricade rails so that the signs do not cover more than 50 percent of the top two rails or 33 percent of the total area of the three rails. Signs shall be mounted a minimum of 1 foot from the ground to the bottom of the sign.

2) Work Zone Signs (Portable)

Install the portable work zone sign and sign stand to stand plumb within 10° left and right, within 20° front and back and be capable of standing erect in windy conditions.

When not in use for periods longer than 30 minutes, lay the portable work zone sign flat on the ground and collapse the sign stand and lay it flat on the ground.

Clean the sign face prior to use.

Install portable work zone sign stands to carry roll up or approved composite signs at a minimum height of 1 foot from the bottom of the sign to the edge of pavement elevation on two-lane two-way roadways and at least 5 feet from the bottom of the sign to the edge of pavement elevation on multi-lane roadways.

(C) Flashing Arrow Panels, Type C

Use arrow panels that have the capability to display mode selections.

Do not use straight-line caution or chevron displays.

Mount flashing arrow panels on trucks, trailers, or other mobile units.

(D) Changeable Message Signs

Mount all changeable message signs on a trailer, or truck, as specified in the Plans, designed to adequately support the message board in a level position. Align and sight the changeable message sign to provide optimal driver visibility. Sign operator will adjust flash rate so that no more than two messages will be displayed and be legible to a driver when approaching the sign at the posted speed.

Relocate the units for the various stages of construction as shown in the Plans or as needed to adequately inform the motorists.

Provide an experienced operator for the changeable message sign during periods of operation to ensure that the messages displayed on the sign panel are in accordance with the Plans and in accordance with message content guidelines. Ensure that the message sign is illuminated properly to meet the existing light conditions, and that all adjustments for operation of the sign are made as needed to properly guide motorists.

Expedite repairs due to failure, malfunction, or damage to a changeable message sign. Furnish another changeable message sign (approved by the Engineer and at no additional cost) during the repair time. Repair and/or replace changeable message sign immediately; otherwise, suspend all construction activities requiring the use of the sign until the sign is restored to operation.

(E) Drums

Use the same type of reflective sheeting on all drums installed at any one time during the life of the project.

Use a ballasting method in accordance with the manufacturer's specification. When using tire ballasting method, use approved manufacturer's tires and place the tires flush with the ground.

(F) Cones

Use reflective collars on all cones used between dusk and dawn. Use the same type of reflective sheeting on all cone collars installed at any one time during the life of the project. Do not use cones in the upstream taper of lane or shoulder closures for multilane roadways and use for no longer than 3 consecutive days.

(G) Barricades

At the end of the workday, properly close the road where construction equipment accesses a road closure through Type III barricades.

Use sandbags or other approved ballasting methods to prevent overturning of barricades by the wind. If needed, place sandbags or other acceptable ballasting on the feet of the frame. Do not ballast barricades with objects such as rocks or chunks of concrete.

Do not anchor barricades to any pavement surfaces unless such anchoring method has passed the crash test requirement of NCHRP 350 for work zone category II devices.

Point the striped diagonals on the barricade rails in the direction traffic is being directed.

(H) Flaggers

Provide the services of competent and properly equipped flagger(s) (see Roadway Standard Drawing No. 1150.01) at locations and times for such periods as necessary for the control and protection of vehicular and pedestrian traffic. Use flagging methods that comply with the guidelines in the MUTCD.

(I) Truck Mounted Impact Attenuator

Prior to use, furnish the Engineer detailed brochures, specifications, and other manufacturer's data that completely describes the performance criteria, installation, and instructions for the TMIA.

Use only TMIAs that meet the crash test requirements of *Standard Specifications* Article 1089-9(A).

Do not park TMIAs against rigid objects (i.e. bridge piers or portable concrete barrier) except as a temporary safety measure and in no case for longer than 72 hours. Install the TMIA on a truck that is fully operational, in good running order, and in accordance with the manufacturer's specifications.

Use the appropriate lighting and delineation on the truck and TMIAs as shown in the contract.

(J) Skinny Drums

Use the same type of reflective sheeting (minimum of Type III) on all skinny drums installed at any one time during the life of the project.

Use ballasting methods in accordance with the manufacturer's specification.

Use skinny drums as follows:

Skinny drums may be used in lieu of cones.

Space skinny drums equal in feet to the posted speed limit, not to exceed 50 foot spacing in the tangent sections on multilane roadways.

Do not use skinny drums as follows:

Do not use skinny drums for tapers on multilane roadways.

Do not substitute skinny drums for normal drums or intermix with drums unless directed by the Engineer or the Traffic Control Plans.

Do not use skinny drums to separate two directions of travel that have been shifted on a multilane roadway unless directed by the Engineer or Traffic Control Plans.

Do not use skinny drums for lane closures on multilane roadways for longer than 3 consecutive days.

(K) Police

Use uniformed police officers and marked police vehicles equipped with police lights mounted on top of the vehicle and police vehicle emblems to direct or control traffic as required by the Plans or by the Engineer.

Use a police officer(s) when an existing traffic signal must be taken out of operation in order to remove and replace the existing cabinet and controller. Use a police officer(s) when a traffic signal must be deactivated while constructing a conduit entrance into an existing cabinet foundation (subject to the Engineer's prior approval), while overlaying an existing cabinet foundation with a new preformed foundation and while removing and replacing an existing foundation with a new preformed foundation in the same location.

(L) Pedestrian Safety

Install measures for separating pedestrian traffic from the work area and from adjacent vehicular traffic where pedestrian paths are evident or sidewalks are present. Use protective barricades, warning and guidance devices and signs to provide a safe, well-defined passageway for pedestrians. When a sidewalk must be closed temporarily to perform construction work, refer to Chapter 6D, "Pedestrian and Worker Safety," and Typical Applications 28 and 29 (TA-28 and TA-29) of the 2003 Edition of the *Manual on Uniform Traffic Control Devices* (MUTCD 2003) for appropriate pedestrian traffic control measures. The MUTCD 2003 is available for downloading via the Internet from the following web address: http://mutcd.fhwa.dot.gov

3.6. MAINTENANCE AND INSPECTION

(A) Work Zone Traffic Control Devices

Submit a proposed traffic control device maintenance schedule and checklist for approval prior to construction. Perform continuous maintenance and scheduled inspections of traffic control devices. Review and maintain all traffic handling measures to ensure that adequate provisions are in place for the safety of the public and workers.

Maintenance activities include cleaning of dirty devices or repair or replacement of traffic control devices that are damaged (torn, crushed, discolored), displaced by traffic or other means, or deteriorated beyond effectiveness.

If there are traffic control devices in use, perform inspection on a daily basis.

The name and telephone number of the agency, contractor or supplier may be shown on the non-retroreflective surface of all channelizing devices. Use letters and numbers that are a non-reflective color and not over 2 inches in height.

(B) Changeable Message Signs

Perform all maintenance operations recommended by the manufacturer of the sign. Include the periodic cleaning of the sign face and associated solar panels in maintenance operations.

(C) Drums

At no cost to the Department, immediately replace any drum, ballast or reflective sheeting that is torn, crushed, discolored, or otherwise damaged.

(D) Cones

At no cost to the Department, immediately replace any cone or reflective collar that is torn, crushed, discolored, or otherwise damaged.

(E) Barricades

At no cost to the Department, periodically inspect barricades and ballast. Replace any ballast as needed, including sandbags that have loose sand outside the bag.

(F) Truck Mounted Impact Attenuators

Repair or replace within 24 hours any truck mounted impact attenuator that becomes crushed or otherwise damaged so that it will perform its intended purpose. Suspend all construction activities until the attenuator is repaired or replaced. Provide safe control of traffic until the attenuator has been repaired by using approved methods.

(G) Skinny Drums

At no cost to the Department, immediately replace any Skinny Drum, ballast, or reflective sheeting that are torn, crushed, discolored, or otherwise damaged.

3.7. FAILURE TO MAINTAIN TRAFFIC CONTROL

Failure to maintain temporary traffic control measures and traffic control devices in accordance with this Special Provision may result in formal notification of noncompliance. Implement remedial action immediately for imminent danger situations as directed. Implement remedial action within 48 hours after notification of a safety issue that is not an imminent danger situation.

Failure to comply may result in having the work performed with available forces and equipment. The Contractor is held responsible for this work, and the actual cost of performing said work will be deducted from the moneys due the Contractor on the contract. In cases of willful disregard for the safety of the public, the Engineer may proceed immediately to implement the measures necessary to provide the appropriate level of traffic control to ensure that the safety of all concerned parties is maintained.

3.8. MEASUREMENT AND PAYMENT

Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this Special Provision.

Work zone signs (barricade mounted) will be measured and paid for as the actual number of square feet that have been satisfactorily installed on barricades and accepted by the Engineer. Payment will be made for the initial installation only. Relocation of signs will be considered incidental to the measurement of the quantity of signs.

Work zone signs (portable) will be measured and paid for as the actual number of square feet that have been satisfactorily installed and accepted by the Engineer. Payment will be made for the initial installation only. Relocation of signs will be considered incidental to the measurement of the quantity of signs.

No direct payment will be made for stationary work zone sign supports or portable work zone sign stands. All stationary work zone sign supports or portable work zone sign stands are considered incidental to the work of providing work zone signs.

Flashing arrow panels, Type C will be measured and paid for as the maximum number of panels that have been satisfactorily placed and accepted by the Engineer in use at any one time during the life of the project as required by the contract.

Changeable message signs will be measured and paid for as the maximum number of changeable message signs acceptably placed and in operation, at any one time during the life of the project. Payment for changeable message signs will be made according to the following schedule:

70% of the unit bid upon placing the unit in service.
20% of the unit bid when the project is 50% complete.
10% of the unit bid when the project is 100% complete.

Drums will be measured and paid for as the maximum number of drums acceptably placed and in use at any one time during the life of the project. Relocation of drums is considered incidental to the measurement of the quantity of drums and no separate payment will be made.

Cones will be measured and paid for as the maximum number of cones acceptably placed and in use at any one time during the life of the project. Relocation of cones is considered incidental to the measurement of the quantity of cones and no separate payment will be made.

Barricades (Type III) will be measured and paid for as the maximum number of linear feet of barricades acceptably placed and in use at any one time during the life of the project. Measurement will be made of the total length of each barricade along one rail. Relocation of barricades is considered incidental to the measurement of the quantity of barricades.

Flaggers (hour) will be measured and paid for as the actual number of hours that each flagger is satisfactorily provided and accepted by the Engineer during the life of the project. The Department will pay for all flaggers that are used in conjunction with a lane closure. Flaggers used for operations not involving a lane closure will be considered incidental to that operation and no payment will be made.

TMIA will be measured and paid for as the maximum number of TMIAs acceptably placed and in use at any one time during the life of the project for all operations other than moving and mobile operations. TMIAs are considered incidental to all moving and mobile operations. In the case of emergency situations, TMIAs will not be paid for when payment has already been made for a stationary unit. Relocation of TMIAs are considered incidental to the measurement of the quantities of TMIAs and no separate payment will be made.

Skinny drums will be measured and paid for as the actual number of skinny drums satisfactorily placed, accepted by the Engineer and in use at any one time during the life of the project. Relocation of skinny drums is considered incidental to the measurement of the quantity of skinny drums and no separate payment will be made.

Police will be measured and paid for as the actual number of hours that each police officer is provided during the life of the project as approved by the Engineer and subject to the following conditions:

- Measurement and payment will not exceed 3 hours per police officer provided to direct traffic at a given signalized intersection during the removal and replacement of a controller cabinet.
- Measurement and payment will not exceed 1 hour per police officer provided to direct traffic at a given signalized intersection while constructing a new conduit entrance into an existing cabinet foundation, overlaying an existing

cabinet foundation with a new preformed foundation or replacing an existing foundation with a new preformed foundation in the same location.

There will be no direct payment for marked police vehicles as they are considered incidental to the pay item.

No measurement will be made of orange plastic mesh construction fencing or other approved methods of protecting open excavations/hazards from pedestrian intrusion as such measures will be considered incidental to the excavation work.

Payment will be made under:

Pay Item	**Pay Unit**
Work Zones Signs (Barricade Mounted)	Square Foot
Work Zones Signs (Portable)	Square Foot
Flashing Arrow Panel, Type C	Each
Changeable Message Sign	Each
Drums	Each
Cones	Each
Barricades (Type III)	Linear Foot
Flaggers	Hour
TMIA	Each
Skinny Drums	Each
Police	Hour

4. MESSENGER CABLE

4.1. DESCRIPTION

Furnish and install messenger cable (span wire) with cable clamps, machine bolts, eyebolts, 3-bolt clamps, eye nuts, split-bolt connectors, metal pole clamps, stainless steel bands and all necessary hardware.

4.2. MATERIAL

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

Comply with ASTM A 475 for extra high strength grade wire strand, Class A zinc coating. Fabricate messenger cable from seven steel wires twisted into a single concentric strand.

Provide universal grade strandvises used for extra high strength steel messenger cable. Provide other pole line hardware constructed of hot-dipped galvanized steel. Provide machine bolts, eyebolts, and thimbleye bolts with minimum tensile strength of 12,400 lbs. Provide galvanized nuts, washers, and thimbleyelets.

Provide galvanized metal pole clamps and stainless steel banding hardware for attaching pole line hardware (e.g., strandvises, three-bolt clamps, etc.) to metal signal poles.

4.3. CONSTRUCTION METHODS

Install new messenger cable and new guy assemblies within 120 days of notice to proceed. Refer to Section 1, "General Requirements", of these Project Special Provisions for additional requirements.

Install guy assemblies before installing messenger cable.

Use 3/8-inch messenger cable for spans supporting vehicle signal heads, and/or signs.

Use 1/4-inch messenger cable for spans supporting only cables unless otherwise specified.

For messenger cable crossing over railroad tracks, provide a minimum of 27 feet of vertical clearance, unless otherwise specified.

For permanent installations, install messenger cable in continuous lengths with no splices except where an insulator is required. With prior approval, existing messenger for temporary installations may be extended instead of installing new messenger cable.

Tension messenger cable to match sag of surrounding utilities. Otherwise, allow 3 to 4 percent sag of the span length between poles.

Provide three-bolt clamp assemblies consisting of 5/8-inch diameter machine bolts, J-hooks, washers, and square nuts to attach messenger cable to wood poles. Provide machine bolts that are 3 inches longer than the pole diameter.

Attach messenger cable to poles using three bolt cable clamps with J-hooks in mid-runs and dead-end strandvises at termination poles.

Attach messenger cable to metal signal poles using approved galvanized metal pole clamps or stainless steel bands to attach strandvises and three-bolt clamps. Do not drill holes in metal poles to attachment messenger cable. Do not attach messenger cable to metal or concrete poles that are owned by anyone other than the City or the Department without prior approval of the Engineer and the pole owner. Where such attachments are approved, use attachment methods and hardware approved by the pole owner.

Maintain electrical continuity at all splices.

For messenger cable attached to joint use poles, bond messenger cable to existing pole ground using # 6 AWG minimum solid bare copper grounding wire terminated with split bolt connectors or Burndy clamps (UCG25RS) at each end. If existing poles do not have a grounding system, install new grounding system that complies with the Construction Methods in the "Wood Poles" section of these Project Special Provisions for bonding messenger cable. Bond messenger cable that supports communications cable to pole ground at 1300-foot intervals.

On multiple messenger cable arrangements, connect all messenger cable ends with # 6 AWG minimum solid bare copper wire and bond with split bolt connectors or Burndy clamps (UCG25RS) or equivalent and terminate to pole ground.

On joint use poles at signal and ITS equipment installations (i.e., controller cabinets, CCTV cabinets, DMS cabinets, etc.), do not use existing utility company grounds. Install a grounding system for the signal and ITS equipment.

4.4. MEASUREMENT AND PAYMENT

Messenger cable (_____) will be measured and paid for as actual horizontal linear feet of messenger cable of each size furnished, installed, and accepted. Measurement will be point to point with no allowance for sag.

No measurement will be made of cable clamps, machine bolts, eyebolts, three-bolt assemblies, eye nuts, split bolt connectors, metal pole clamps, stainless steel banding hardware and pole grounding systems as these will be considered incidental to furnishing and installing messenger cable.

Payment will be made under:

Pay Item	Pay Unit
Messenger Cable (1/4")	Linear Foot

5. UNDERGROUND CONDUIT

5.1. DESCRIPTION

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

5.2. MATERIAL

(A) General

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

Refer to the following articles of the *Standard Specifications*:

Backfill 1018-2
Graded Stone 545-2 and 545-3

Use conduit bodies, boxes, and fittings that meet UL Standard 514B Conduit, Tubing, and Cable Fittings for electrical and communications installations.

(B) Conduit Types

(1) Rigid Metallic Conduit

Provide rigid hot dipped galvanized steel conduit that meets UL Standard 6 Electrical Rigid Metal Conduit-Steel with rigid full weight sherardized or galvanized threaded fittings.

(2) Polyvinyl Chloride (PVC)

Provide non-metallic conduit and duct including associated couplings, approved for above and below ground use with or without concrete encasement in accordance with UL Standard 651A Type EB and A Rigid PVC Conduit and HDPE Conduit. Provide Schedule 40 conduit unless otherwise specified.

(3) 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 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 a smooth outer wall and either a smooth or 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.

(C) Conduit Plugs, Sealing Putty, Pull Line, and Tracer Wire

Furnish duct plugs that provide a watertight barrier when installed in conduit. Furnish duct plugs sized in accordance with conduit. Ensure duct plug provides a means to secure a pull line to the end of the plug. Provide removable and reusable duct plugs.

Furnish mechanical sealing devices that provide a watertight barrier between conduit and cables in conduit. Furnish mechanical sealing devices sized in accordance with conduit and with appropriately sized holes to accommodate and seal cables. Provide removable and re-usable mechanical sealing devices.

Furnish moldable sealing putty that has the following characteristics:

- Comply with Subarticle 1400-2(H) Duct and Conduit Sealer of the *Standard Specifications;*
- Contains no asbestos;
- Designed for use with electrical and telecommunications cables housed in conduits;
- Requires no mixing or additives (single-component) and requires no volatile solvents; and
- Can be applied by hand.

Furnish 1/2", pre-lubricated, woven polyester tape, pull line with minimum rated tensile strength of 2,500 lb.

Provide green insulated # 14 AWG, THW, stranded copper wire to serve as tracer wire.

Furnish non-detectable underground marker tape with the wording "WARNING – Fiber-Optic Cable" in all trenches containing one or more conduits that will house fiber-optic communications cable.

5.3. CONSTRUCTION METHODS

(A) General

Except where the Plans call for a specific installation method or where the Engineer directs otherwise, underground conduit may be installed by either trenching, directional drilling or plowing at the option of the Contractor.

Refer to Section 1 of these Project Special Provisions for additional requirements concerning work within and adjacent to historic districts.

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

Where cable is not immediately installed and where conduit is for future use (spare), seal the ends of the conduit with a duct plug immediately upon installation of the conduit. 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.

Where the Plans call for installation of 1.25" HDPE conduit, the Contractor may substitute 2" HDPE conduits in the same quantity at no additional cost to the Department. However, all conduits installed in a common trench or bore must be the same size and all conduits in a continuous longitudinal run must be the same size. Do not intermix different size conduits in the same run.

Install a minimum of two conduits for all underground communications cable routes unless shown otherwise on the Plans.

Install a minimum of two conduits for all directional drill installations beneath roadways, railroad rights-of-way or streams or which run longitudinally beneath a sidewalk.

Install junction boxes in underground conduit runs as shown on the Plans. Do not exceed 1500 feet between junction boxes in any underground conduit route that conveys communications cable without the prior approval the Engineer.

1) Conduit Entering Junction Boxes

Terminate conduits installed for communications cables in oversized or special-sized, heavy-duty junction boxes as shown on the Plans. Do not install other conduits in these junction boxes 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 fiber-optic communications cable with mechanical sealing devices or with moldable sealing putty. Seal conduits containing signal cable and loop lead-in wire with moldable sealing putty.

2) Tracer Wire

Install tracer wire in all conduits containing fiber-optic cable. Pull tracer wire simultaneously in a continuous length with the fiber-optic cable. Where multiple pulls of

fiber-optic cable are required and conduit is placed in the same trench, only one tracer wire is required. Where multiple pulls of fiber-optic cable are required and conduits may separate into individual trenches, install a tracer wire in each conduit run. Provide waterproof butt splices where tracer wire is spliced. Splicing is allowed only in cabinets and junction boxes. Label all tracer wires entering the equipment cabinet.

3) Ground Surface Restoration

Upon completion of conduit installation and backfilling of all trenches and other excavations, restore the disturbed ground to its original condition as determined and approved by the Engineer. For paved areas, replace removed or damaged pavement with in kind materials, matching the elevation, color, texture/finish and general appearance of the surrounding pavement. Refer to Section 1 of these Project Special Provisions for additional requirements concerning sidewalks and curbs in historic districts. For unpaved areas, backfill excavations with removed material, tamp the backfilled material and rake smooth the top 1-1/2 inches. Finish unpaved areas flush with surrounding natural ground and to match the original contour of the ground. Seed the unpaved areas with same type of grass as surrounding area and mulch the newly seeded area. If unpaved area was not grassed, replace the original ground cover in kind as directed by the Engineer.

4) Plan of Record Drawings

Upon completion of the conduit system for communications, furnish the Engineer with a plan of record drawing detailing locations of the conduit system. For directionally drilled conduits, provide both the horizontal and the vertical (i.e., depth) locations.

(B) Trenching

1) General

Install PVC, HDPE, or rigid metallic conduit for all underground runs as specified in the Plans. Install rigid metallic conduit for all underground runs located inside railroad right-of-way. Clean existing underground conduit to be incorporated into a new system. Bond all metallic conduit.

If more than one (1) conduit is required between the same points, install conduit in one (1) common trench.

Install non-detectable marker tape longitudinally in the trench 6" to 12" below the unpaved ground surface or below the underside of the paved surface.

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 (7) 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.

Use HDPE conduit in trenched areas unless otherwise specified in the Plans. Use 2-inch PVC or rigid galvanized conduit between junction boxes adjacent to the controller cabinet and the 2-inch conduit stub-outs from the cabinet foundation.

2) Unpaved Trenching

Install conduit in 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 and match the original concrete as to color and finish 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 to temporarily maintain traffic where repairs cannot be performed immediately. Comply with Article 545-4 of the *Standard Specifications*.

(C) Plowing (HDPE Conduit Only)

Direct plow HDPE ducts simultaneously using chute plow method. Direct plow ducts at a minimum depth so the top of the highest duct is 30 inches deep unless otherwise approved.

Provide sufficient personnel to feed chute, operate prime mover and equipment carrying reels (if separate equipment is used), observe chute feeding, observe plowing, and observe reel payout. Use chute with adequate dimensions to allow for passage of duct without damage. During plow operation, continuously check chute opening and path to be sure there are no obstructions and monitor payout reels to be sure reels are turning at a steady rate.

(D) 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.

(E) Maximum Length of Directional Drill

The length of a directional drill shall not exceed 1000 feet measured horizontally along the route of the directionally drilled conduit(s), unless otherwise approved by the Engineer. On or before the 1000-foot mark, transition from directional drill to trenching to continue the route up to the maximum spacing of 1500 feet between junction boxes. Alternatively, continue the route by beginning a successive directional drill and installing an oversized heavy-duty junction box where the two directional drilled conduit runs meet.

(F) Splicing and Coupling of HDPE Conduit

Install HDPE in continuous lengths. Splicing or joining of HDPE conduits is prohibited. If unforeseen problems are encountered at a specific location during installation necessitate the splicing or coupling of HDPE conduits, obtain the Engineer's prior approval to install a junction box and splice or join the conduits in the junction box using an Engineer-approved splicing or coupling method. Approval of splicing/coupling at one location does not constitute approval for splicing/coupling conduits at any other location on the project.

5.4. MEASUREMENT AND PAYMENT

Tracer wire will be measured as the horizontal linear feet of tracer wire furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be made in linear feet. No payment will be made for excess tracer wire in junction boxes and/or cabinets.

Underground conduit (qty)(size) will be measured horizontal linear feet of underground conduit installation of each type furnished, installed, and accepted, without regard to the installation method. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

Directional drill (qty)(size) will be measured horizontal linear feet of directional drill for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. When directional drilling is used where the Plans call for "Underground Conduit", directional drilling will be measured as Underground Conduit.

No measurement will be made of vertical segments, non-metallic conduit, metallic conduit, sealing devices, pull lines and miscellaneous fittings as these will be considered incidental to conduit installation. No measurement will be made of restoration of paved and unpaved ground surfaces with like materials, including but not limited to backfill, graded stone, paved materials, seeding and mulching, as this work will also be considered incidental to conduit installation. No measurement will be made of removing, stockpiling and resetting existing granite curb, bricks, stones and pavers as such work will be considered incidental to conduit installation.

No measurement will be made of horizontal segments between the base of a riser and an adjacent junction box or base-mounted cabinet foundation that are 10 feet or less in length measured from the center of the riser to the center of the junction box or from the center of the riser to the near edge of the cabinet foundation as these will be considered incidental to riser installation.

Conduit will be paid for per linear foot based on quantity and size of conduits. As examples, an installation of a single 1.25" HDPE conduit would be paid as:

Directional Drill (1)(1.25") Linear Foot

An installation of two 1.25" and four 2" HDPE conduits would be paid as:

Directional Drill (2)(1.25")&(4)(2") Linear Foot

Payment will be made under:

Pay Item	**Pay Unit**
Tracer Wire	Linear Foot
Underground Conduit (2)(1.25")	Linear Foot
Underground Conduit (1)(2")	Linear Foot
Directional Drill (1)(1.25")	Linear Foot
Directional Drill (2)(1.25")	Linear Foot

6. JUNCTION BOXES

6.1. DESCRIPTION

Furnish and install junction boxes (pull boxes) with covers, graded stone, grounding systems, and all necessary hardware.

6.2. MATERIAL

(A) General

Comply with Article 1411-3 Electrical Junction Boxes, except as follows:

Provide junction box covers with standard *Traffic Signal* or *NCDOT Fiber Optic* logos, pull slots and stainless steel pins. For standard size junction boxes, provide covers with *Traffic Signal* logo. Provide covers with *Traffic Signal* logo on oversized heavy-duty junction boxes used to intercept, splice and extend existing field wiring for a traffic signal. Provide covers with *NCDOT Fiber Optic* logo on all oversized and special-sized, heavy-duty junction boxes that house fiber-optic communications cable.

Do not provide sealant compound between junction boxes and covers.

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

Refer to Section 545, "Graded Stone," of the *Standard Specifications*.

(B) Standard Size Junction Boxes

Provide standard size junction boxes with minimum inside dimensions of 16"(l) x 10"(w) x 10"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77. Vertical extensions of 6" to 12" shall be available from the junction box manufacturer.

(C) Oversized Heavy-Duty Junction Boxes

Provide oversized heavy-duty junction boxes and covers with minimum inside dimensions of 30"(l) x 15"(w) x 24"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

(D) Special-sized, Heavy-Duty Junction Boxes

Provide special-sized heavy-duty junction boxes and covers with minimum inside dimensions of 36"(l) x 24"(w) x 24"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

6.3. CONSTRUCTION METHODS

Comply with Article 1411-3 Electrical Junction Boxes of the *Standard Specifications*, except as follows:

Install 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.

Install oversized, heavy-duty junction boxes in underground fiber-optic communications cable runs at maximum intervals of 1500 feet, or where shown in the Plans, whichever is less.

Install special-sized, heavy-duty junction boxes at all underground splice enclosure locations.

Install standard size junction boxes in underground runs of signal cable and lead-in cable at maximum intervals of 250 feet or where shown in the Plans, whichever is less.

6.4. 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 grounding systems as these will be considered incidental to furnishing and installing junction boxes.

Payment will be made under:

Pay Item	Pay Unit
Junction Box (Standard Size)	Each
Junction Box (Oversized, Heavy-Duty)	Each
Junction Box (Special-Sized, Heavy-Duty)	Each

7. EXTENSION OF EXISTING FIELD WIRING

7.1. DESCRIPTION

Furnish and install terminal splice cabinets to splice and extend existing signal and loop lead-in cables (i.e., field wiring) to new controller cabinets and furnish and install gel-filled splice connectors to splice and extend existing conductors inside new controller cabinets.

7.2. MATERIALS

(A) Terminal Blocks

Provide terminal block (i.e., terminal strips) constructed of electrical grade thermoplastic or thermosetting plastic with the terminals recessed between molded barriers for splicing and extending existing field wiring. Provide terminal blocks with the number of terminals required in these Project Special Provisions or with a sufficient number to accommodated splicing and extending of incoming existing field wiring conductors. Each terminal shall have two (2) terminal screws that have a minimum outside diameter of 3/16 inches. A removable shorting bar shall be provided between the screws of each terminal. Both the screws and shorting bar shall be made of corrosion resistant nickel-plated brass. Provide separate terminal blocks for signal conductors and loop lead-in conductors.

(B) Terminal Splice Cabinets

Provide NEMA Type 3 or Type 4 enclosures fabricated of sheet steel or sheet aluminum with continuous weld construction and with a drip shield top. The steel enclosures shall be stainless steel. Aluminum enclosures shall have a standard mill finish.

Provide an enclosure with a terminal block having at least 20 terminals with each terminal having two terminal screws. Mount the terminal block on the back wall of the enclosure in such a manner that no mounting screws, nuts, etc., protrude through the enclosure. Center the terminal block both horizontally and vertically on the back wall of the enclosure in line with the long dimension of the enclosure. Install additional terminal blocks as necessary.

Provide an enclosure of sufficient size to accommodate entrances for a minimum of four 2-inch galvanized rigid metal conduits in the bottom of the enclosure. The dimensions of the enclosure shall not be less than 16" wide x 20" high x 8" deep. The enclosure shall have a hinged front door which opens to the side and which is secured by a Corbin No. 2 lock and latch. A door handle is not required.

Provide conduit entrances in the bottom of the cabinet only which are of the size and number required for the specific location where cabinet will be installed. Conduit entrances in the top or sides of the cabinet are prohibited. Conduit entrances may be either pre-drilled or field-drilled, but shall not exceed the number required for the location. Extra or spare entrances, capped or otherwise, are not acceptable. Field-verify the required number, size and position of entrances prior to drilling.

The front door of the enclosure shall be equipped with a Corbin No. 2 lock and latch.

Provide all necessary hardware and mounting brackets for attaching the terminal splice cabinet on the pole. Such hardware shall provide for mounting the cabinet to metal or wood signal poles using at least two stainless steel bands (straps) of the size recommended by the manufacturer, one near the top of cabinet and one near the bottom.

Furnish 2-inch rigid galvanized conduit, fittings and conduit outlet bodies along with new pull boxes where required to replace existing short risers. Furnish conduit fittings and outlet bodies as required to install existing risers into base of new terminal splice cabinet.

(C) Gel-Filled Splice Connectors

Furnish gel-filled connectors of the appropriate wire gauge to butt splice and extend the existing conductors of signal cables and loop lead-in cables inside controller cabinets.

(D) Signal Cable and Loop Lead-In Cable

Furnish new traffic signal cables and loop lead-in cables for extending existing cables from new terminal splice cabinet. Furnish equivalent size conductor signal cable. Furnish loop lead-in cable which complies with the "Loop Lead-In Cable" section of these Project Special Provisions.

7.3. CONSTRUCTION METHODS

(A) General

Prior to splicing and extending existing conductors or rerouting existing conductors through new conduits and risers, place permanent labels on all incoming and outgoing conductors in the controller cabinet using a naming convention such as Phase 1 Green, Phase 2 Yellow, Loop 2A, etc., unless the conductors are already labeled. Where there are existing labels on the conductors, confirm that they are labeled correctly and replace any labels that are incorrect.

Place similar permanent labels on the ends of all new conductors used to extend the existing conductors.

Perform standard megger tests on loops after splicing and extending loop lead-ins. Upon approval of the Engineer, replace lead-in cables or loop and lead-in cable assemblies that do not pass standard megger tests.

(B) Inside Controller Cabinets

Where a new controller cabinet is being mounted over existing conduit stubouts on an existing foundation or over existing riser bases at a pole-mounted location and the existing field wiring will not reach the terminal blocks provided inside the new cabinet, splice and extend the incoming and outgoing signal and loop lead-in conductors inside the controller cabinet using gel-filled butt splice connectors.

(C) External to Controller Cabinets

Where new controller cabinets are being installed in a different location from the existing cabinet location and the Plans do not call for re-cabling of the intersection, install, as shown on the Plans, a terminal splice cabinet to splice and extend existing

signal and loop lead-in conductors as required to reach the new controller cabinet through new risers and conduits.

Do not splice and extend conductors external to the controller cabinet where the existing field wiring is of sufficient length to reach the new cabinet in its new location. An example would be where the Plans call for the new cabinet to be placed on a new foundation located at the same or lesser distance from the adjacent signal pole than the existing base-mounted cabinet and foundation. At such locations, pull the existing cables out of the existing cabinet, risers and conduit and reroute them to the new cabinet via the new risers and conduits.

Use a terminal splice cabinet when an existing pole-mounted cabinet is being replaced with a new base-mounted cabinet and the Plans do not call for re-cabling the intersection. Use a terminal splice cabinet where an existing base-mounted cabinet is being replaced with a new base-mounted cabinet on a new foundation in a new location and the existing cabling is not long enough to reach the base of the new cabinet and the Plans do not call for re-cabling the intersection.

Do not route electrical service wire through the terminal splice cabinet.

(D) Terminal Splice Cabinet Where Existing Cabinet is Pole-Mounted

Disconnect the conductors from the existing cabinet, remove the existing pole-mounted controller cabinet, but retain the existing risers, conduit outlet bodies and cables housed therein. Install the new terminal splice cabinet on the pole at same location as removed cabinet with bottom of splice cabinet at the same vertical height as the bottom of the removed cabinet. Install conduit entry holes into base of new cabinet and attach existing risers. Adjust existing conduits and modify/add conduit outlet bodies as necessary to attach to new cabinet. Splice the existing signal cables and loop lead-in cables to the new cables on the terminal splice block and extend new signal cables and new lead-in cables to new base mounted cabinet via two separate, new 2-inch rigid galvanized short risers and underground conduits as shown in the Plans. Bond the terminal splice cabinet to the equipment ground in the controller cabinet using a # 14 AWG stranded THHN copper wire. Do not bond loop grounds and other grounds with neutral conductors.

At certain intersections with existing pole mounted controller cabinets, existing lead-in cables or pedestrian signal cables are routed underground to existing pole mounted cabinets and enter the bottom of existing cabinet via a short riser. A short riser is defined as a short section of vertical conduit between the bottom of a pole-mounted cabinet and the ground below that conveys cables between an underground conduit and the cabinet. Where these short risers are attached to the face of the pole, attach the short riser into a conduit entrance on the bottom of the new terminal splice cabinet and splice the existing cables to the new cables on the terminal block in the cabinet.

Where the existing short riser is "freestanding"(i.e., it is offset horizontally more than one inch from the face of the signal pole and is not secured to the face of the signal pole) or is damaged (i.e., crimped or severely bent), replace the existing short riser with a new short riser attached to the face of the pole as shown in the Plans. Feed the existing cables

through the new conduit and short riser and into the new terminal splice cabinet. Splice the existing conductors to the new conductors on the terminal block.

(E) Terminal Splice Cabinet Where Existing Cabinet is Base-Mounted

Mount the terminal splice cabinet on the pole with the center of the cabinet 48 inches above the ground at the base of the pole. Install new risers to the terminal splice cabinet and short risers from the terminal splice cabinet to the underground conduits leading to the new controller cabinet foundation. Disconnect field wiring from existing base-mounted controller cabinet, carefully pull the cables out of the tops of the existing risers and reroute the existing cables through new risers to a terminal splice cabinet. Splice the existing signal cables and loop lead-in cables to the new cables on the terminal splice block and extend new signal cables and new lead-in cables to new base mounted cabinet via two separate, new 2-inch rigid galvanized short risers and underground conduits as shown in the Plans. Bond the terminal splice cabinet to the equipment ground in the controller cabinet using a # 14 AWG stranded THHN copper wire. Do not bond loop grounds and other grounds with neutral conductors.

Where a loop lead-in cable or pedestrian signal cable enters the existing cabinet foundation directly via an existing underground conduit instead of through a riser, take care to protect the existing cables and the conduit stubout so as not to damage them when removing the existing controller cabinet and its existing foundation. Pull the cables back out of the foundation stubouts from a junction box, handhole, or transformer base, if available, before removing the cabinet foundation. Upon removal of the cabinet foundation, install a junction box over the conduit stubouts and install new underground conduit(s) from the junction box to a stubout in the new cabinet foundation. Splice the loop lead-in cable to new lead-in cable in the junction box using gel-filled butt splice connectors and run the new lead-in cable from the junction box directly to the new controller cabinet via the new underground conduit. Do not splice and extend existing pedestrian signal cable. Remove the existing pedestrian signal cable and install new, continuous pedestrian signal cable from the pedestrian signal to the new controller cabinet via the existing and new underground conduits.

Where these short risers are attached to the face of the pole, attach the short riser into a conduit entrance on the bottom of the new terminal splice cabinet and splice the existing cables to the new cables on the terminal block in the cabinet.

7.4. MEASUREMENT AND PAYMENT

Terminal splice cabinet will be measured and paid for as the actual number of terminal splice cabinets, furnished, installed, and accepted.

New full-height risers attached to the bottom of terminal splice cabinet will be measured and paid for as "Riser with Weatherhead" in accordance with the "Riser Assemblies" section of these Project Special Provisions.

No measurement will be made of replacement of existing conduit bodies and fittings, and installation of new conduit bodies and fittings as these will be considered incidental to furnishing and installing terminal splice cabinets

No measurement will be made of new short risers that replace of existing short risers as they will be considered incidental to furnishing and installing terminal splice cabinets.

When required to intercept existing underground conduit, new junction boxes will be paid for in accordance with the "Junction Boxes" section of these Project Special Provisions as approved by the Engineer.

No measurement will be made of additional signal cable/conductors and loop lead-ins, as the 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 will be considered incidental to furnishing and installing terminal splice cabinets.

No measurement will be made of gel-filled splice connectors and additional signal and loop lead-in cable/conductors as the splicing and extending of conductors inside the controller cabinet will be considered incidental to furnishing and installing the new controller and cabinet.

No measurement will be made of testing of loops after splicing and extending lead-in cables as performing standard megger tests will be considered incidental to splicing and extending the lead-in cables.

Engineer-approved replacement of loops will be paid as provided for under *Inductive Loop Sawcut*. Engineer-approved replacement of loop lead-ins will be paid as provided for under *Lead-In Cable*.

Payment will be made under:

Pay Item	**Pay Unit**
Terminal Splice Cabinet	Each

8. WOOD POLES

8.1. DESCRIPTION

Furnish and install wood poles with grounding systems and all necessary hardware.

8.2. MATERIALS

(A) General

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

Furnish treated timber poles that meet the requirements of ANSI O5.1, except the timber shall be treated Southern Pine or treated Douglas Fir. Unless otherwise specified in the plans, use Class 3 wood poles that have a minimum length of 40 feet and are of a sufficient length to maintain the minimum required clearances above the roadway, obstructions, and affected railroad tracks.

Treat poles in accordance with Standard C4 of the American Wood-Preserver's Association with be applicable to the treatment of poles, except that the required retention of preservative will be as below.

Give all poles a preservative treatment of either pentachlorophenol, or chromated copper arsenate. The same type of preservative shall be used throughout the entire length of the project.

Minimum retention for poles treated with pentachlorophenol will be 0.45 lb. by assay of dry chemical per cubic foot of wood. Minimum retention for poles treated with chromated copper arsenate will be 0.6 lb. by assay of dry chemical per cubic foot of wood.

(B) Wood Poles for Signals and Aerial Cable Routes

Unless otherwise specified in the Plans, furnish Class 3 wood poles that have a minimum length of 40 feet and are of a sufficient length to maintain the minimum required clearances above the roadway, obstructions, and affected railroad tracks.

(C) CCTV Wood Poles

Unless otherwise specified in the Plans, furnish Class 3 or better wood poles to mount CCTV cameras and cabinets that are a minimum of 60 foot long to permit the CCTV camera to be mounted 45 feet above the ground at the pole.

(D) Service Pole

Furnish Class 4 or better wood poles for mounting aerial electrical service assemblies (i.e., service riser with disconnect and meter base) and attaching aerial service drops. Provide poles of sufficient length to attain the vertical clearance beneath the service drop required by the NESC and power company but no less than 25 feet in length.

8.3. CONSTRUCTION METHODS

Install poles at location shown on the Plans. Mark final pole locations and receive approval from the Engineer before installing poles. Unless otherwise shown in the Plans

(i.e., dimensions from a known point or physical feature), locate poles in accordance with the following table:

Speed Limit	Desirable Minimum Setback Distance	
	from face of curb in curb & gutter section	from edge of travel way in shoulder section (no curb)
≤40 mph	12 ft.	14 ft.
45-50 mph	16 ft.	18 ft.
≥55 mph	22 ft.	22 ft.

Within intersection radii, install poles a minimum of 7 feet behind face of curb or 10 feet from the edge of travel way where there is no curb. Field conditions may require the pole to be located at setback distances less than those listed above, subject to the approval of the Engineer, but in no case shall the pole be installed closer than 1.5 feet from face of curb. Measure the setback distance from the face of curb or edge of travel lane to the face of the pole.

Drill or auger a hole for placement of pole and to allow for compacting. Set pole at manufacturer's recommended depth or at a depth equal to 10% of the pole length plus 2 feet, whichever is greater, but in no case less than of 5 feet deep. Ensure the pole is within 2 degrees of vertical when fully loaded.

Backfill hole with pole installed and tamp backfill in 6 inch lifts with a mechanical tamp until compacted density is at least 95% of original density.

On new Department-owned or City-owned poles, install a grounding system consisting of # 4 AWG solid bare copper wire that is exothermically welded to a ground rod. Install ground wire so as to minimize damage from vandalism and environmental exposures. Install ground wire up pole to a point adjacent to the uppermost span. Use hot-dipped galvanized wire staples to secure ground wire to pole. Install ground rod at base of pole.

8.4. MEASUREMENT AND PAYMENT

Wood pole will be measured and paid for as the actual number of wood poles furnished, installed, and accepted.

CCTV wood pole will be measured and paid for as the actual number of CCTV wood poles furnished, installed, and accepted.

Service pole will be measured and paid for as the actual number of service poles furnished, installed, and accepted.

No measurement will be made for installing grounding systems as these will be considered incidental to furnishing and installing wood poles.

Payment will be made under:

Pay Item	Pay Unit
Wood Pole	Each
CCTV Wood Pole	Each
Service Pole	Each

9. GUY ASSEMBLIES

9.1. DESCRIPTION

Furnish and install guy assemblies with all necessary hardware.

9.2. MATERIAL

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

Furnish guy assemblies with anchor assemblies, guy cable, and guy cable guard.

Provide anchor assemblies with all miscellaneous hardware consisting of either expanding anchor with rod and triple-eye attachment, screw anchor with extension rod and triple-eye attachment, or expanding rock anchor with triple-eye attachment. Ensure anchor assembly size is adequate for site conditions. Provide rods constructed of hot-dipped galvanized steel sized according to the soil bearing conditions in the area. Provide triple-eye guy attachments constructed of hot-dipped galvanized steel. Anchor assemblies with double-strand eyes may be used in lieu of those with the triple-eye feature when only one guy cable is to be attached. Ensure anchor assemblies are 7 feet minimum in length.

For type of anchor assembly furnished, ensure the following:

(A) Expanding anchor - provide steel construction with protective paint or heat shrink of 6 mil plastic to protect metal during shipping and storage.

(B) Screw anchor - provide hot-dipped galvanized steel construction.

(C) Expanding rock anchors - provide malleable iron and rust-resisting paint construction.

Provide 3-bolt clamp fabricated from galvanized steel with minimum length of 5-3/4". Ensure clamp has parallel grooves (one on each side of bolt holes) for cable placement. Provide three 1/2" diameter galvanized bolts and nuts to tighten the clamp around the messenger cable. Ensure clamp fits 1/4" to 3/8" messenger cable.

Provide full round guy cable guards that are 8 feet in length and constructed of ultraviolet stabilized, high impact, bright yellow, high density polyethylene.

Provide guy cables consisting of messenger cable of the same size as the largest sized messenger cable to be guyed. Comply with the "Messenger Cable" section of these Project Special Provisions.

9.3. CONSTRUCTION METHODS

(A) General

Comply with Roadway Standard Drawing (RSD) No. 1721.01 when constructing guy assemblies.

(B) Guy Assemblies for Signal Heads or Loop Lead-in Cable

Install guy assemblies with guy cable, guy guards, anchors, three-bolt clamps and associated fittings. Use two-bolt attachment method where there is adequate room on the

pole to comply with the NESC. Attach guy assembly and guy cable to two (2) separate bolts with one (1) bolt for span and one bolt for guy cable.

Where adequate spacing is not available and a violation of the NESC would occur with the two-bolt attachment method, use approved one-bolt attachment method for attaching messenger cable and guy assembly.

Bond guy assembly to new pole grounding system as described below.

Do not attach to existing guy assemblies unless specifically approved by owner. When proposed guy assembly replaces an existing guy assembly, remove the existing guy assembly, including guy anchor if not reused for the new guy assembly.

(C) Guy Assemblies for Communications Cable

When installing messenger cable for supporting only communications cable, use approved one-bolt attachment method for attaching messenger cable and guy assembly.

Bond guy assembly to existing pole ground using Burndy Clamp (UCG25RS) or equivalent. If existing City or Department poles do not have a grounding system install a grounding system consisting of # 4 AWG solid bare copper wire that is exothermically welded to a ground rod. Install ground wire so as to minimize damage from vandalism and environmental exposures. Install ground wire up pole to a point adjacent to the uppermost span. Use hot-dipped galvanized wire staples to secure ground wire to pole. Install ground rod at base of pole.

Do not attach to existing guy assemblies unless specifically approved by owner.

9.4. MEASUREMENT AND PAYMENT

Down guy assembly will be measured and paid as the actual number of direct down guys assemblies furnished, installed, and accepted.

Sidewalk guy assembly will be measured and paid as the actual number of sidewalk guys assemblies furnished, installed, and accepted.

Aerial guy assembly will be measured and paid as the actual number of aerial guys assemblies furnished, installed, and accepted without regard to the length of the aerial guy. Measurement and payment for aerial guy will include all horizontal components of the aerial guy assembly. The down guy or sidewalk guy that makes up the vertical component of the aerial guy assembly will be measured and paid for separately under its respective pay item.

No measurement will be made of guy cable, guy guards, anchors, clamps, strandvises, 2" galvanized pipe, pole plates, or other fittings or of the removal of existing guy assemblies as these will be considered incidental to furnishing and installing guy assemblies.

Payment will be made under:

Pay Item	Pay Unit
Down Guy Assembly	Each
Sidewalk Guy Assembly	Each
Aerial Guy Assembly	Each

10. RISER ASSEMBLIES

10.1. DESCRIPTION

Furnish and install riser assemblies with weatherheads or heat shrink tubing, galvanized pole attachment fittings, and all necessary hardware.

10.2. MATERIAL

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

Provide rigid metallic conduit for risers. Refer to Subarticle 1098-4(B)(1) Rigid Metallic Conduit.

Provide Tyco™(Raychem™) part number 066193-000 or equivalent heat shrink tubing for the installation of fiber-optic in new risers.

Provide Tyco™(Raychem™) part number 704289-000 (formerly FOSC-ACC-CABLE-SEAL-2-NW) or equivalent heat shrink tubing retrofit kits for the installation of new fiber-optic in existing risers.

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-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 a separate riser with heat shrink tubing for fiber-optic communications cables and for coaxial cable. For pole-mounted cabinets only, use 1-inch risers with heat shrink tubing for all new risers that will contain fiber-optic communications drop cables. Connect 1-inch risers with fiber-optic communications drop cables to the bottom of the pole mounted cabinet using a pair of standard 90-degree elbows to form a 180-degree turn into the bottom of the cabinet. Standard 90-degree elbows for 1-inch conduit have a 5.75-inch centerline radius and equal horizontal and vertical legs that measure approximately 8 inches each. Smaller elbows are prohibited. Larger elbows may only be used if approved by the Engineer. For all other locations use 2-inch risers with heat shrink tubing. Install risers with heat shrink tubing so that cable can be installed without violating its minimum bending radius. Install fiber-optic 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 risers of each type and size furnished, installed, and accepted.

No measurement will be made of weatherheads, heat shrink tubing, conduit outlet bodies such as condulets, elbows, conduit fittings or pole attachment hardware as these will be considered incidental to furnishing and installing risers.

No measurement will be made for horizontal sections of underground conduit that connect the riser to stub-outs in an adjacent cabinet foundation or to an adjacent junction box and that measure 10 feet or less in horizontal length from the center of the riser to the center of junction box or from the center of the riser to the near edge of the controller cabinet foundation. Such conduit will be considered incidental to furnishing and installing the riser assembly.

No measurement will be made for vertical conduit segments (i.e., short risers) extending from an entrance in the bottom of a pole-mounted cabinet to ground level below the cabinet to tie directly onto an underground conduit as such conduits will be considered incidental to furnishing and installing the pole-mounted cabinet.

Heat shrink tubing retrofit kit will be measured and paid for as the actual number of heat shrink tubing retrofit kits furnished, installed, and accepted.

Payment will be made under:

Pay Item	**Pay Unit**
1" Riser with Weatherhead	Each
2" Riser with Weatherhead	Each
1" Riser with Heat Shrink Tubing	Each
2" Riser with Heat Shrink Tubing	Each
Heat Shrink Tubing Retrofit Kit	Each

11. INDUCTIVE DETECTION LOOPS

11.1. DESCRIPTION

Furnish and install inductive detection loops with loop slot sealant, loop wire, conduit with fittings, and all necessary hardware.

11.2. MATERIAL

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

(A) Loop Sealant

Provide loop slot sealant that completely encapsulates loop wire when installed according to manufacturer's instructions. Provide loop sealant that does not generate temperatures greater than 220 degrees F. Ensure sealant bonds with asphalt and concrete pavement saw slots so sealant and encapsulated loop wire do not come out of slot. Ensure sealant is self-leveling, but with sufficient viscosity to prevent exit from saw slot when installed along a ten percent grade.

Provide sealant that protects loop wire by preventing the entrance of dirt, water, rocks, sticks, and other debris into saw slot, and is resistant to traffic, water, gasoline, chemical and chemical fumes, mild alkalis, oils, and mild acids. Ensure sealant will not be affected by water and sealant does not chemically interact with pavement and loop wire insulation.

Ensure loop sealant has sufficient flexibility to permit expected pavement expansion and contraction due to weather and to permit pavement movement due to traffic without cracking for a temperature range of -40 to 160 degrees F.

Provide sealant with a usable life of at least ten minutes once mixed, when the ambient temperature is 75 degrees F. Ensure sealant dries to tack free state in less than two hours, and does not flow within or out of saw slot after exposed surface has become tack free. Tack free time will be determined by testing with a cotton ball until no sealant adheres to cotton ball and no cotton adheres to sealant.

Ensure two-part sealant cures within 48 hours to attain 95 percent of published properties for the cured material.

Ensure one-part sealant cures within 30 days to attain 95 percent of published properties for the cured material.

(B) Loop Wire

Provide loop wire composed of 19-strand conductor insulated by a cross-linked polyethylene compound. Ensure insulated conductors are completely encased in tubes of low density polyethylene compound. Print manufacturer's name, manufacture year, and any applicable part number on encasing tube at intervals of 2 feet or less.

Provide # 14 AWG copper conductors fabricated from 19 strands that comply with ASTM B 3 before insulating. Ensure stranded conductors use either concentric or bunch stranding, and comply with circular mil area and physical requirements of ASTM B 8 or ASTM B 174 for bunch stranding.

Provide insulating compound that is cross-linked thermosetting black polyethylene (ASTM D 2655). Ensure insulation is applied concentrically about conductor. Provide insulation thickness not less than 0.026" at any point and minimum average thickness of 0.030" as measured by UL Standard 62.

Ensure insulation of finished conductor will withstand application of a 60 Hertz or 3000 Hertz, 7500 volt (RMS) essentially sinusoidal spark test potential as specified in UL Standard 83.

Provide insulated conductors that are factory-installed in protective encasing tube that comply with the following:

Encasing tube fabricated of polyethylene compound conforming to ASTM D 1248 for Type I, Class C, Grade E5.

Minimum inside diameter of 0.150"
Wall thickness of 0.040" ± 0.010"
Outside diameter of 0.240" ± 0.010" Conduit

(C) Conduit

Comply with the Underground Conduit section of these Project Special Provisions for non-metallic conduit.

11.3. CONSTRUCTION METHODS

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

Notify Engineer one (1) week before installing inductive detection loops.

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

Before sawcutting, pre-mark inductive detection loop locations and receive approval. Sawcut 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 sawcut through curb. Do not drill holes for conduit or wires through granite curb. See additional requirements for work in historic districts in Section 1 of these Project Special Provisions.

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 bottom of 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 form. The form is located on the Department's Web site.

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.

Twist loop conductor pairs a minimum of 5 turns per foot from where conductors leave saw slot to junction box. 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.

11.4. MEASUREMENT AND PAYMENT

Inductive loop sawcut will be 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.

No measurement will be made of removing and resetting granite curb when necessary to install underground conduit for loop lead-in cable as such work will be considered incidental to furnishing and installing inductive detection loops.

Payment will be made under:

Pay Item	Pay Unit
Inductive Loop Sawcut	Linear Foot

12. LOOP LEAD-IN CABLE

12.1. DESCRIPTION

Furnish and install loop lead-in cable with all necessary hardware.

12.2. MATERIAL

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

Furnish lead-in cable with two (2) conductors of number 14 AWG fabricated from stranded tinned copper that complies with IMSA Specification 50-2 except as follows:

Ensure conductor is twisted with a maximum lay of 2.0 inches, resulting in a minimum of 6 turns per foot.

Provide a ripcord to allow cable jacket to be opened without using a cutter.

Provide length markings in a contrasting color showing sequential feet and within one percent of actual cable length. Ensure character height of the markings is approximately 0.10 inch.

12.3. CONSTRUCTION METHODS

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.

12.4. MEASUREMENT AND PAYMENT

Lead-in cable will be measured and paid as the actual linear feet of lead-in cable 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.

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:

Pay Item	Pay Unit
Lead-in Cable	Linear Foot

13. FIBER-OPTIC CABLE

13.1. DESCRIPTION

Furnish and install single mode fiber-optic (SMFO) communications cable and drop cable assemblies with grounding systems, fiber-optic cable storage racks (snow shoes), communications cable identification markers, lashing wire, and all necessary hardware.

13.2. MATERIAL

(A) SMFO Communications Cable

Furnish single-mode fiber-optic communications cable that is pre-approved on the Department's QPL. Furnish fiber-optic cable that is all-dielectric and gel-free.

Furnish loose tube fiber-optic cable with required fiber count that complies with RUS CFR 1755.900, single mode with dielectric central member. Use single mode fiber in cable that does not exceed attenuation of 0.25 dB/km at 1550 nm and 0.35 dB/km at 1310 nm. Provide cable with all fibers that are useable and with surface sufficiently free of imperfections and inclusions to meet optical, mechanical, and environmental requirements. Provide cable with minimum of one (1) ripcord under sheath for easy sheath removal and with shipping, storage, installation, and operating temperature of at least -40 to 160 degrees F with a dual layered, UV cured acrylate fiber coating applied by cable manufacturer that may be stripped mechanically or chemically without damaging fiber.

Provide fibers inside loose buffer tube. Use doped silica core surrounded by concentric silica cladding for each fiber. Distinguish each fiber and buffer tube from others by means of color coding that meets EIA/TIA-598 *Color Coding of Fiber-Optic Cables* and the following requirements. Provide six (6) fibers per buffer tube in cables containing 6, 12, 24 and 36-fiber. Provide 12 fibers per buffer tube in cables containing 48 or more fibers. In buffer tubes containing multiple fibers, ensure colors are stable during temperature cycling and not subject to fading, sticking, or smearing into each other or into filling material. Use fillers in cable core if necessary to provide a symmetrical cross-section of cable. Fill buffer tubes with super-absorbent, water-blocking material that is that is non-hygroscopic, non-nutritive to fungus, electrically non-conductive and homogenous.

Provide a central member consisting of a dielectric glass reinforced plastic rod. Apply binders with sufficient tension to secure buffer tubes and binders to the central member without crushing buffer tubes. Ensure that binders are non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

Provide cable that has cable core interstices filled with super-absorbent, water-blocking compound that is non-conductive and homogenous. Ensure compound is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide cable with high tensile strength aramid yarns or fiberglass yarns that are helically stranded evenly around cable core.

Provide cable jacket of consistent thickness that is free of holes, splits, and blisters, and contains no metal elements. Provide outer jacket of medium density polyethylene with minimum nominal sheath thickness of 0.050 inch. Ensure polyethylene contains carbon black for ultraviolet light protection and does not promote fungus growth.

Provide length markings in sequential feet and within one (1) percent of actual cable length. Ensure character height of the markings is approximately 0.10".

(B) Drop Cable Assembly

Furnish factory-preassembled, factory-preterminated drop assemblies with integral pre-attached interconnect centers/patch panels designed to mount inside equipment cabinets. Furnish drop cable assemblies to provide communications links between splice enclosures and fiber-optic transceivers.

Provide an assembly that is factory-assembled with the designated drop cable length as shown in the Plans. The assembly may be rail mounted or rack mounted. If the assembly is rack mounted it shall occupy only one rack unit.

Construct the drop cable assembly using single-mode, fiber-optic cable containing a minimum of six fibers. Furnish patch panel with a minimum of six ST connectors.

Furnish low bend radius single mode cable described above. A low bend radius cable is defined as a fiber-optic cable whose manufacturer-specified minimum bend radius does not exceed 5 inches when loaded and 4 inches when installed. Provide outdoor-rated, non-armored, riser rated cable. Provide UV-rated cable.

Use single mode fiber-optic cable that does not exceed attenuation of 0.30 dB/km at 1550 nm and 0.40 dB/km at 1310 nm. Ensure attenuation loss for complete drop cable assembly does not exceed a mean value of 1.5 dB.

Provide metal connector housing, ceramic ferrules and coupler inserts. Provide a connector attenuation of .20 dB and a reflectance of < -40 dB SPC/<-55 dB UPC. Use heat-cured epoxy material.

Provide length markings in sequential feet and within one percent of actual cable length. Ensure character height of markings is approximately 0.10".

Furnish SMFO jumpers that are a minimum of 3 feet in length with factory-assembled ST connectors on each end for connecting fiber-optic transceivers to the fiber-optic patch panels on the drop cable assemblies. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which they are to be coupled.

(C) Communications Cable Identification Markers

Furnish yellow communications cable identification markers that are resistant to fading when exposed to UV sources and changes in weather. Use markers designed to coil around fiber-optic cable that do not slide or move along the surface of the cable once installed. Ensure exposure to UV light and weather does not affect the markers natural coiling effect or deteriorate performance. Provide communications cable wraps that permit writing with an indelible marking pen and contain the following text in black:

WARNING
CITY OF WILMINGTON FIBER-OPTIC CABLE
CONTACT TELEPHONE NO.: (910) 341-4696

WARNING
CITY OF WILMINGTON FIBER-OPTIC CABLE

Overall Marker Dimensions: 7(l) x 4 (w) inches
Lettering Height: 3/8 inch for "WARNING"; 1/4" for all other lettering

Submit a sample of proposed communications cable identification markers to the Engineer for approval before installation.

(D) Fiber-Optic Cable Storage Guides

Furnish fiber-optic cable storage guides that are pre-approved on the Department's QPL.

Furnish fiber-optic storage guides (snowshoes) that are non-conductive and resistant to fading when exposed to UV sources and changes in weather. Ensure snowshoes have a captive design such that fiber-optic cable will be supported when installed in the rack and the minimum bending radius will not be violated. Provide stainless steel attachment hardware for securing snowshoes to messenger cable and black UV resistant tie-wraps for securing fiber-optic cable to snowshoe. Ensure snowshoes are stackable so that multiple cable configurations are possible.

(E) Aerial Cable Protectors

Furnish SquirrelGuard™ manufactured by Osmose Utility Services, Inc., or a Department-approved equivalent to protect aerial fiber-optic communications cable from damage by squirrels and from tree limb abrasion. Provide cable protectors that are designed to fit over the cable as a protective sleeve and that have a round shape. Size the cable protectors to properly fit over the cable(s) lashed to messenger cable in accordance with the manufacturer's guidelines. Provide cable protectors that are constructed of rugged, durable dielectric material that is black in color, that is formulated for outdoor use and to be UV-resistant, and that is designed for a service life of at least 10 years.

13.3. CONSTRUCTION METHODS

(A) General

Provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable.

Install SMFO communications cable, snow shoes, communications cable identification markers, lashing wire, and all necessary hardware.

Comply with manufacturer's recommendations. Install communications cable on signal poles, utility poles, messenger cable, and in conduits as required to bring the fiber-optic cable into and, if necessary, out of each splice enclosure.

Take all precautions necessary to ensure cable is not damaged during storage, handling, and installation. Do not violate minimum bending radius of 20 times the radius of cable diameter or manufacturer's recommendation, whichever is greater. Do not step on cable nor run over cable with vehicles or equipment. Do not pull cable over or around obstructions, or along the ground.

Determine lengths of cable necessary to reach from termination point to termination point. Install cable in continuous lengths between approved splicing facilities. Additionally, provide a sufficient amount of slack cable to allow for an additional 20 feet of cable to be present after removal of outer sheath for termination. Measure slack cable by extending cable straight out of cabinet door.

Keep cable ends sealed at all times during installation to effectively prevent the ingress of moisture. Use approved heat shrink cable end cap. Do not use tape to seal cable ends.

Before installing cable, provide three (3) copies of cable manufacturer's recommended and maximum pulling tension. Do not exceed manufacturer's recommended pulling tension. Use pulling grips containing a rotating swivel. Coil cable in a figure-8 configuration whenever cable is unreeled for subsequent pulling.

Install fiber-optic cable in separate risers with heat shrink tubing or conduits. Do not share risers or conduits containing fiber-optic cable with other type cable unless the Plans specify otherwise or the Engineer directs or approves otherwise.

(B) Aerial Installation

Install one communications cable identification marker within 36 inches of pole attachment points and at locations where more than one cable originates or terminates.

Double lash fiber-optic cable to messenger cable with one 360-degree spiral per foot.

Use pole attachment hardware and roller guides with safety clips to install aerial run cable.

Use a breakaway swivel so as not to exceed 80% of the maximum allowable pulling tension specified by the cable's manufacturer if cable is pulled by mechanical means. Do not allow cable to contact the ground or other obstructions between poles during installation.

Use a cable suspension clamp when attaching cable tangent to a pole. Select and place cable blocks and corner blocks so as not to exceed the cable's minimum bending radius. Do not pull cable across J-hooks.

Double lash fiber-optic cable to messenger cable with one 360 degree spiral per foot.

Store 100 feet of each fiber-optic cable on all cable runs that are continuous without splices as shown on the Plans. Obtain approval for spare cable storage locations. Store spare fiber-optic cable on fiber-optic cable storage racks (snow shoes). Locate spare cable storage in the middle of spans between termination points. Do not store spare fiber-optic cable over the roadway or driveways.

(C) Underground Installation

Install fiber-optic cable underground in conduit using cable pulling lubricants recommended by the fiber-optic cable manufacturer.

Obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

Use a breakaway swivel so as not to exceed 80% of the maximum allowable pulling tension specified by the cable's manufacturer if cable is pulled by mechanical means.

Keep tension on cable reel and pulling line at start of each pull. Do not release tension if pulling operation is halted. Restart pulling operation by gradually increasing tension until cable is in motion.

For pulling cable through manholes, junction boxes, and vaults, feed cable by manually rotating the reel. Do not pull cable through intermediate junction boxes, handholds, or openings in conduit unless otherwise approved.

Install communications cable identification markers on each communications cable entering a junction box.

(D) Installation of Drop Cable Assembly

Determine length of drop cable needed, including slack, to reach from termination point to termination point.

For existing riser locations, remove the existing weatherhead. Install fiber-optic cable with heat shrink tubing.

At aerial splice enclosures, install the aerial splice enclosure and corresponding cable storage rack at least 50 feet apart and store at least 50 feet of slack cable for each cable entering and exiting the splice enclosure between the splice enclosure and corresponding cable storage rack. Coil and store any drop cable in excess of what is needed for overhead storage in the base of the equipment cabinet.

At below ground splice enclosures, coil at least 50 feet of slack cable for each cable entering and exiting the splice enclosure in the manhole or junction box where enclosure is located. Coil and store any drop cable in excess of what is needed for storage in the manhole or junction box in the base of the equipment cabinet.

Mount drop cable assembly using screws to either the rack frame or rack mount in 19-inch communications rack in a location convenient to the fiber-optic transceiver. Mount the drop cable assembly close enough to the fiber-optic transceiver to connect them using 3-foot fiber-optic jumpers. Secure drop cable in cabinet using cable ties and wire management hardware.

Install SMFO jumpers between the appropriate connectors on the patch panel and the corresponding connectors on the fiber-optic transceiver.

Label all connectors, pigtails, and the connector panel. At the aerial splice enclosure location, cap off all unused fibers and label to correspond with the connector panel.

Where the Plans call for a fiber-optic drop cable to be installed in an existing riser, remove all existing cables from the riser and remove the existing weatherhead, sealing

bushing or heat shrink tubing. Install the new fiber-optic drop cable in the existing riser and install new heat shrink tubing at the top of the existing riser using a heat shrink tubing retrofit kit. If the riser contains existing fiber-optic communications cable, carefully remove the fiber-optic cable from the riser so as not violate its minimum bending radius or otherwise damage the cable. Temporarily coil and store the existing fiber-optic cable overhead in a manner approved by the Engineer until the new drop cable can be spliced into the existing cable in an aerial splice enclosure.

Using an OTDR, test the end-to-end connectivity of the drop cable assembly from the patch panel installed inside the signal or CCTV cabinet to the corresponding communications hub. Comply with the OTDR testing and reporting requirements of the "Fiber-Optic Splice Centers" section of these Project Special Provisions when testing drop cable.

(E) Aerial Cable Protectors

As directed by the Engineer at locations where aerial fiber-optic communications cables are subject to damage by squirrels or from tree-limb abrasion, install cable protectors over the fiber-optic cable of sufficient length to protect the cable from the potential threat. Do not install aerial cable protectors at any locations without the prior approval of the Engineer. Do not install cable protectors for lengths of application that are shorter or longer than approved/directed by the Engineer.

13.4. MEASUREMENT AND PAYMENT

Communications cable (____-fiber) will be measured and paid as the actual linear feet of fiber-optic cable of each fiber count furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed cable and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period). 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 fibers before determining length of cable run.

Drop cable assembly (___') will be measured and paid as the actual number of fiber-optic drop cable assemblies of each length furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed cable and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Aerial cable protectors will be measured and paid as the actual linear feet of aerial cable protectors furnished, installed, and accepted. No measurement and payment will be made of any aerial cable protectors installed without the prior approval of the Engineer or for cable protectors installed at locations or for lengths of application other than approved or directed by the Engineer.

No measurement will be made for terminating, splicing, and testing fiber-optic cable, communications cable identification markers, fiber-optic cable storage racks, or SMFO jumpers, as these will be considered incidental to the installation of fiber-optic cable.

No measurement will be made of removing existing cables from existing risers as such removals will be considered incidental to furnishing and installing the fiber-optic drop cable assemblies.

No measurement will be made of removing existing weatherheads, sealing bushings, heat shrink tubing and riser caps to install new fiber-optic drop cables in existing risers as such removals will be considered incidental to furnishing and installing heat shrink tubing retrofit kits. Heat shrink tubing retrofit kits will be measured and paid for in accordance with the "Riser Assemblies" section of these Project Special Provisions.

Payment will be made under:

Pay Item	**Pay Unit**
Communications Cable (24-Fiber)	Linear Foot
Drop Cable Assembly (50')	Each
Drop Cable Assembly (150')	Each
Drop Cable Assembly (200')	Each
Drop Cable Assembly (300')	Each
Drop Cable Assembly (400')	Each
Drop Cable Assembly (>400')	Each
Aerial Cable Protector	Linear Feet

14. FIBER-OPTIC SPLICE CENTERS

14.1. DESCRIPTION

Furnish and install fiber-optic splice enclosures and all necessary hardware. Modify existing splices in existing splice enclosures.

14.2. MATERIALS

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

(A) Splice Enclosure

Furnish splice enclosures that are re-enterable using a mechanical dome-to-base seal with a flash test valve, and are impervious to the entry of foreign material (water, dust, etc.). Ensure enclosures are manufactured in such a manner to be suitable for aerial, pedestal, buried, junction box, and manhole installation.

Provide enclosures with a minimum of one oversized oval port that will accept two cables and with a minimum of four round ports (for single cables) that will accommodate all cables entering enclosure. Provide heat shrink cable shields with enclosure to ensure weather-tight seal where each cable enters enclosure.

Within enclosures, provide enough hinged mountable splice trays to store the number of splices required, plus the capacity to house six additional splices. Provide a fiber containment basket for storage of loose buffer tubes expressed through the enclosure. Ensure enclosures allow sufficient space to prevent microbending of buffer tubes when coiled.

Provide splice trays that hold, protect, organize optical fibers, and secure fibers inside splice tray. Provide splice trays that are dielectric.

(B) Existing Splice Centers

When adding a new fiber-optic cable to an existing splice enclosure or otherwise modifying an existing splice inside an existing splice enclosure, furnish heat shrink cable shields that are compatible with the enclosure to ensure weather-tight seal where each new cable enters the existing enclosure and to replace any existing seals that are broken or removed while modifying the splice.

Provide splice trays that hold, protect, organize optical fibers, and secure fibers inside splice tray for new or modified splices inside existing splice enclosures. Provide splice trays that are dielectric and that are compatible with the existing splice enclosure. Provide splice trays that are sized to accommodate all fibers entering the splice tray and to provide sufficient space to prevent microbending of optical fibers.

Furnish SMFO jumpers that are a minimum of 3 feet in length with factory-assembled PC-ST connectors on each end. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

14.3. CONSTRUCTION METHODS

(A) General

Fusion splice and secure SMFO cable in splice trays inside the splice center. Ensure all buffer tubes are contained within splice trays so no bare fibers are outside the tray.

Do not exceed 0.05 dB of attenuation per splice.

Furnish strain relief so that no tensile force is on SMFO cable when it is held within the interconnect center or splice enclosure.

Do not damage fiber or violate the minimum bending radius of the fiber.

Terminate and splice all fibers as shown in the Plans.

(B) Splice Enclosure

Install splice enclosures with splice trays, basket containment assemblies, racking for slack cable or fibers, mounting and strain relief hardware, and all other necessary hardware.

Do not install aerial splice enclosures over roadways or driveways

Fusion splice all fibers including fibers designated to be coupled with fibers from a drop cable assembly. For all fibers designated to pass through splice enclosure, coil and express the fibers without cutting.

For all buffer tubes designated to pass through splice enclosure, neatly coil excess tubing inside basket provided with enclosure.

Label all fiber-optic splices. Obtain approval of fiber-optic connector labeling method.

Install heat shrink cable shields using methods recommended by the manufacturer of the enclosure. Perform a pressurization flash test on enclosure in accordance with manufacturer's recommended procedures at the conclusion of splicing procedure and before final placement of enclosure.

For aerial installations, secure enclosures to messenger cable using manufacturer supplied hardware. Secure SMFO cable and drop cable assemblies to snowshoes.

Install enclosures with enough slack cable to allow enclosure to be lowered to ground level and extended into a splicing vehicle.

For underground, manhole and junction box facility installations, place the enclosure along with required spare cables in the facility in a neat and workmanship like manner.

(C) Modify Existing Splice

Terminate and splice new fibers and re-splice existing fibers within splice enclosures as shown in Plans. Use existing splice trays inside the splice center and install new splice trays as needed. Comply with all requirements of the "Splice Enclosure subsection above.

Relocate existing aerial splice enclosure and corresponding existing fiber-optic cable storage rack(s) as shown on the Plans. Unlash existing, reroute and relash existing fiber-optic cable as required to relocate the existing aerial splice enclosure.

14.4. MEASUREMENT AND PAYMENT

Splice enclosure will be measured and paid as the actual number of fiber-optic splice enclosures furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed splice enclosures and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period). No measurement will be made between aerial, underground, manhole, or junction box installation of the fiber-optic splice enclosure.

Modify existing splice will be measured and paid as the actual number of existing fiber-optic splice enclosures where existing splices are reconfigured, new fibers are spliced to existing fibers and new fibers are terminated in the existing splice center. Measurement will be made per existing splice center without regard to type and location of splice center and without regard to the number of splices and terminations required at each location. Payment for modify existing splice will be full compensation for all materials and work required to modify the existing splices in accordance with the Plans. No measurement will be made of relocating an existing aerial splice enclosure and associated fiber-optic cable storage rack(s) as such work will be considered incidental to modifying the existing splice.

No measurement will be made of splice trays, pigtails, jumpers, connector panels, and testing, as these will be considered incidental to furnishing and installing fiber-optic interconnect centers and splice enclosures.

Payment will be made under:

Pay Item	Pay Unit
Splice Enclosure	Each
Modify Existing Splice	Each

15. FIBER-OPTIC TRANSCEIVERS

15.1. DESCRIPTION

Furnish and install fiber-optic transceivers with all necessary hardware according to the Plans and specifications.

Furnish and install fiber-optic transceivers in the following configurations:

- Shelf-mount RS-232 serial data drop and repeat,
- Rack-mount RS-232 serial data drop and repeat,
- Shelf-mount video/data transmitter, and
- Rack-mount video/data receiver.

15.2. MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL. Furnish fiber-optic transceivers that are compatible, interoperable and completely interchangeable with the existing fiber-optic transceivers currently in use by the City.

(A) Serial Data Transceivers

1) General

Furnish single mode fiber-optic data transceivers that transmit and receive optical signals over a fiber-optic communications medium of two (2) fibers and interface with traffic signal controllers and cabinets. Ensure the transceivers are asynchronous in operation. Ensure transceivers are capable of operating up to 20 miles without boosting signal and without distortion. Ensure transceivers are switch selectable for either local or master operation.

Do not provide transceivers internal to system equipment. Provide identical transceivers at all locations capable of being interchanged throughout system.

Provide LEDs on the front panel of transceivers for power, and transmitting and receiving indications. Comply with the following:

- Input Power: 115 VAC,
- Minimum Loss Budget: 12 dB with corresponding receiver,
- Operating Wavelength: 1310 or 1550 nm,
- Bit Error Rate < 1 in 10^{-9} @ maximum optical loss budget,
- Data Rate DC – 100kbps
- Operating Mode Asynchronous, Simplex or Full Duplex,
- Optical Connector: ST,
- Data Connector: DB-25S,
- Signal Connector: Female Plug Type,
- Temperature Range: 0 to 150 degrees F,
- Humidity 0-95% (non-condensing),

- Certifications, Compliance and Compatibility
  - RS-232C/D (Simplex or Duplex)
  - Supports Request to Send (RTS) and Clear to Send (CTS)
  - NTCIP
  - UL
  - FCC Part 15

Furnish transceivers that transmit and receive data in drop-and-repeat poll-response data network mode with EIA/TIA-232, EIA/TIA-422, and EIA/TIA-485 protocols.

Provide transceivers that meet or exceed NEMA TS-1/TS-2 and Caltrans Specifications.

2) Shelf-Mounted Drop and Repeat Data Transceivers

Provide modular, standalone transceivers that can be shelf-mounted (i.e., surface-mounted) for use in traffic signal cabinets. Furnish transceivers with an aluminum housing that are environmentally-hardened units designed for unconditioned roadside installation inside signal controller cabinets.

3) Rack-Mounted Drop and Repeat Data Transceivers

Provide rack-mounted transceiver cards for use in the TMC. Provide rack-mounted transceiver cards for installation in the rack-mounted card chassis previously installed by others in the 19-inch equipment rack inside the City's TMC. Provide transceiver cards with all hardware and fasteners required to securely install the cards in the existing card chassis. Provide data transceiver cards that are fully compatible electronically as well as in physical dimensions and characteristics with existing data transceiver cards and the existing data transceiver card cages.

(B) Video/Data Transceivers

1) General

The fiber-optic video transceivers (w/ data) must meet the following minimum functional requirements:

• Video:	10-bit digitally encoded video transmission
• Input:	1 volt pk-pk (75 ohms)
• Connector:	BNC (gold plated center pin)
• Bandwidth:	5Hz – 10MHz
• Diff. Gain:	< 2%
• Diff. Phase:	< 1%
• Signal / Noise:	>67dB @ maximum optical loss budget
• Frame Rate:	Broadcast quality (30fps)
• Data Connector:	Terminal Block with Screw Clamps or DB-9
• Data Interface:	RS-232, RS-422 / RS-485
• Data Format:	NRZ, RZI, Manchester, Bi-phase
• Data Rate:	DC to 512 kbps
• Bit Error Rate:	< 1 in 10^{-9} @ maximum optical loss budget
• Operating Mode:	Simplex or Full Duplex
• Optical Connector:	ST

- Wavelength: 1310 / 1550 nm, single mode
- Optical Budget: 23 dB
- Max Distance: 43 miles
- Operating Temp: -40 to +74 degrees Celsius
- Humidity: 0-95% (non-condensing)
- Certifications, Compliance and Compatibility:
  - RS-250C Medium Haul Transmission
  - NTSC / PAL / SECAM / Full Color
  - UL
  - CE
  - FCC Part 15

Provide transceivers that meet or exceed NEMA TS-1/TS-2 and Caltrans Specifications.

2) Shelf-Mounted Video/Data Transmitters

Provide modular, standalone video/data transmitters that can be shelf-mounted (i.e., surface-mounted) for use in CCTV cabinets. Furnish transmitters with an aluminum housing that are environmentally-hardened units designed for unconditioned roadside installation inside CCTV cabinets.

3) Rack-Mounted Video/Data Receivers

Provide rack-mounted video/data receiver cards for installation in the rack-mounted card chassis the rack-mounted card chassis previously installed by others in the 19-inch equipment rack inside the City's TMC. Provide receiver cards with all hardware and fasteners required to securely install the cards in the existing card chassis. Provide video/data receivers that are fully compatible electronically as well as in physical dimensions and characteristics with existing video/data cards and the existing video/data card cages.

15.3. CONSTRUCTION METHODS

(A) Shelf-Mounted Drop and Repeat Data Transceivers

Install the shelf-mount fiber-optic transceivers in each traffic signal cabinet as shown in the Plans and comply with manufacturer's installation instructions. Connect the optical port of the transceiver to fiber-optic drop cable as shown in the splice details. Connect the serial data port with the serial data port of the 2070L controller.

(B) Rack-Mounted Drop and Repeat Data Transceivers

Install the rack-mount fiber-optic transceiver cards in the card chassis mounted in the communications rack inside TMC as shown in the Plans. Comply with the manufacturer's installation instructions. Install fiber-optic jumpers between the optical ports of the transceiver and the appropriate connectors on the fiber-optic patch panel to connect the transceiver with the appropriate fibers of the incoming communications cable as shown in the splice details. Connect the transceiver cards with the port server.

(C) Shelf-Mounted Video/Data Transmitters

The fiber-optic video/data transmitters will transmit CCTV video and bi-directional PTZ data over a single fiber. Install the shelf-mount fiber-optic video/data transceivers in each CCTV cabinet as shown in the Plans and comply with manufacturer's installation instructions. Connect the optical port of the transceiver to fiber-optic drop cable as shown in the splice details. Connect the analog video input to the coaxial cable from the CCTV camera. Connect the serial data port to the serial data cable from the CCTV camera.

(D) Rack-Mounted Video/Data Receivers

The fiber-optic video/data receivers will receive CCTV video and transmit bi-directional PTZ data over a single fiber. Install the rack-mount video/data receiver cards in the card chassis mounted in the communications rack inside the TMC as shown in the Plans. Comply with manufacturer's installation instructions. Install fiber-optic jumpers between the optical ports of the receiver and the appropriate connectors on the fiber-optic patch panel to connect the receiver with the appropriate fibers of the incoming communications cable as shown in the splice details. Connect the receiver cards with the port server.

15.4. MEASUREMENT AND PAYMENT

Fiber-optic transceiver – drop and repeat will be measured and paid as the actual number of fiber-optic transceivers – drop and repeat furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed fiber-optic transceiver and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Furnish fiber-optic transceiver – drop and repeat will be measured and paid as the actual number of fiber-optic transceivers – drop and repeat furnished and accepted.

Fiber-optic video/data transmitter will be measured and paid as the actual number of fiber-optic video/data transmitters furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed video/data transmitter and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Furnish fiber-optic video/data transmitter will be measured and paid as the actual number of fiber-optic video/data transmitters furnished and accepted.

Fiber-optic video/data receiver will be measured and paid as the actual number of fiber-optic video/data receivers furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed video/data receiver and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

Furnish fiber-optic video/data receiver will be measured and paid as the actual number of fiber-optic video/data receivers furnished and accepted.

No measurement will be made jumpers or RS-232 cables as they will be considered incidental to furnishing and installing the drop and repeat fiber-optic transceivers and the video/data fiber-optic transmitters/receivers.

No measurement will be made of relocating existing fiber-optic card chassis from the existing communications rack to the new communications rack in the TMC as shown in the Plans as such work will be considered incidental to furnishing and installing the new communications rack.

Removal of the existing video/data transceivers that are replaced with new units will be measured and paid for separately in accordance with the "CCTV Field Equipment" section of these Project Special Provisions.

Payment will be made under:

Pay Item	Pay Unit
Fiber-Optic Transceiver – Drop and Repeat	Each
Furnish Fiber-Optic Transceiver – Drop and Repeat	Each
Fiber-Optic Video/Data Transmitter	Each
Furnish Fiber-Optic Video/Data Transmitter	Each
Fiber-Optic Video/Data Receiver	Each
Furnish Fiber-Optic Video/Data Receiver	Each

16. UNDERGROUND CABLE MARKERS

16.1. DESCRIPTION

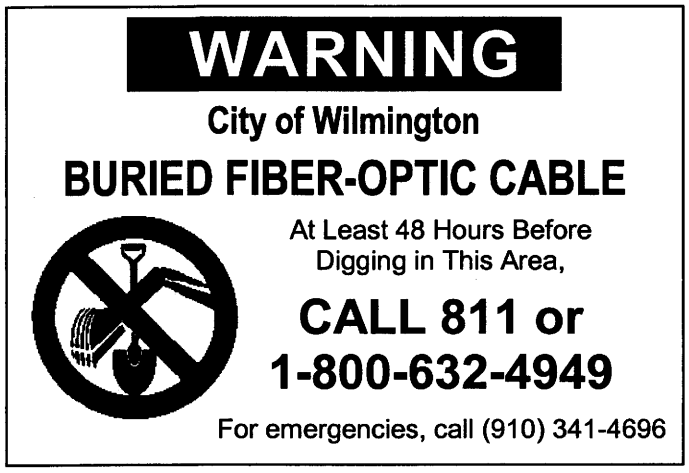
Furnish and install joint-use utility pole tags/decals, equipment cabinet decals, and curb/sidewalk markers/medallions with all necessary hardware and adhesives to warn of buried fiber-optic communications cable.

16.2. MATERIAL

(A) Cabinet Decals

Furnish pressure-sensitive, waterproof decals to apply to the exterior surface of field equipment cabinets. Construct decals of durable vinyl or plastic that is chemical resistant and resists tearing and shrinking. Screen print text and symbols on decal using UV-stable, fade-resistant, waterproof ink. Ensure that decal will adhere permanently to a milled aluminum surface under a variety of weather conditions and a wide range of air temperatures (0° F to 150° F minimum). Provide a decal that can be applied without special surface preparation.

Provide cabinet decals that contain the text and symbols, text emphasis and text proportions depicted in the following examples format:



Overall Decal Dimensions:
6"(w) x 4"(h) minimum,
7"(w) x 5"(h) maximum

Text Height (min.):
1/2" for *WARNING*
3/8" for *BURIED FIBER-OPTIC CABLE* and *CALL 811*
1/4" for all other

Background Color: Yellow
Text Color: Black
Symbol Color: Black
Symbol Size: 1.5"- 2" DIA

Submit sample of proposed cabinet decals to the Engineer for approval before installation. In lieu of designing a custom decal, the contractor may submit for the Engineer's approval a stock/standard decal format (i.e., off-the-shelf format) from the decal manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

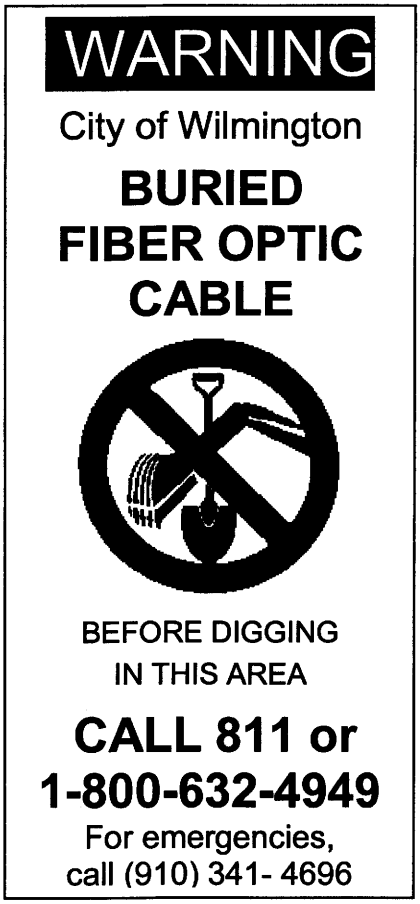
(B) Utility Pole Signs

Furnish signs for installation on wood utility poles that are constructed of 40 mil aluminum or high-impact, UV-resistant plastic such as high impact polyolefin. Provide signs with rounded corners and that have pre-drilled/pre-punched fastener holes at the top

and bottom edge of the sign and centered horizontally on the sign. Provide hot-dipped, galvanized wood screws for attaching the sign to wood utility poles.

Ensure that background of sign is fade resistant. Screen print text and symbols on decal using UV-stable, fade-resistant, waterproof ink.

Provide utility pole signs that contain the text and symbols, text emphasis and text proportions depicted in the following examples format:



Overall Tag Dimensions: 3.5"(w) x 7"-12"(h)

Text Height (min.):

1/2" for *WARNING;*
3/8" for B*URIED FIBER-OPTIC CABLE*;
3/8" for *CALL 811 or 1-800-632-4949*;
1/4" for all other

Text Color: Black
Background Color: Yellow
Symbol Color: Black
Symbol Size: 2" Diameter

Submit sample of proposed pole sign to the Engineer for approval before installation. In lieu designing a custom sign, the contractor may submit for the Engineer's approval a stock/standard sign format (i.e., off-the-shelf format) from the sign manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

(C) Curb Markers

Furnish durable, non-reflective curb markers fabricated from UV-resistant, non-metallic materials other than ceramic material, such as polyurethane or high impact polypropylene or other high impact plastic. Provide curb markers that are designed for outdoor use, that are waterproof, that resist fading, that are temperature stable and that resist chemical and mechanical abrasion. Furnish curb markers with a quick-setting adhesive to permanently adhere curb markers to Portland cement concrete and granite as well as other non-porous hard surfaces. Do not provide markers that require intrusive

fasteners to secure the marker to the surface. Provide curb markers that do not require special tools such as torches, tamping machines or drills or hardware or special surface preparation for installation. Furnish curb markers from a manufacturer that has been producing such curb markers for a minimum of 10 consecutive years. Provide curb markers with a manufacturer's warranty of 10 years or more.

Provide curb markers that contain the text and symbols, text emphasis and text proportions depicted in the following examples format:

Overall Curb Marker Dimensions: 2.5" diameter
Text Color: Black
Background Color: Orange

Submit sample of proposed curb marker to the Engineer for approval before installation. In lieu designing a custom curb marker, the Contractor may submit for the Engineer's approval a stock/standard curb marker format (i.e., off-the-shelf format) from the curb marker manufacturer that differs from the example format proposed above but that still embodies the content and intent conveyed by the example format.

Have the curb marker manufacturer provide a list of references along with contact information for at least five different municipal government agencies and/or state departments of transportation that have installed the proposed manufacturer's curb marker and can attest to the performance of the manufacturer's curb marker over a continuous period of no less than 7 years. Submit these references to the Engineer for review in conjunction with submission of the sample.

16.3. CONSTRUCTION METHODS

(A) Underground Cable Markers in Historic Districts

Obtain the Engineer's approval prior to installing any underground cable markers (i.e., cabinet decals, utility pole signs/decals, and curb markers) within historic districts. The Engineer may modify the application criteria described herein or delete the requirement for some or all underground cable markers based upon the requirements of the particular historic district.

(B) Cabinet Decals

Clean the surface to which the decal will be applied using a mild cleaner that will not damage, deface or discolor the milled aluminum finish of the equipment cabinet. Ensure surface is thoroughly dry before applying decal. Observe any application temperature restrictions specified by the manufacturer when applying the decals.

Apply decal to the two sides of the cabinet and not to the front or rear of the cabinets. Do not apply to cabinet doors or over any cabinet vents/louvers. Place the decals in the top right corner.

Do not apply decals to cabinets where cable is fed to the cabinet from aerial drop on a nearby pole unless the Engineer directs otherwise. Apply decals to cabinet where fiber-optic cable is routed to and/or from the cabinet in an underground conduit run other than the stub-out from a nearby riser that conveys an aerial drop cable.

(C) Utility Pole Signs

Using the hot-dipped, galvanized wood screws, mount the pole sign on the side of pole facing the adjacent street at a height of approximately 5 feet above the ground at the pole. Secure the sign to the pole with at least one fastener at the top of the sign and one at the bottom through the pre-drilled/pre-punched fastener holes provided. Do not field-drill or field-punch signs. Do not install over cables, ground wires, other pole signs, pole tags or pole birthmark (embossed class and length). Mount sign to wood poles only; do not attach sign to metal poles.

Install signs on pole line that is parallel to and adjacent to the underground cable route. Install on each pole in the line along the route, unless otherwise approved by the Engineer. When two or more poles are located in close proximity to one another, install the sign on only one of the poles as approved by the Engineer.

(D) Curb Markers

Install curb markers along curbed streets where the presence of underground fiber-optic communications cable cannot be marked otherwise by placing signs or decals on utility poles. Examples could include but are not limited to: streetscaped areas, residential neighborhoods, areas without utility poles and downtown areas.

Install the curb markers at the beginning and end of the underground run, at the beginning and end of each street block along the underground run, at the midpoint of each street block that is approximately 200-500 feet long, and at intervals of approximately 200 feet elsewhere along the underground run. Premark the proposed locations of the curb markers with 2" x 3" wire flags and obtain the Engineer's approval of the proposed locations prior to installing the curb markers. Remove wire flags immediately upon installation of curb markers. Do not mark fiber-optic drop cable that originates at an aerial splice enclosure and travels a short distance underground between the riser pole and the equipment cabinet, unless otherwise directed by the Engineer. Do not install any curb markers without the Engineer's prior approval.

Clean surface to which curb marker will be applied. Make sure application surface is flat, dry, and free of any loose debris or cracks. Apply adhesive to back side of curb marker in accordance with manufacturer's instructions. When installing on curb, position

marker on top of curb, not on the face of the curb, and center the marker on the top of the curb. Align the curb marker so that arrows (if any) are parallel to underground cable run and so that text can be read from the adjacent street. Apply the curb marker to the application surface and press firmly. Ensure that entire edge around perimeter of marker is sealed to the application surface.

Where underground conduit runs and associated junction boxes are within 10 feet of the adjacent curb and junction boxes are visible from the curb (e.g., in sidewalk, between curb and sidewalk, at back of sidewalk, etc.), install the curb markers on the lids of each oversized and special-sized junction box in lieu of installing them on the curb unless directed otherwise by the Engineer. Where the junction boxes are greater than 10 feet from the curb, install curb markers on the lids of each oversized and special-sized junction box in addition to installing them on the curb unless directed otherwise by the Engineer.

Where there is no curb and there are no poles on which to install pole tags or decals to mark the underground run, install curb markers on the lids of each oversized and special-sized junction box.

16.4. MEASUREMENT AND PAYMENT

No measurement will be made of utility pole signs, cabinet decals and curb markers as they will be considered incidental to furnishing and installing fiber-optic communications cable.

17. REMOVE EXISTING COMMUNICATIONS CABLE

17.1. DESCRIPTION

Remove existing fiber-optic and copper communications cable.

17.2. CONSTRUCTION METHODS

Removal of existing aerial communications cable also includes removal and proper disposal of aerial splice enclosures, messenger cable and mounting hardware, associated guy assemblies, as well as abandoned risers, splice boxes and splice cabinets. Removal of splice cabinets includes the removal of cabinet base if base mounted. Removal of guy assemblies includes the removal of guy anchors if not used by any other guy assembly.

Removal of existing underground communications cable includes proper disposal of junction boxes, if required. Where junction boxes have been removed, backfill hole to 95% of surrounding density and finish level with surrounding ground.

Do not reuse any removed communications cable, messenger cable, junction boxes, pole attachment hardware or abandoned risers on the project, unless otherwise specified. In the event that any of the removed communications cable, junction boxes or pole attachment hardware is to be returned to the Engineer, it will be so noted on the Plans.

Remove all existing twisted-pair communications cable splice boxes and cabinets and associated risers and in-ground junction boxes as shown in the Plans.

Unless otherwise directed by the Engineer, remove and properly dispose of existing wood poles that are vacated upon removal of the existing communications cable (i.e., where the communications cable was the only attachment to the pole).

At several locations, fiber-optic cable owned by New Hanover County is overlashed to the City's existing aerial communications cable. Unless directed otherwise by the Engineer, do not remove the existing City communications cable and supporting messenger cable when the County fiber-optic cable is lashed to them. Cut the City cable but not the supporting messenger at the end of the coincident route instead and abandon the overlashed City cable in place. Do not disturb, unlash or damage the New Hanover County fiber-optic cable.

17.3. MEASUREMENT AND PAYMENT

Remove existing communications cable will be measured in horizontal linear feet of existing communications cable removed. Payment will be in linear feet. Sag, vertical segments, or spare segments of communications cable will not be paid for, as these distances will be considered incidental to the removal of existing communications cable.

Remove splice cabinet will be measured as the actual existing twisted-pair communications cable splice boxes/cabinets successfully removed without regard to the size or type of cabinet, mounting location or mounting method.

No additional measurement will be made for multiple cables being removed from the same conduit or same pole. Where multiple adjacent conduits exist (each containing

multiple cables), each conduit will be considered separately for purposes of payment. No payment will be made for cable that cannot be removed and is abandoned in place.

No measurement will be made of the removal of messenger cable, pole attachment hardware, guy assemblies, vacated wood poles, risers and in-ground junction boxes, and foundations for base-mounted splice cabinets, as these will be considered incidental to removing existing communications cable and splice cabinets.

Payment will be made under:

Pay Item	Pay Unit
Remove Existing Communications Cable	Linear Foot
Remove Splice Cabinet	Each

18. CABLE TRANSFERS

18.1. DESCRIPTION

Remove and reinstall existing communications cable for pole relocations.

18.2. CONSTRUCTION METHODS

During project, transfers of existing communications cable to new poles may be required. Perform transfers as directed by the Engineer. Remove existing cables from pole to be removed and reinstall these cables and any existing attachment hardware on new pole. Remove all communications hardware from existing pole. Furnish and install any new attachment hardware as required.

18.3. MEASUREMENT AND PAYMENT

Cable transfer will be measured and paid as the actual number of cable transfers with attachment hardware to new poles furnished, installed, and accepted.

Payment will be made under:

Pay Item	**Pay Unit**
Cable Transfer	Each

19. SIGNS INSTALLED FOR SIGNALS

19.1. DESCRIPTION

Furnish and install signs for signals with cable hangers, rigid sign mounting brackets, U-channel posts, and all necessary hardware.

19.2. MATERIAL

Comply with Section 901, Sign Fabrication, Article 901-2, 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 messenger cable mounting, furnish either messenger cable hangers with free-swinging, 360 degree adjustable sign brackets or three bolt clamps as directed. Furnish aluminum, galvanized steel, or stainless steel sign supporting hardware.

For ground mounting, furnish steel, 3 lb., U-channel posts with hardware for ground mounting. Comply with Section 903, Ground Mounted Sign Supports, Article 903-2, of the *Standard Specifications*.

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

19.3. CONSTRUCTION METHODS

Install signs with applicable mounting hardware. Comply with sign offsets and mounting heights as shown in the *MUTCD* and NCDOT Roadway Standard Drawing No. 904.50.

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

For ground mounting, comply with Section 903, Ground Mounted Supports, Article 903-3(D), and Section 904, Sign Erection, Articles 904-3(A) and 904-3(C) of the *Standard Specifications*.

For mast arm mounting, install attachment brackets to allow adjustment so signs:

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

19.4. MEASUREMENT AND PAYMENT

Sign 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:

Pay Item	Pay Unit
Sign for Signals	Each

20. SIGNAL CABINET FOUNDATIONS

20.1. DESCRIPTION

Furnish and install signal cabinet foundations and all necessary hardware.

Furnish either poured concrete foundations or preformed cabinet pad foundations and all necessary hardware. Obtain approval of foundation type.

20.2. MATERIAL

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

Refer to Article 1000-4, Portland Cement Concrete, of the *Standard Specifications.*

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

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

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

20.3. CONSTRUCTION METHODS

Comply with Section 825, Incidental Concrete Construction – General, of the *Standard Specifications.*

Obtain approval for final cabinet foundation locations before pouring concrete base. Locate new cabinets so as not to obstruct sight distance of vehicles turning right on red.

Do not install foundations over uncompacted fill or muck.

When installing a new foundation to replace an existing foundation, remove the existing cabinet foundation following completion of the new foundation and installation of the controller cabinet on the new foundation unless the Plans or the Engineer direct otherwise.

Use procedures, equipment, and hardware as follows:

Hand tamp soil before placing concrete. Maintain 12 inches minimum from service pole to closest point on foundation unless otherwise approved.

Use a minimum of four 1/2-inch diameter expanding type anchor bolts to secure cabinet to foundation. Install minimum 4 inches above and 4 inches below finished grade. Locate external stubbed out conduit at cabinet foundation so conduit is in middle of cabinet. Provide service conduit as the rightmost conduit coming into cabinet. Provide two spare conduits stubbed out; one pointed toward service pole and the other toward direction of lead-in cable. Inscribe identification arrow in foundation indicating direction of spare conduits.

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

If using preformed cabinet pad, ensure ground is level before installation. Use loop sealant to seal the conduit stub-outs within the knock-out.

20.4. MEASUREMENT AND PAYMENT

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

No measurement will be made of the removal of existing foundations as these will be considered incidental to furnishing and installing the new foundation.

Payment will be made under:

Pay Item	Pay Unit
Signal Cabinet Foundation	Each

24. MODIFY CABINET FOUNDATIONS

24.1. DESCRIPTION

Where approved by the Engineer, install conduit entrances into existing foundations in accordance with the Plans and these Project Special Provisions.

Modify existing foundations in accordance with the Plans and these Project Special Provisions.

24.2. MATERIALS

Comply with the provisions of the Signal Cabinet Foundations section of these Project Special Provisions.

24.3. CONSTRUCTION METHODS

(A) General

Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinet foundations. Standby status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

(B) Install Conduit Entrance into Existing Foundation

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. If it is not possible to maintain traffic signal operations while constructing new conduit entrance and if approved by the Engineer, provide a police officer to direct traffic through the intersection while the signal is inoperable. Complete drilling and restore signal operations within one hour of deactivation of the signal.

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.

(C) 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 6 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"	18"
>6" and <16"	11"
= 6"	8"

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.

(D) Alternate Methods of Modifying Foundations

Where the Plans call for a new conduit entrance to be installed into an existing cabinet foundation or for the existing foundation to be modified by expanding it, the Contractor may, subject to the approval of the Engineer and at no additional cost to the Department, use one of the following methods in lieu of core-drilling and/or expanding the existing base:

- Remove the existing cabinet foundation and replace it with a new preformed cabinet pad in the same location.
- Overlay the existing cabinet foundation with a new preformed cabinet pad.
- Install a new cabinet foundation adjacent to the existing foundation.

Comply with the construction methods for each method described below.

1) In Situ Replacement

Carefully remove the existing concrete from around the existing conduit spread, taking care not to damage the conduit stubs or the existing field wiring. Construct additional conduit stub-out(s) where the Plans call for a new conduit entrance in the existing foundation. Once existing concrete has been completely removed and new stub-out(s) has been constructed, immediately set a preformed cabinet pad over the existing

conduit spread and new stubout(s). Install preformed cabinet pad in accordance with the manufacturer's instructions. Reinstall existing controller and cabinet or install new controller and cabinet on the new preformed pad. Provide preformed cabinet pads that are listed on the Department's QPL.

2) Overlay Existing Foundation

Where the top of the existing cabinet foundation is no more than 2 inches above the surrounding ground, overlay the existing foundation by setting a preformed cabinet pad over the existing conduit spread and existing foundation. Level and hand tamp the ground around the existing foundation and install the preformed pad in accordance with the manufacturer's instructions. Furnish and install couplings, nipples, and bushings to extend the existing conduit stub-outs so that the tops of the conduits are 2-3 inches above the top of the preformed pad. Use existing field wiring, splicing and extending the field wiring inside the controller cabinet as needed (refer to Extension of Existing Field Wiring section of these Project Special Provisions). Install new conduit entrance(s) into the existing foundation if necessary.

Immediately reinstall the existing controller and cabinet or install the new controller and cabinet once the preformed pad is set in place.

Backfill around the perimeter of the new pad with topsoil to a point 4 inches below the top surface of the new pad. Gently slope the backfill to tie into the existing ground line with a gradual slope no steeper than 4:1; do not create an abrupt or unsightly mound. Ensure the preformed pad and backfill does not block the flow of runoff or impound water. Hand tamp the new soil and apply grass seed and mulch.

Do not use this method where the top of the existing cabinet foundation is more than 2 inches higher than the surrounding ground, unless the Engineer approves otherwise.

3) Construct New Foundation Adjacent to Existing Foundation

Construct a new cabinet foundation with all necessary hardware adjacent to the existing foundation and rewire the cabinet using one of the following methods:

- Install new risers on adjacent cabinet pole, "pull back" existing field wiring to the top of the existing risers, reinstall existing wiring through the new risers to the new foundation and splice and extend field wiring with gel-filled butt splice connectors in base of new cabinet if necessary.
- Install new risers with terminal splice cabinet on adjacent cabinet pole, "pull back" existing field wiring to the top of the existing risers, and reinstall existing wiring through the new risers to the terminal splice cabinet. Inside the terminal splice cabinet, splice the existing wiring to new conductors from the new base-mounted controller cabinet.

Comply with the "Signal Cabinet Foundations" section and the "Extension of Existing Field Wiring" section of these Project Special Provisions.

24.4. MEASUREMENT AND PAYMENT

Conduit entrance into existing foundation will be measured and paid for the actual number of conduit entrances drilled into existing cabinet foundations furnished, installed and accepted. As approved by the Engineer, police provided for directing traffic while a

signal is inoperable during construction of conduit entrance into existing foundation will be measured and paid for separately in accordance with the "Temporary Traffic Control" section of these Project Special Provisions.

Modify foundation for controller cabinet will be measured and paid as the actual number of existing cabinet foundations modified and accepted.

Alternate methods for adding conduit entrances to and modifying existing cabinet foundations will be measured and paid as *conduit entrance into existing foundation* and/or *modify foundation for controller cabinet*, as specified in the Plans for the given location. Such payment will be full compensation for all work required to add the conduit entrance and/or modify the cabinet foundation using one of the alternate methods described above. No separate measurement will be made of preformed cabinet pads, removal of existing foundations or splicing and extending existing field wiring required due to the use of an alternate method for adding a conduit entrance or for modifying an existing cabinet foundation.

Payment will be made under:

Pay Item	**Pay Unit**
Conduit Entrance into Existing Foundation	Each
Modify Foundation for Controller Cabinet	Each

25. CONTROLLERS WITH CABINETS

25.1. DESCRIPTION

Furnish and install controllers with cabinets and all necessary hardware. Furnish all pole or foundation mounting hardware, detector sensor cards, one Corbin Number 2 cabinet key, one police panel key, conflict monitors, surge protection, grounding systems, AC/DC isolator cards, auxiliary files (where required) and all necessary hardware. Install Department-furnished local controller software on existing controllers where required. Install updates of local controller and operating system software.

25.2. MATERIALS - GENERAL

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

25.3. MATERIALS – TYPE 2070L CONTROLLERS

Conform to CALTRANS *Transportation Electrical Equipment Specifications* (TEES) (11-19-99) 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 local controller software at the beginning of the burning-in period. Contractor shall give five working days notice before needing software. The Department will provide updates to the local controller software for installation by the Contractor up through final acceptance of the project.

Provide model 2070L controllers with the latest version of OS9 operating system 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)

Provide all updates to the OS9 operating system software released up through final acceptance of the project at no additional cost to the Department.

Furnish one additional MODEL 2070-7A, Async Serial Com Module (9-pin RS-232) for all master controller locations, if such a configuration need should arise.

25.4. MATERIALS – GENERAL CABINETS

Provide a moisture resistant coating on all circuit boards.

Provide one V150LA20 MOV or equal protection on each load switch field terminal.

Provide a power line surge protector that is a two-stage device that will allow connection of the radio frequency interference filter between the stages of the device. Ensure that a maximum continuous current is at least 10A at 120V. Ensure that the device

can withstand a minimum of 20 peak surge current occurrences at 20,000A for an 8x20 microsecond waveform. Provide a maximum clamp voltage of 280V at 20,000A with a nominal series inductance of 200μh. Ensure that the voltage does not exceed 280V. Provide devices that comply with the following:

Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

25.5. MATERIALS – TYPE 170E CABINETS

(A) Type 170 E Cabinets General

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

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

Furnish CALTRANS Model 332A base mounted cabinets 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.

Furnish cabinets with auxiliary file pre-wired into the cabinet for future implementation of FYA left-turn signals at the following locations.

- 3rd Street at Front/Davis (03-0082)
- 3rd Street at Market Street (03-0018)
- 23rd Street at MLK EB (03-0478)
- Eastwood Road at Rogersville (03-0778)
- Eastwood Road at Pembroke Jones (03-0751)
- Eastwood Road at Wrightsville (03-0213)
- Kerr Ave at MLK (03-0786)
- Market Street at MLK/Eastwood (03-0721)

Where auxiliary output files have been installed and wired into traffic signal cabinets for future use, no field wiring is required to the output terminals of the auxiliary output file.

(B) 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 (1) 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 # 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 an 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 megohms. Provide an absolute maximum operating line current of one (1) 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 2010ECL-NC enhanced 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 2010ECL-NC 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 (1) 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.

(C) 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 # 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.

(D) Type 170 E Model 2010 Enhanced Conflict Monitor

Furnish Model 2010 Enhanced Conflict Monitors that provide monitoring of 16 channels. Ensure each channel consists of a green, yellow, and red field signal input. Ensure that the conflict monitor meets or exceeds CALTRANS Transportation Electrical Equipment Specifications dated August 16, 2002 with Erratum 1 and 2 (hereafter referred to as CALTRANS's 2002 TEES) for a model 210 monitor unit and other requirements stated in this specification.

Ensure the conflict monitor is provided with a 16 channel conflict programming card. Pin 16 and Pin T of the programming card shall be connected together. Ensure that the absence of the conflict programming card will cause the conflict monitor to trigger (enter into fault mode), and remain in the triggered state until the programming card is properly inserted and the conflict monitor is reset.

Provide a conflict monitor that incorporates LED indicators into the front panel to dynamically display the status of the monitor under normal conditions and to provide a comprehensive review of field inputs with monitor status under fault conditions. Ensure that the monitor indicates the channels that were active during a conflict condition and the channels that experienced a failure for all other per channel fault conditions detected. Ensure that these indications and the status of each channel are retained until the Conflict Monitor is reset. Furnish LED indicators for the following:

- AC Power
- VDC Failed

- WDT Error
- Conflict
- Red Fail
- Dual Indication
- Short Yellow/Sequence Failure
- Program Card/PC Ajar
- Monitor Fail/Diagnostic Failure
- Channel Indicators (One indicator for each green, yellow, and red field signal input for each channel)

In addition to the connectors required by CALTRANS's 2002 TEES, provide the conflict monitor with a red interface connector mounted on the front of the monitor (3M-3428-5302 or equivalent with polarizing keys) which ensures proper mating with a 20 pin ribbon cable connector that conducts the signals from the P20 connector on the cabinet assembly. Keying of the connector shall be between pins 3 and 5, and between 17 and 19. The odd numbered pins are on one side, and the even pins are on the other. Provide connector pins on the monitor with the following functions:

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

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

Provide Special Function 1 and Special Function 2 inputs to the unit which shall disable only Red Fail Monitoring when either input is sensed active. A Special Function input shall be sensed active when the input voltage exceeds 70 Vrms with a minimum duration of 550 ms. A Special Function input shall be sensed not active when the input voltage is less than 50 Vrms or the duration is less than 250 ms. A Special Function input is undefined by these specifications and may or may not be sensed active when the input voltage is between 50 Vrms and 70 Vrms or the duration is between 250 ms and 550 ms.

Ensure the conflict monitor recognizes field signal inputs for each channel that meet the following requirements:

- consider a Red input greater than 70 Vrms and with a duration of at least 500 ms as an "on" condition;

- consider a Red input less than 50 Vrms or with a duration of less than 200 ms as an "off" condition (no valid signal);
- consider a Red input between 50 Vrms and 70 Vrms or with a duration between 200 ms and 500 ms to be undefined by these specifications;
- consider a Green or Yellow input greater than 25 Vrms and with a duration of at least 500 ms as an "on" condition;
- consider a Green or Yellow input less than 15 Vrms or with a duration of less than 200 ms as an "off" condition; and
- consider a Green or Yellow input between 15 Vrms and 25 Vrms or with a duration between 200 ms and 500 ms to be undefined by these specifications.

Provide a conflict monitor that recognizes the faults specified by CALTRANS's 2002 TEES and the following additional faults. Ensure the conflict monitor will trigger upon detection of a fault and will remain in the triggered (in fault mode) state until the unit is reset at the front panel or through the external remote reset input for the following failures:

1. **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 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.

2. **Short/Missing Yellow Indication Error (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 for a minimum of 2.7 seconds (± 0.1 second) following the detection of an "on" signal at a Green input for that channel, ensure that the monitor triggers and generates a sequence/short yellow error fault indication. This fault shall not occur when the channel is programmed for Yellow Inhibit or when the Red Enable signal is inactive.
3. **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 200 ms, ensure that the monitor does not trigger. G-Y-R dual indication monitoring shall be enabled on a per channel basis by use of switches located on the conflict monitor. G-Y dual

indication monitoring shall be enabled for all channels by use of a switch located on the conflict monitor.

4. **Configuration Settings Change:** The configuration settings are comprised of (as a minimum) the permissive diode matrix, dual indication switches, yellow disable jumpers, any option switches, any option jumpers, and the Watchdog Enable switch. Ensure the conflict monitor compares the current configuration settings with the previous stored configuration settings on power-up, on reset, and periodically during operation. If any of the configuration settings are changed, ensure that the conflict monitor triggers and causes the program card indicator to flash. Ensure that configuration change faults are only reset by depressing and holding the front panel reset button for five seconds. Ensure the external remote reset input does not reset configuration change faults.

Ensure the conflict monitor will trigger and the AC Power indicator will flash at a rate of 2 Hz ± 20% with a 50% duty cycle when the AC Line voltage falls below the "drop-out" level. Ensure the conflict monitor will resume normal operation when the AC Line voltage returns above the "restore" level. Ensure the AC Power indicator will remain illuminated when the AC voltage returns above the "restore" level. The "drop-out" level is at 98 Vrms and the "restore" level is at 103 Vrms with timing at 400 ms. Should an AC Line power interruption occur while the monitor is in the fault mode, then upon restoration of AC Line power, the monitor will remain in the fault mode and the correct fault and channel indicators will be displayed.

Provide a flash interval of at least 6 seconds and at most 10 seconds in duration following a power-up, an AC Line interruption, or a brownout restore. Ensure the conflict monitor will suspend all fault monitoring functions, close the Output relay contacts, and flash the AC indicator at a rate of 4 Hz ± 20% with a 50% duty cycle during this interval. Ensure the termination of the flash interval after at least 6 seconds if the Watchdog input has made 5 transitions between the True and False state and the AC Line voltage is greater than the "restore" level. If the watchdog input has not made 5 transitions between the True and False state within 10 ± 0.5 seconds, the monitor shall enter a WDT error fault condition.

Ensure to monitor an intersection with up to four approaches using the four-section Flashing Yellow Arrow (FYA) vehicle traffic signal as outlined by the NCHRP 3-54 research project for protected-permissive left turn signal displays. Ensure the conflict monitor will operate in the FYA mode and FYAc (Compact) mode as specified below to monitor each channel for the following fault conditions: Conflict, Red Fail, Dual Indication, and Clearance. Provide a switch to select between the FYA mode and FYAc mode. Provide a switch to select each FYA phase movement for monitoring.

FYA mode

FYA Signal Head	Phase 1	Phase 3	Phase 5	Phase 7
Red Arrow	Channel 9 Red	Channel 10 Red	Channel 11 Red	Channel 12 Red
Yellow Arrow	Channel 9 Yellow	Channel 10 Yellow	Channel 11 Yellow	Channel 12 Yellow
Flashing Yellow Arrow	Channel 9 Green	Channel 10 Green	Channel 11 Green	Channel 12 Green
Green Arrow	Channel 1 Green	Channel 3 Green	Channel 5 Green	Channel 7 Green

FYAc mode

FYA Signal Head	Phase 1	Phase 3	Phase 5	Phase 7
Red Arrow	Channel 1 Red	Channel 3 Red	Channel 5 Red	Channel 7 Red
Yellow Arrow	Channel 1 Yellow	Channel 3 Yellow	Channel 5 Yellow	Channel 7 Yellow
Flashing Yellow Arrow	Channel 1 Green	Channel 3 Green	Channel 5 Green	Channel 7 Green
Green Arrow	Channel 9 Green	Channel 9 Yellow	Channel 10 Green	Channel 10 Yellow

Ensure that the conflict monitor will log at least nine of the most recent events detected by the monitor in non-volatile EEPROM memory (or equivalent). For each event, record at a minimum the time, date, type of event, status of each field signal indication with RMS voltage, and specific channels involved with the event. Ensure the conflict monitor will log the following events: monitor reset, configuration, previous fault, and AC line. Furnish the signal sequence log that shows all channel states (Greens, Yellows, and Reds) and the Red Enable State for a minimum of 2 seconds prior to the current fault trigger point. Ensure the display resolution of the inputs for the signal sequence log is not greater than 50 ms.

Provide a RS-232C/D compliant port (DB-9 female connector) on the front panel of the conflict monitor in order to provide communications from the conflict monitor to the 170/2070L controller or to a Department-furnished laptop computer. Electrically isolate the port interface electronics from all monitor electronics, excluding Chassis Ground. Ensure that the controller can receive all event log information through a controller Asynchronous Communications Interface Adapter (Type 170E) or Async Serial Comm Module (2070L). Provide a Windows based graphic user interface software to communicate directly through the same monitor RS-232C/D compliant port to retrieve and view all event log information to a Department-furnished laptop computer. The RS-232C/D compliant port on the monitor shall allow the monitor to function as a DCE device with pin connections as follows:

Conflict Monitor RS-232C/D (DB-9 Female) Pinout		
Pin Number	**Function**	**I/O**
1	DCD	O
2	TX Data	O
3	RX Data	I
4	DTR	I
5	Ground	-
6	DSR	O
7	CTS	I
8	RTS	O
9	NC	-

25.6. MATERIALS – DETECTOR SENSOR UNITS

Furnish detector sensor units (i.e., detector cards) that comply with Chapter 5, "General Requirements for Detector Sensor Units," of the CALTRANS Specifications, and the requirements for Model 222 and Model 224 loop detector sensor cards.

25.7. 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. Provide a police officer(s) to direct traffic through the signalized intersection while the signal is inoperable. Complete installation of the new controller and cabinet and restore signal operations within 3 hours of taking the existing controller and cabinet out of service.

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

For all Department-owned signals, stencil the signal inventory number on cabinet side facing roadway. Use 3-inch black characters. For City-owned signals, apply the city intersection number to all sides of cabinet on sides of the cabinet visible from the street using 3-inch high, pre-cut vinyl numerals.

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.

When installing a pole mounted cabinet in a new location or in an existing location where new risers and cabling are replacing existing risers and cabling, mount the cabinet so that the height to cabinet middle is 4 feet from the ground below. Avoid mounting cabinets so that they overhang and encroach upon an adjacent sidewalk or pedestrian path. Where a minor overhang of the sidewalk or pedestrian path cannot be reasonably avoided, ensure that that a minimum of 4 feet of clear sidewalk width will remain once the cabinet is installed. Do not mount cabinets where one of its doors opens into a street, driveway or other area subject to vehicular traffic or where an existing physical feature such as a pole, sign post, down guy, shrub or tree prevents its doors from being opened at least 90 degrees.

When replacing an existing pole-mounted cabinet with a new pole-mounted cabinet and the existing risers and cabling are being retained, mount the new cabinet so that the cabinet bottom rests upon the existing riser connections even though this causes the cabinet middle to be higher or lower than 4 feet above ground, unless the Plans indicate or the Engineer directs otherwise. Except where the "Summary of Work by Intersection" sheet calls for use of the "Reconfigured Pole Mounted 336S Cabinet Detail" to mount the 2070L controller lower in the rack inside such cabinets, comply with the cabinet layout shown in RSD No. 1751.01, Sheet 2 of 2.

Activate controllers with proposed phasing and timing.

Install all updates to the local controller software and OS9 operating system software during the life of the project up through final acceptance of the project, including existing 2070L controllers that will be retained and incorporated into the upgraded and expanded Wilmington Signal System.

For the existing traffic signals on east side of the Isabel Holmes bridge, 03-0916 and 03-0918, electrical power and some video detection lead-in cables enter the existing NEMA cabinet through flex conduits attached to the sides of the existing cabinets. When replacing these cabinets with new Model 332A cabinets on base extenders, attach these flex conduits to entries in the side of the base extender instead of the side of the cabinet. Do not attach any conduits to and part of the new controller cabinet. Replace or extend the existing flex conduits as needed to reach the base extenders in a manner approved by the Engineer. Replace the electrical service wires between the service disconnect and the controller cabinet as needed if existing conductors are too short once flex conduits are rerouted/extended to attach to the cabinet base extender.

(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 City-furnished central computer.

(C) Workshop

Provide enclosed workshop to set up and test new controllers and cabinets before installation. Locate workshop within the city limits of Wilmington. 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 Web site.

Test the cabinet and controller for 8 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.

25.8. MEASUREMENT AND PAYMENT

Controller with cabinet (____) will be measured and paid as the actual number of each type of controllers with cabinets furnished, installed, and accepted, subject to the following conditions: 90% of the payment will be made upon acceptance of the unit; 10% of the payment will be made following final acceptance of the integrated system (including completion of the 30-day observation period).

Detector cards (Type 2070L) will be measured and paid as the actual number of Type 2070L detector cards furnished, installed, and accepted.

Auxiliary files will be measured and paid as the actual number of auxiliary files furnished, installed, and accepted.

No measurement will be made of conflict monitors, grounding systems, modems, workshop and installing Department-furnished local controller software on existing controllers as these will be considered incidental to furnishing and installing controllers with cabinets.

No measurement will be made of reworking flex conduit entrances into cabinet base extenders, replacing or extending flex conduits and replacing service wires at signals 03-0916 and 03-0918 as such work will be considered incidental to furnishing and installing controllers with cabinets and furnishing and installing base extenders.

Furnish detector card (Type 2070L) will be measured and paid as the actual number of Type 2070L detector cards furnished and accepted.

Furnish 2070L controller will be measured and paid as the actual number of 2070L controllers furnished and accepted.

Furnish _____ cabinet will be measured and paid as the actual number of each type of controller cabinet furnished and accepted.

Furnish 2010 ECL-NC Enhanced Conflict Monitor will be measured and paid as the actual number of type 170 E model 2010 enhanced conflict monitors furnished and accepted.

Payment will be made under:

Pay Item	**Pay Unit**
Controller with Cabinet (2070L, Pole Mounted)	Each
Controller with Cabinet (2070L, Base Mounted)	Each
Detector Card (Type 2070L)	Each
Auxiliary File	Each
Furnish Detector Card (Type 2070L)	Each
Furnish 2070L Controller	Each
Furnish 336S Cabinet	Each
Furnish 332 Cabinet	Each
Furnish 2010 ECL-NC Enhanced Conflict Monitor	Each

26. CABINET BASE ADAPTER AND BASE EXTENDER

26.1. DESCRIPTION

Furnish and install cabinet base adapters and base extenders with all necessary hardware for 170 Cabinets.

26.2. MATERIAL

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".

26.3. CONSTRUCTION METHODS

Unless otherwise shown in the Plans, install a cabinet base extender at locations requiring new Model 332A cabinet on an existing/modified or new foundation and where an existing base-mounted Model 332A cabinet that is being retained does not have a cabinet base extender.

Install a cabinet base adapter at locations requiring a new Model 332A cabinet to be installed on an existing/modified foundation where the opening in the bottom of a cabinet base extender will not fit over the existing conduit spread. Unless otherwise directed by the Engineer, install cabinet base adapters only at locations indicated in the Plans. Do not install cabinet base adapters where the Plans call for use of a cabinet base extender without the prior approval of the Engineer.

Where Model 336 cabinet is used as base mount cabinet, install adapter or extender, as required.

Use permanent, flexible waterproof sealing material to:

- Seal between cabinet base and cabinet base adapter/extender,
- Seal two-piece cabinet base adapter/extender seams, and
- Seal space between cabinet base adapter/extender and foundation

26.4. MEASUREMENT AND PAYMENT

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

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

Payment will be made under:

Pay Item	Pay Unit
Cabinet Base Adapter	Each
Cabinet Base Extender	Each

27. ELECTRICAL SERVICE

27.1. DESCRIPTION

At locations called out in the Plans, install a new electrical service for a CCTV camera assembly and modify an existing traffic signal controller cabinet electrical service to add a meter base.

27.2. MATERIALS

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

Provide, revise and/or upgrade all materials necessary to form a complete electrical service assembly as shown in NCDOT Roadway Standard Drawing No. 1700.01. Furnish new external electrical service disconnects, meter bases, and extend or replace electrical service conductors and conduits between the disconnects and the controller cabinets as required.

Provide external electrical service disconnects at all new and existing cabinet locations unless otherwise specified in the Plans. Furnish external electrical service disconnects with one 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 listed as meeting UL Standard UL-489 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 meter base rated 100 ampere minimum that meets the requirements of the local utility. Provide meter base with socket's ampere rating based on sockets being wired with minimum of 167 degrees F insulated wire. 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
- With or without horn bypass
- Made of galvanized steel
- Listed as meeting UL Standard UL-414
- Overhead or underground service entrance as specified

Ensure meter bases have electrostatically applied dry powder paint finish, light gray in color, with minimum thickness of 2.4 mils.

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

If meter base and electrical service disconnect are supplied in the same enclosure (i.e., combination panel), ensure assembly is marked as being suitable for use as service equipment. Ensure combination meter and disconnect mounted in a pedestal for underground service is listed as meeting UL Standard UL-231. Otherwise, ensure combination meter and disconnect is listed as meeting UL Standard UL-67.

For all new ground-mounted electrical service assemblies for underground electrical service, provide a combination panel with pedestal extension as shown in the Plans. Do not provide wood posts, steel U-channel posts, square tube sign posts (i.e., Telespar, etc.), Unistrut metal framing or any method other than an underground service pedestal to mount meter bases and disconnects for new underground electrical service.

27.3. CONSTRUCTION METHODS

(A) General

All work involving electrical service shall be coordinated with the appropriate electric utility company. Coordinate with the utility company to ascertain the feasibility of installing electrical service at each location before performing any work. Obtain all required local permits before beginning work.

Run service conductors separately from all other conductors in a 1-inch rigid galvanized conduit. Do not allow service conductors to share conduits with any other conductors or cables. Do not route unfused electrical service conductors inside of metal poles.

(B) New Electrical Service for CCTV

At locations identified in the Plans, install new electrical service for a CCTV cabinet in accordance with the details shown in the Plans. Install a new electrical service comprised of an external service disconnect and a meter base housed in a combination panel. Mount the combination panel on the CCTV camera pole as shown in the Plans. If the CCTV camera and cabinet are being mounted on an existing signal pole, the combination panel may be ground-mounted on a pedestal adjacent to the pole subject to the approval of the Engineer. After installation of the meter base, the local power company will install a new meter and make any necessary connections to the power lines.

Unless the Plans indicate otherwise, have the power company route the service drop underground to the combination panel, even where source power lines are overhead. Except at locations where the Plans specifically call for use of a wood service pole, do not set a wood service pole with an overhead feed from the power company without the prior approval of the Engineer.

Where the Plans specifically call for installation of a service pole to facilitate an overhead feed, install a wood service pole in accordance with the "Wood Poles" section of these Project Special Provisions. Install the service pole at a location approved by the Engineer and the local power company. Install a 1-inch rigid galvanized riser with weatherhead and a meter base/disconnect combination panel on the service pole such that the disconnect can be seen be personnel standing at the nearby CCTV controller cabinet. Install a 1-inch rigid galvanized conduit containing new service wires (conductors) underground between the disconnect and the pole-mounted CCTV cabinet, including the short risers at each end of the run to connect the underground conduit to the cabinet and disconnect on their respective poles. After installation of the meter base, the local power company will install a new meter and make any necessary connections to the power lines.

(C) Modify Existing Electrical Service for Traffic Signal

At locations identified in the Plans, modify an existing electrical service assembly for a traffic signal to add a new meter base where none presently exists. Comply with NCDOT Roadway Standard Drawing No. 1700.01.

Extend or replace electrical service conductors and conduits between the disconnect and the controller cabinet as required. Modify existing risers as needed to add the meter base to the existing electrical service assembly. After installation of the meter base, the local power company will install a new meter.

27.4. MEASUREMENT AND PAYMENT

New electrical service for CCTV (_____) will be measured and paid for as the actual number of complete, functional electrical services of each type for CCTV locations furnished, installed and tested.

No measurement will be made of short risers (i.e., from disconnect to underground conduit), meter bases, service disconnects, underground conduit runs between ground-mounted combination pedestals and CCTV or signal cabinets, underground conduits between traffic signal controller cabinets and a service disconnect mounted on a nearby pole, acquisition of service fees, electrical service conductors, grounding electrode, ground wire and any remaining hardware and conduit to connect the electrical service to the cabinet as they will be considered incidental to furnishing and installing new electrical service.

Risers with weatherheads will be measured and paid for separately in accordance with the "Riser Assemblies" section of these Project Special Provisions. Underground conduit runs between a new service pole and an adjacent CCTV camera pole will be measured and paid for separately in accordance with the "Underground Conduit" section of these Project Special Provisions.

Wood service poles for new overhead electrical service, where required, will be measured and paid for separately in accordance with the "Wood Poles" section of these Project Special Provisions.

Modify existing electrical service for traffic signal will be measured and paid for as the actual number of electrical service locations that have been modified to add a meter base.

No measurement will be made of the following as they are considered incidental to modifying an existing electrical service for traffic signal: electrical service conductors; conduit and hardware required to connect the electrical service to the cabinet; and upgrading existing grounding systems, where required.

Payment will be made under:

Pay Item	Pay Unit
New Electrical Service for CCTV (Overhead)	Each
New Electrical Service for CCTV (Underground)	Each
Modify Existing Electrical Service for Traffic Signal	Each

28. SPREAD SPECTRUM WIRELESS RADIO

28.1. DESCRIPTION

Furnish and install a spread spectrum radio system with all necessary hardware 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), Underwriters 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.

28.2. MATERIALS

(A) General

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

(B) 900MHz 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)
- Serial interface capable of operating at 1200 bps to115 Kbps sustained data throughput,
- DB9-F connector for RS-232/422/485 serial port,
- Maximum of 8 mSec. end-to-end latency
- 32 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)
- Data encryption 28 bit WEP, 128 bit WPA, 256 Bit AES ,
- 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, and
  - Signal Strength.
- 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 600 mA when powered with 12 VDC input, and transmitting 1 watt of RF output power, and
  - Radio sleep mode with a maximum current draw of <1μA.
- Shelf mounted design not to exceed 5" long x 2" wide x 7" 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 radio system with a fully functional field device (i.e., traffic signal controller or DMS) does not require any field device modifications with regards to hardware or software.

(C) Software

Furnish units with a Windows® based software program that uses a GUI (Graphical User Interface) to provide "remote programming, radio configuration, remote maintenance, diagnostics and spectrum analyzer" features. Provide software approved by the Engineer that is designed to function with the approved 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 (DMS) controllers.

(D) 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) @ 900MHz	3.9 dB
Power Rating @ 900MHz	0.58 kW
Center Conductor	0.108" 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
End Connectors	Standard N-Type male connectors on both ends

(E) 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
Impedance	50 ohms
Length	24"
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.26 sq. ft.
Number Elements	6
Allows for Vertical or Horizontal polarization	
Minimum separation distance from persons installing and using an active device	9"
Minimum separation distance from other RF sources including radios and antennas	6.5'
Welded construction	

Cushcraft Model # PC9013N (13 dB Gain)

Frequency Range	902 – 928 MHz
Nominal Gain	13 dB
Front to Back Ratio	20 dB
Horizontal Beam Width (at half power points)	40 degree
Vertical Beam Width (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
Impedance	50 ohms
Length	53"
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.46 sq. ft.
Number Elements	13
Allows for Vertical or Horizontal polarization	
Minimum separation distance from persons installing and using an active device	9"
Minimum separation distance from other RF sources including radios and antennas	6.5'
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.

(F) Omni Directional Antenna

Furnish an omni directional antenna that will allow the system to function as designed. Furnish 3 dB Antenex Model # FG9023 or 6 dB Antenex Model # FG9026 antenna or an approved equivalent antenna that meets 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	3 dB – 25" 6 dB – 65"
Rated Wind Velocity	125 mph
Solid, single piece construction	
Minimum separation distance from persons installing and using an active device	9"
Minimum separation distance from other RF sources including radios and antennas	6.5'
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.

(G) Signal Splitter

Furnish a coaxial antenna splitter at a repeater site to provide for connection of two antennae. The splitter shall be compatible with the antenna cable and antenna.

(H) Standard N-Type Male Connector

Furnish Standard N-Type Male Connector(s) of proper sizing to mate with the 400 series coaxial cable and utilize a crimping method to secure the connector to the coaxial cable. Furnish a connector that meets the following minimum specifications:

- Center Contact: Gold plated beryllium copper (spring loaded, not soldered),
- Outer Contact: Silver plated brass,
- Body: Silver Plated brass,
- Crimp Sleeve: Silver plated copper,
- Dielectric: Teflon PTFE,
- Water Proofing Sleeve: Adhesive lined polyolefin heat shrink, and
- Attachment Size: Crimp size 0.429" (minimum) hex.

Electrical Properties:

- Impedance: 50 ohms,
- Working Voltage: 1000 Vrms (max),
- Insertion loss: 0.1 x $\sqrt{F}$ghz, and
- VSWR: 1.25:1 (max) up to 3GHz.

Provide instructions on properly installing the connector.

(I) Coaxial Cable Shield Grounding and Weatherproofing Kits

Furnish a coaxial cable shield grounding kit containing components that will adequately bond and ground the cable shield to the pole ground. Ensure the grounding kit complies with MIL-STD-188-124A Specifications *Military Standard for Grounding, Bonding and Shielding* for coaxial cable and protects the cable from lightning currents in excess of 200kA. Ensure each kit is supplied, as a minimum, with the following:

- Preformed Strap: 24 gauge copper strap that is a minimum of 1-5/8 inch long and is sized to mate with the 400 series coaxial cable,
- Tensioning Hardware: Copper nuts and lock washers,
- Grounding Lead Cable: #6 AWG, stranded, insulated copper wire, and
- Instructions on properly installing the shield grounding system.

Furnish a weatherproofing kit containing components that will protect the coaxial cable shield grounding system against the ingress of moisture and prevent vibrations from loosening the connections. Ensure the weatherproofing kit is supplied, as a minimum, with the following:

- Butyl Mastic Tape: 3/4 inches wide by 24 inches long (approximately),
- Electrical Tape: 1/2-inch wide by 20 inches long (approximately), and
- Instructions on properly installing the weatherproofing system.

(J) Surge Protector

Provide a two-stage power line surge protector between the electrical equipment receptacles and the equipment breaker. Ensure a maximum continuous current of at least 10A at 120V. Ensure that the device can withstand a minimum of 20 peak surge current occurrences at 20,000A for an 8x20 microsecond waveform. Provide a maximum clamp voltage of 280V at 20,000A with a nominal series inductance of 200μh. Ensure that the voltage does not exceed 280V. Provide devices that comply with the following:

Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

Ensure the two-stage power line surge protector will allow connection of a radio frequency interference filter between the two stages of the device. Ensure the radio frequency interference filter minimizes interference generated in the cabinet in both the broadcast and aircraft frequencies. Ensure the filter(s) provide attenuation of at least 50 decibels over a frequency range of 200 kilohertz to 75 megahertz. Furnish a filter that is

hermetically sealed in an insulated metal case. Ensure the filter is rated at least at the rated current of the main circuit breaker, 125-volts, 60Hz.

Provide a neutral that is not connected to the earth ground or the logic ground anywhere within the cabinet. Ensure that the earth ground bus and the neutral ground bus each have ten compression type terminals each of which can accommodate wires ranging from # 14 through # 4.

Furnish a cabinet wiring schematic to be placed in the cabinet. See the special details shown in the Plans.

(K) 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 # DSXL lightning arrestor or an approved equivalent that meets the following minimum specifications:

- Surge: 20kA, 800MHz to 2.0GHz ≤ 1.1:1 VSWR,
  18kA, 800MHz to 2.3GHz ≤ 1.1:1 VSWR,
  700MHz to 2.7GHz ≤ 1.2:1 VSWR,
- Insertion Loss: ≤0.1 dB over frequency range,
- Max Power: 500 w @ 920MHz (750 W @ at 122° F),
- RF Power: 300 watts,
- Let Through Voltage: ≤+/- 3 volts for 3kA @ 8/20 μs waveform,
- Throughput Energy: ≤ 0.5 μJ for 3kA @ 8/20 μs waveform,
- Temperature: -40 to 185° F storage/operating 122° F,
- Vibration: 1G at 5 Hz up to 100Hz,
- Unit Impedance: 50Ω,
- VSWR: 1.1:1,
- Frequency Range: 800 MHz to 2200 MHz,
- Multistrike capability,
- Low strike throughput energy,
- Flange mount and bulkhead mount options, and
- Standard N-Type female connector on both the surge side and protected side connectors.

28.3. CONSTRUCTION METHODS

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 antennas in accordance with the following table:

Location	Radio Configuration	Antenna	
		Direction Pointing	Type/ Gain
Market Street at Gordon Road	Receiver	Northwest	1- Yagi (8.5 dB)
Gordon Road at Netherlands Drive	Transmitter	Southeast	1- Yagi (8.5 dB)
Oleander Drive at Airlie Road	Receiver	South	1- Yagi (8.5 dB)
Oleander Drive at Greenville Avenue	Transmitter	North	1- Yagi (8.5 dB)
Military Cutoff Road at Eastwood Road	Receiver	Northwest	1- Yagi (8.5 dB)
Eastwood Road at Rogersville Road	Transmitter	Southeast	1- Yagi (8.5 dB)
Hawthorne Road at Wrightsville Avenue	Transmitter	South	1- Yagi (8.5 dB)
Oleander Drive at Hawthorne Road	Transmitter / Repeater	West **	1- Yagi (8.5 dB)
		North	1- Yagi (8.5 dB)
M.L. King Jr. Parkway north of T-Bridge (CCTV-21)	Receiver	N/A	1- Omni (6 dB)
US 421 at NC 133	Transmitter	East	1- Yagi (8.5 dB)
NC 133 at Y-Bridge	Transmitter	East	1- Yagi (8.5 dB)
NC 133 at T-Bridge	Transmitter	Northeast	1- Yagi (8.5 dB)

**This signal is repeated by antenna at Oleander Dr and S. Wallace Ave, installed in previous phase of project.

Install the antenna in such a manner that avoids conflicts with other utilities (separation distances in accordance with the guidelines of the NESC) 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 N-Type male 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. Install two antennae at a repeater site with a coaxial antenna cable splitter. Secure splitter to pole.

Fasten all wiring and harness supports to the cabinet with screws or other removable mechanical means. Do not use adhesives.

Do not locate terminals on the underside of the shelf or at other places where they are not readily visible and accessible, or where they may be a hazard to personnel. Provide a clear plastic guard for exposed 120-volt AC terminals on the power panel.

Install the coaxial cable shield grounding system by carefully removing the outer jacket of the coaxial cable without damaging the cable shield. Install the shield grounding system following the cable manufacturer's recommendations. Install and weatherproof the connection using the appropriate weatherproofing materials and following the manufacturer's recommendations. On wood poles, secure the #6 AWG grounding lead cable to the pole ground using split bolt or compression type fitting or an Engineer approved method. On metal poles, secure the #6 AWG grounding lead cable to the pole using an Engineer approved method.

Do not exceed the 1-inch bend radius of the coaxial cable as it traverses 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 the power supply for the radio system is **NOT** connected to the GFCI receptacle circuit located in the cabinet. Place a copy of all manufacturer equipment specifications and instruction and maintenance manuals in the equipment cabinet.

Where the Plans call for the antenna to be mounted on a metal signal pole or signal mast arm, route the coaxial cable from the antenna to the controller cabinet through the inside of the mast arm and metal pole using existing conduit stubouts between the pole foundation and the controller cabinet foundation. For an antenna mounted on a mast arm, field drill a hole no larger than 1" diameter on the underside of the mast arm near the antenna, paint the exposed metal with galvanized paint and insert a grommet into the hole. For an antenna mounted near the top of a metal pole, field drill a hole near the top of the pole and install a rigid galvanized coupling 1"-2" in diameter. Install the coupling above messenger cable attachment points and in the vicinity of existing weatherheads if present. Apply heat shrink tubing to the coupling once the coaxial cable has been routed through the coupling and into the metal pole.

At certain locations, it may be necessary to integrate the radio system with a fiber-optic system. Follow the details shown in the fiber-optic splice plans.

28.4. MEASURMENT AND PAYMENT

900MHz Radio will be measured and paid as the actual number of 900MHz radios furnished and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed radio system and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period). This item includes the appropriate antenna(e), antenna mounting hardware, power supplies, power cords, adapters, connectors, coaxial cable, splitter cable, coaxial cable shield grounding system with weatherproofing, lightning arrestor, serial data cables installation materials, configuration software, any integration between the radio system and a fiber-optic network (if necessary) and warranties.

Furnish 900MHz Radio will be measured and paid as the actual number of 900MHz radios furnished and accepted. This item includes one spare antenna, lightning arrestor, power supply and power cord per radio.

Riser assemblies will be measured and paid for separately in accordance with the "Riser Assemblies" section of these Project Special Provisions.

No measurement will be made of field-drilling holes in existing metal poles and installing and heat-shrink tubing in order to route coaxial cable inside existing metal poles as such work will be considered incidental to furnishing and installing 900MHz radios. Similarly, no measurement will be made of field-drilling holes in existing traffic signal mast arms and installing grommets in order to route coaxial cable inside existing metal poles with mast arms as such work will be considered incidental to furnishing and installing 900MHz radios.

Payment will be made under:

Pay Item	**Pay Unit**
900MHz Radio	Each
Furnish 900MHz Radio	Each

29. CCTV FIELD EQUIPMENT

29.1. DESCRIPTION

Furnish and install CCTV field equipment, cabinets and local camera control software described in this Section. Furnish equipment that is compatible and interoperable with the existing SpectraDome IV cameras using the Pelco protocol and the Pelco video switches currently in use by the City of Wilmington. Ensure that the equipment is fully compatible with all features of the video matrix switch and the CCTV control software.

Furnish and install new electrical service for CCTV as shown in the Plans.

Provide a system to protect field devices and electronic equipment from lightning and surge protection using transient voltage and surge suppression (TVSS) technology and standards.

29.2. MATERIALS

(A) General

Furnish new CCTV camera assemblies, CCTV cabinets, and CCTV wood poles.

Each CCTV camera assembly shall consist of the following:

- NEMA environmental dome enclosure;
- CCTV color digital signal processing camera unit with zoom lens, filter, control circuit, and accessories;
- Control receiver/driver that complies with the NTCIP specifications listed below;
- Motorized pan, tilt, and zoom;
- Pole-mount camera attachment hardware;
- All necessary cable, connectors and incidental hardware to make a complete and operable system;
- Furnish a NEMA Type 4, IP 66 enclosure constructed of aluminum with a clear acrylic dome or approved equal camera unit housing; and
- Transient voltage surge suppressors.

(B) Standards

- ANSI,
- ASTM,
- CE, Class B,
- EIA Standards 170, 232, 422, 250C and 485,
- FCC Rules Part 15, Sub-part J,
- FCC Class A,
- FCC, Class B,
- IEEE,
- ICEA,
- IMSA,
- ISO 9001,

- NEC,
- NEMA 4X, IP 66,
- NEMA Type 1,
- NTCIP 1201,
- NTCIP 1205 v01.08,
- NTCIP 1208,
- NTCIP 2104,
- NTCIP 2202,
- NTCIP 2301,
- NTSC, and
- UL Listed.

Provide UL listed TVSS devices according to the *UL 1449, 2nd edition* standard and shall comply with the NEMA requirements as detailed in the *NEMA LS 1 (1992)* standard.

Provide UL listed air terminal according to the *UL 96A* standard and be suitable for use in a UL master label lightning protection system.

(C) Camera and Lens

1) Cameras

Furnish new ¼-inch charged-coupled device (CCD) color cameras. Furnish cameras with automatic gain control (AGC) for clear images in varying light levels. The camera must meet the following minimum requirements:

• Video signal format:	NTSC composite color video output, 1 volt peak to peak,
• Image sensor resolution:	470 horizontal by 350 vertical TVL,
• Image resolution:	724 horizontal pixels by 494 vertical pixels,
• Automatic gain control (AGC):	0-20 dB, peak-average adjustable,
• White balance:	Automatic through the lens with manual override,
• Electronic-shutter:	Dip-switch selectable NTSC electronic shutter with speed range from 1/2 of a second (off) to 1/30,000th of a second,
• Overexposure protection:	Built-in circuitry or a protection device to prevent any damage to the camera when pointed at strong light sources, including the sun,
• Sensitivity:	1.5 lux at 90% scene reflectance,
• Signal to noise ratio:	Greater than 50 dB,
• Video output connection:	1-volt peak to peak, 75 ohms terminated, BNC connector, and
• Primary power:	120 VAC, and
• Power:	24 VAC or less.

2) Zoom Lens

Furnish each camera with a motorized zoom lens with automatic iris control with manual override and neutral density spot filter. Furnish lenses that meet the following optical specifications:

- Automatic focus: Automatic with manual override,
- Horizontal angle of view: 54 degrees at 3.6 mm wide zoom and 2.5 degrees at 82 mm telephoto zoom,
- Focal length: 0.14" – 3.25", 23X optical zoom, 12X electronic zoom,
- Zoom speed: 2.9, 4.2 and 5.8 seconds,
- Lens aperture: Minimum of f/1.6,
- Maximum sensitivity at 35 IRE: .08 lux at ½ color, .3 lux at 1/60 black and white, .013 lux at ½ black and white,
- Preset positioning: Minimum of 64 presets.

The lens must be capable of both automatic and remote manual control iris and focus override operation. The lens must be equipped for remote control of zoom and focus, including automatic movement to any of the preset zoom and focus positions. Mechanical or electrical means must be provided to protect the motors from overrunning in extreme positions. The operating voltages of the lens must be compatible with the outputs of the camera control.

(D) Camera Housing

Furnish new dome style enclosure for assemblies with a high performance integrated dome system or approved equal. Equip each housing with mounting assembly for attachment to the CCTV camera pole. The enclosures must be equipped with a strip heater and a sunshield and be fabricated from corrosion resistant aluminum and finished in a neutral color of weather resistant enamel. The viewing area of the enclosure must be tempered glass.

A dome-type environmental housing shall have a sustained ambient operating temperature of -50° F to 122° F, with 100 percent non-condensing relative humidity as defined within the NEMA TS-2 (1998) standard.

The enclosure shall have a NEMA 4X/IP-66 rating.

(E) Pan and Tilt Unit

Each new dome style assembly must be equipped with a pan and tilt unit. The pan and tilt unit must be integral to dome system. The pan and tilt unit must be rated for outdoor operation, provide dynamic braking for instantaneous stopping, prevent drift, and have minimum backlash. The dome must have an auto flip dome rotation to rotate and reposition camera for viewing objects passing below camera. The pan and tilt units must meet or exceed the following specifications:

- Pan: Continuous 360 degrees,
- Tilt: Up/down 180 degrees minimum,
- Presets: Minimum of 64,
- Pan speed: .1 degrees/second to 150 degrees/second,

- Tilt speed: .1 degrees/second to 200 degrees/second,
- Input voltage: 24 VAC 50/60Hz, and
- Motors: Two-phase induction type, continuous duty, instantaneous reversing.

(F) Control Receiver/Driver

Each new camera unit must contain control receiver/driver that is integral to the CCTV dome assembly. The control receiver/driver must receive serial asynchronous data initiated from a camera control unit, decode the command data, perform error checking, and drive the pan/tilt unit, camera controls, and motorized lens. As a minimum, the control receiver/drivers must provide the following functions:

- Zoom in/out,
- Automatic focus with manual override,
- Tilt up/down,
- Automatic iris with manual override,
- Pan right/left, and
- Minimum of 64 preset positions for pan, tilt, and zoom.

In addition, each control receiver/driver must accept status information from pan/tilt unit and motorized lens for preset positioning of those components. The control receiver/driver must relay pan, tilt, zoom, and focus positions from the field to remote camera control units. The control receiver/driver must accept "goto" preset commands from the camera control unit, decode the command data, perform error checking, and drive the pan/tilt and motorized zoom lens to the correct preset position. The preset commands from the camera control unit will consist of unique values for the desired pan, tilt, zoom, and focus positions.

(G) Software

Furnish vendor-supplied software to program and configure the cameras in the field. This software shall include features to set communications addresses and protocols, define presets, tours, privacy zones and camera ID. The software shall allow the user to control all functions of the camera locally from the CCTV cabinet at the base of the pole with a serial cable.

(H) CCTV Camera Attachment to Pole

At locations shown in the Plans where new CCTV cameras are to be installed on new CCTV poles, design, fabricate, and furnish an attachment assembly for the CCTV camera unit. Use stainless steel banding approved by the Engineer. Submit shop drawings for review and approval by the Engineer prior to installation.

Furnish CCTV attachment that allows for the removal and replacement of the CCTV enclosure as well as providing a weatherproof, weather-tight, seal that does not allow moisture to enter the enclosure.

Furnish CCTV camera attachment assembly that is able to withstand wind loading at the maximum wind speed and gust factor called for in the interim revision of the *2002 ASHTO Specifications for Structural Supports for Highway Signs, Luminares and Traffic Signals* and can support a minimum camera unit dead load of 45 pounds.

(I) Surge Suppression

Provide a maximum 20 Ω ground impedance measurement, and the placement of transient voltage protection both ahead of and behind the ITS device electronics for CCTV installations. All TVSS devices shall have an ambient operating temperature of -40° F to 165° F with 95 percent non-condensing relative humidity.

1) Grounding

Furnish a grounding system as shown in the Plans. Provide all connections to the grounding electrode with an exothermic weld. Bond (i.e., connected) all metal components of the camera and cabinets to the grounding system with a grounding cable that uses a mechanical connection on the equipment side and an exothermic welded connection at the down cable.

Furnish an air terminal and ensure it extends at least 5 feet above the CCTV camera, as shown in the Plans.

2) CCTV Power Source Supply Side

Power source supply side protection is designed to restrict surge current transients from entering the power source from the CCTV device and/or site. The TVSS for the CCTV power source shall have an operating voltage of 120 volts single phase and a maximum continuous operating voltage of 150 volts single phase.

The device's TVSS shall be rated at a minimum of 90,000 amps per phase and have maximum clamping voltage ratings of 330 volts at 500 amps, 395 volts at 3,000 amps, and 533 volts at 10,000 amps. The TVSS shall also be UL listed for a minimum suppressed voltage of 330 volts per line to the neutral/ground. The suppression device shall be of the metal oxide varistor (MOV) type.

3) CCTV Power Line Side

The TVSS for the CCTV power source shall have an operating voltage of 120 volts single phase and a maximum continuous operating voltage of 150 volts single phase. The TVSS shall be rated at a minimum of 150,000 amps per phase, and have minimum clamping voltage ratings of 293 volts at 500 amps, 350 volts at 3,000 amps, and 446 volts at 10,000 amps. The TVSS for the power source shall also be UL listed for a minimum suppressed voltage of 400 volts per line to the neutral/ground. The suppression device shall be an MOV type.

4) CCTV Data/Video Supply and Line Side

The TVSS shall have an operating voltage to match the characteristics of the CCTV, such as 24 volts of direct current (VDC) and less than 5 VDC for data and video functions. These specialized TVSS units shall be UL listed according to the *UL 497A* standard. The minimum surge current rating for the TVSS shall be 2,000 amps for data and telecommunications, 2,000 amps for twisted pair video, and 4,000 amps for binary network connectors (BNC).

(J) CCTV Cabinet

Furnish and install cabinets to house CCTV related equipment described herein. Provide the cabinets with 19-inch communications rack for all equipment. It is the

Contractor's responsibility to size the cabinet appropriate to fit all the equipment installed within the cabinet at the particular location.

Furnish Type 336 CCTV cabinets meeting the following minimum requirements:

- Video/data transceiver (furnished and paid for separately);
- Termination of the composite cable to the camera; and
- Maintenance access points for data and video connections to observe camera images and program/monitor camera status.
- Fiber-optic interconnect center (furnished and paid for separately),
- Grounding busbar,
- 19-inch rack system for mounting of all devices in the cabinet,
- Pull-out shelf for laptop and maintenance use,
- Fluorescent lighting,
- Ventilation fans,
- Thermostats,
- 120 VAC power supply,
- 120 VAC GFCI-protected duplex outlets for tools,
- 120 VAC TVSS-protected duplex outlets for equipment,
- TVSS lightning and surge protection on incoming and outgoing electrical lines (power and data), and
- Power strip along vertical rail.

Provide cabinets complete with a prefabricated cabinet shell, and all internal components and equipment, back and side panels, front and back doors, terminal strips, cabling and harnesses, surge protection for power and communication circuits, power distribution blocks or assemblies, shelves, connectors and all mounting hardware necessary for installation of equipment.

Construct the cabinets using unpainted sheet aluminum with a minimum thickness of 0.125 inch.

Provide the rack assembly with a removable, standard 19-inch EIA compliant rack. Equip each cabinet with an aluminum storage compartment mounted in the rack assembly with the following dimensions (±0.5 inch): 16 inches wide, 14 inches long and 1.75 inches deep. Provide the compartment with a ball bearing telescoping drawer guides to allow full extension from the rack assembly. The storage compartment shall open to provide storage space for cabinet documentation and other miscellaneous items. The storage compartment shall be of adequate construction to support a weight of 20 pounds when extended without sagging. The top of the storage compartment shall be hinged aluminum. Provide at least one removable metal shelf with each cabinet.

Provide all cabinets and door exterior seams with continuously welded and all exterior welds shall be smooth. Provide all cabinets with two full-size doors. Provide the doors with three hinges, or a full-length stainless steel piano hinge, with stainless steel pins spot-welded at the top. The hinges shall utilize stainless steel hinge pins. Mount the hinges so that they cannot be removed from the door or cabinet without first opening the door. Brace the door and hinges to withstand a 100-pound per vertical foot of door height load applied vertically to the outer edge of the door when standing open. There shall be

no permanent deformation or impairment of any part of the door or cabinet body when the load is removed. Provide the cabinet door with a #2 Corbin lock. Provide two keys for each cabinet. Provide the cabinet doors so they can be padlocked. Provide door openings with double flanges on all four sides.

Doorstops shall be included at 90 and 180-degree positions. Provide both the door and the doorstop mechanism of sufficient strength to withstand a simulated wind load of 5 pounds per square foot of door area applied to the both inside and outside surfaces without failure, permanent deformation, or compromising of door position and normal operation. Provide the cabinets without auxiliary police doors.

Ensure that cabinet doors include a gasket to provide a dust and weather-resistant seal when closed. Provide the gasket material with closed-cell neoprene and shall maintain its resiliency after exposure to the outdoor environment. The gasket shall show no sign of rolling or sagging, and shall ensure a uniform dust and weather-resistant seal around the entire door facing.

Ventilation: Provide all cabinets with a 100 CFM, minimum, cooling fan capacity. Provide a thermostat incorporated into the ventilation system. Provide dual fans.

Provide the cabinets with vent openings in the door to allow convection cooling of electronic components. Locate the vent opening on the lower portion of the cabinet door and shall be covered fully on the inside with a commercially available disposable three-layer graded type filter.

Provide cabinets with a serial number unique to the manufacturer. Engrave the entire identification code on a metallic plate that is epoxied to the cabinet on the upper right hand sidewall.

Electrical: Provide AC isolation within the cabinet. Configure all cabinets to accept 120 VAC from the utility company.

Provide UL listed circuit breakers with an interrupt capacity of 5,000 amperes and insulation resistance of 100 MΩ at 500 VDC. Provide power distributions blocks for use as power feed and junction points for two-wire and three-wire circuits. The line side of each shall be capable of handling up to 2/0 AWG conductors. Isolate the AC neutral and equipment ground wiring and terminal blocks from the line wiring by an insulation resistance of at least 10 MΩ when measured at the AC neutral.

29.3. CONSTRUCTION METHODS

(A) Electrical and Mechanical Requirements

Ground all equipment as called for in the *Standard Specifications*, these Project Special Provisions, and the Plans.

Install surge protectors on all ungrounded conductors entering the CCTV enclosure as described below. House the protectors in the CCTV cabinet on the pole in a manner approved by the Engineer. The air terminal ground wire must not pass through this cabinet.

(B) CCTV Camera

Mount CCTV camera units at a height of 45 feet above ground level measured from the base of the pole as approved by the Engineer. Mount cameras on existing poles as shown on the Plans.

Install CCTV assemblies at the locations shown on the Plans.

Mount CCTV camera on the side of pole nearest intended field of view and that avoids occluding the view with the pole. Obtain approval of camera orientation from the Engineer.

Use the vendor-supplied software to configure the cameras.

(C) Power Service

Provide 120VAC power from existing or proposed electrical service assemblies as shown on the Plans. Install new electrical service for CCTV in accordance with the "Electrical Service" section of these Project Special Provisions.

(D) Surge Suppression

1) Grounding

Connect all grounding points related to the CCTV camera assembly and its subsystems to a single point main grounding electrode. A 10-foot grounding electrode shall be installed a minimum of 20 feet away from any additional grounding electrodes and/or ground-mounted devices.

This grounding radiant shall consist of one main 10-foot grounding rod located at the structural base of the CCTV camera pole and attached to three additional 10-foot radiant grounding rod placed a minimum of 20 feet away from the main grounding rod. Attach the radiant grounding rod to the main grounding rod with a minimum #4 solid bare copper wire that is exothermically welded at both the main grounding rod and the radiant grounding rod.

2) Device Power Source Supply Side

Install a transient surge voltage suppressor (TVSS) at the CCTV power source on the supply side. This device shall provide protection between line-to-neutral, line-to-ground, line-to-line and neutral-to-ground.

3) Device Power Line Side

Install a TVSS in the power line side ahead of all CCTV electronic equipment. This installation technique is designed to restrict earth current transients induced within the ground or directly from the power source from entering the ITS device through the incoming 120/240-volt power circuit. This device shall provide protection between line to neutral, line to ground, line-to-line and neutral to ground.

4) Device Data/Video Supply and Line Side

Install specialized TVSS devices at the supply and line sides of all low voltage connections to the CCTV device and its operating subsystems. These connections include, but are not limited to, Category 5E data cables, coaxial video cables, twisted pair video cables, and low voltage control cables that comply with EIA requirements as detailed in the EIA-232/422/485 standards.

(E) CCTV Cabinet

Mount the CCTV cabinet on the wood or metal pole using stainless steel bands as shown in the Plans. Attach all risers to the base of pole-mounted cabinet as shown in the Plans.

Ground all cabinets in accordance with the requirements of these Project Special Provisions. Keep the ground wire from the cabinet ground busbar to the ground rod assembly or array as short as possible. Ensure the ground wire is not in contact with any other part of the cabinet.

Tag and identify all cabinet wiring by the use of insulated pre-printed sleeves. The wire markers shall identify in plain words with sufficient details without abbreviations or codes.

Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners. Route and secure all wiring and cabling to avoid sharp edges and to avoid conflicts with other equipment or cabling. Terminate all wiring on a terminal block, strip, busbar, device clamp, lug; or connector, do not splice any wiring. Label all wiring, cables, terminal strips, and distribution blocks. Provide strain relief for all cabling with connectors, all cabling entering knockouts or ports at the equipment, and where appropriate.

Fasten all components of the cabinet assembly to be mounted on cabinet side panels with hex-head or Phillips-head machine screws. Install the screws into tapped and threaded holes in the panels. The components include, but are not limited to, terminal blocks; busbars, panel and socket mounted TVSS, circuit breakers, accessory and equipment outlets, and DC power supply chassis.

Fasten all other cabinet components with hex-head or Phillips-head machine screws installed with nuts (with locking washer or insert) or into tapped and threaded holes. Fasten stud-mounted components to a mounting bracket providing complete access to the studs and mounting nuts. All fastener heads and nuts (when used) shall be fully accessible within a complete cabinet assembly, and any component shall be removable without requiring removal of other components, panels or mounting rails. Do not use self-tapping or self-threading fasteners.

The CCTV camera cabinet will be interconnected to CCTV camera assembly using a composite cable carrying the video, serial data and power. Terminal strips shall be provided to support 4-wire EIA 422 communications and the 24 VAC power as will be required for power and data. The terminal strips shall be accessible such that it shall not be necessary to remove any other components to gain access. The terminal shall secure conductors by means of nickel or cadmium plated brass binder head screws.

Configure the cabinets to allow maintenance access for both video and data channels. This access should provide a means to connect video feed and control data channels to a laptop computer. The connection of the laptop computer to video and data feeds shall not require disassembly or removal of any of the equipment or other components located inside the cabinet with the exception of patch cords for the data and video feeds. Provide a communication cable for connection to a typical laptop and video board or monitor for future maintenance activities. The data cable shall consist of an integral RS-232 to RS-

422 converter as required to support the CCTV camera protocol and shall be compatible with the CCTV camera assembly. The data cable shall plug into the test point connector as provided in the cabinet and into a typical laptop RS-232 serial port. The video cables shall interface with the CCTV camera cabinet test point connection and be prepped for interconnection to a BNC receptacle. Two sets of cables shall be provided, a pair of cables for data and pair of cables for video.

Each cabinet shall be ISO 9001 certified at the time of bid letting.

Equip the cabinets with TVSS lightning and surge protection described separately in these Project Special Provisions.

29.4. MEASUREMENT AND PAYMENT

CCTV camera assembly will be measured and paid as the actual number of CCTV camera assemblies furnished, installed, and accepted according to following conditions: 75% of the payment will be made upon acceptance of the installed CCTV camera assembly and the remaining 25% of the payment will be made following final acceptance (including completion of the 30-day observation period).

No separate measurement will be made for cabling, connectors, CCTV camera attachment assemblies, software, grounding equipment, surge protectors, cabling, and conduit, or any other equipment or labor required to install the CCTV assembly and integrate it with the fiber-optic communications equipment as they are considered incidental to furnishing and installing the CCTV camera assembly and the CCTV cabinet.

Fiber-optic video/data transceivers and fiber-optic interconnect centers/patch panels will be measured and paid for separately in accordance with the "Fiber-Optic Transceivers" and "Fiber-Optic Cable" sections of these Project Special Provisions.

Furnish CCTV camera assembly will be measured and paid as the actual number of CCTV camera assemblies furnished and accepted.

CCTV cabinet will be measured and paid as the actual number of CCTV cabinets furnished, installed, and accepted.

Furnish CCTV cabinet will be measured and paid as the actual number of CCTV camera assemblies furnished and accepted.

Payment will be made under:

Pay Item	Pay Unit
CCTV Camera Assembly	Each
Furnish CCTV Camera Assembly	Each
CCTV Cabinet	Each
Furnish CCTV Cabinet	Each

30. CCTV INTEGRATION AND SOFTWARE MODIFICATION

30.1. DESCRIPTION

Edit the database of the existing graphical user interface and Protronix central CCTV software controlling the video matrix switch to add the additional CCTV devices and update the map coverage. Copy the database to and install the software on the new video server and configure the new video switch. Install same software and configure proposed video server for the additional cameras as shown in the Plans.

Copy the video switch database in the Wilmington Traffic Management Center (TMC) to the new video switch and edit the database to add the additional cameras on the network.

30.2. FUNCTIONAL REQUIREMENTS

(A) Graphical User Interface (GUI) Software

The graphical user interface software includes a zoomable static display map that indicates the location of each ITS device. This map can be dynamically sized. Each ITS device is associated with an icon that loads an executable application. All ITS elements, icon and their respective locations are stored in the 1983 North American Datum North Carolina state plane coordinates in English units (feet). Text notes are stored for each device, which includes the dates of the last modification.

Edit the existing unified device database to add the new CCTV devices with icons. The unified device database contains the coordinates of each device in individual records and contains a maximum of fifty fields. Ensure the map extents have adequate coverage to show the new CCTV devices. Ensure the existing capability to import data from other file formats is maintained.

(B) Central CCTV Software

The existing CCTV central software that controls the existing video matrix switch at the TMC is Protronix's VideoPro. It also interfaces with a DVR. This software includes on screen pan-tilt-zoom controls of each camera in the system.

Modify the Protronix CCTV central software configuration at the TMC to display and map the new and relocated CCTV devices so that the CCTV video can be displayed on the existing monitors and display devices at the TMC and the Signal Shop.

(C) Video Switch Configuration

Edit the configuration setup after transferring from the existing video switch to incorporate the new CCTV analog and serial data ports, DVR and communications hardware. Extend the same priorities and lockout privileges to the TMC users, as they currently exist for other City-owned CCTV devices within the City of Wilmington.

30.3. DOCUMENTATION

Provide updated installation, operations and training manuals for the software. Provide printed copies of the updated database.

30.4. MEASUREMENT AND PAYMENT

CCTV software integration for the editing of the databases and integrating of the new CCTV devices will be measured and paid for at the contract lump sum price. The price and payment will be full compensation for all work required by this section, including the furnishing, testing and all materials, equipment labor, tools, storage, shipping and incidentals necessary to edit the existing system configuration to add the new CCTV devices.

Payment will be made under:

Pay Item	Pay Unit
CCTV Software Integration	Lump Sum

31. SUBMITTAL DATA

31.1. DESCRIPTION

Provide project documentation as described below.

31.2. SUBMITTALS

(A) General

All documentation will be either 11" x 17" or 8½"x 11" format. No documentation may be smaller or larger than these formats.

All submittals will be reviewed and approved by the Department. Absence of comment will not grant approval.

(B) Project Construction Schedule

Prepare and submit for approval by the Engineer a schedule of the proposed working progress on the project in accordance with the instructions and on forms furnished by the Department. Update and submit the schedule monthly.

The proposed progress schedule shall be submitted no later than seven days prior to the date of the project preconstruction conference and shall be approved before any work is begun on the project.

When conditions beyond the Contractor's control have adversely affected his progress, or the Department has extended the completion date, the Contractor may submit a revised progress schedule to the Department for approval. Such revised progress schedule will not be approved unless accompanied by a detailed written statement giving the Contractor's reasons for the proposed revision.

The project construction schedule shall show at least:

- Major Activities,
- Critical Path,
- Task Dependencies,
- Float Time for Each Task,
- Project Start and Completion,
- Task Durations,
- Task Begin and End Dates,
- Milestones,
- Material Submittals,
- Submittal Review Periods,
- Equipment Deliveries,
- Sample and Material Testing,
- Acceptance and Demonstration Testing,
- Training,
- Observation Period,
- Final Acceptance.

(C) Qualified Products

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.

The Signal Equipment Qualified Products List (QPL) is available on the Department's Web site. 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.

(D) Submittal Requirements

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

The intent of submittals is to show completely the materials meet the requirements of the Plans and Project Special Provisions and how the Contractor intends to construct or configure the materials. The Contractor shall clearly demonstrate in the submittals that the desired materials shall meet or exceed the requirements of the Plans and Project Special Provisions. Each submittal shall be sufficiently complete and detailed for the Department to review and approve the submittal. If the Department deems the submittal insufficient in detail or completeness for review or approval, the submittal shall be returned as rejected. Additional time shall not be granted for resubmittal.

Before material submittal data begins, provide to the Department a list of all submittals with approximate dates of submission that the Contractor intends to make. It is incumbent upon the Contractor to schedule reviews in a timely manner that will not delay his schedule.

Certain groups of materials are related in function and operate as a subsystem together. To ensure individual and subsystem compliance with the project requirements materials shall be submitted as packages as follows:

Submittal Packages

Submittal Package	Description
Cabinets and Traffic Signal Controllers	Traffic Signal Cabinets, Controllers, Base Adapters, Base Extenders, Detector Amplifiers, Conflict Monitors
CCTV Equipment	CCTV Cabinets, CCTV Cameras, Composite Video Cable

Submittal Package	Description
Fiber-Optic Cable	Fiber-optic Cable, Drop Cable Assemblies, Splice Enclosures, Aerial Cable Protector, Underground Cable Markers, Communications Cable Identification Markers
Field Infrastructure	Conduit, Junction Boxes, Splice Boxes/Cabinets, Misc. Hardware

Submit cabinet layout and wiring diagrams for all cabinets.

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

For Contractor-furnished material listed on the QPL, furnish submittals in the format defined by the QPL.

For Contractor-furnished material not on the QPL, furnish four (4) copies of the equipment list including four copies of catalog cuts. Identify proposed material on catalog cuts by a reproducible means (highlighter pen does not transfer to copies). Ensure material lists contain material description, brand name, manufacturer's address and telephone number, stock number, size, identifying trademark or symbol, and other appropriate ratings. For submittals showing a variety of models and parts available from the manufacturer, clearly identify by circles, marking or other means the specific materials for which approval is requested.

Allocate 40 days for the Department to review and respond to a submittal. Submittal approval will be granted only to specific materials; do not deviate from what is approved without approval by the Department. Do not fabricate or order material until receipt of the Department's approval. All submittals will be returned as either "Approved (as submitted)", "Approved as Noted" or "Rejected". The Contractor may proceed with fabrication or ordering for items marked "Approved". If an item is marked "Approved as Noted" without any stipulation for resubmittal, then the Contractor may proceed with fabrication or ordering. For any other notations, the Contractor shall revise the submittal, address comments and resubmit for approval.

31.3. MEASUREMENT AND PAYMENT

There will be no direct payment for work covered in this section. Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this section.

32. TRAINING

32.1. DESCRIPTION

Provide training for the installation, operation and maintenance of:

- Fiber-optic transceivers,
- 2070 traffic signal controllers and controller software,
- CCTV field equipment,
- Spread spectrum radios, and
- Controller hardware and local controller software including:
  - Controllers,
  - Cabinets
  - Conflict monitors,
  - Detectors.

32.2. MATERIALS

(A) General

Provide training in the installation, operation, maintenance, troubleshooting and repair of all equipment and software. Prepare training outline, agenda, training manuals, training exercises, instructor resumes and any other teaching aids for approval by the Department. For exercises requiring computers, furnish enough computers to have one computer per two students.

Provide draft-training material to the Department for review and approval at least 60 days prior to the scheduled training. Provide adequate time for review and revision of the draft training materials. Furnish audio-visual equipment, demonstration equipment, and "hands-on" equipment in support of the envisioned training. Each training participant shall receive a copy of course materials including both comprehensive and presentation manuals. Assume there will be 12-15 students in the class. Provide two additional copies of these documents to the Department.

Utilize training personnel well versed in the subject matter and with extensive field experience dealing with real world problems. Utilize training personnel that have been certified by the respective manufacturers.

Video record the entire training on digital videodisc (DVD) and provide the DVD(s) to the Department for later use.

The training shall be conducted locally after the completion of all system integration tests. The City shall provide the training facility. Provide the Department with a 30-day notification to carry out the training so that arrangements can be made for attendance. Coordinate a mutually agreeable date, time and location with the City through the Engineer. The Engineer shall approve the training schedule time and location.

Develop the course content specifically for the products supplied for this project. The course shall include the following topics:

- Introductory-level briefing to familiarize attendees

- Terminology
- Theory of operation
- Installation
- Hardware and software configuration
- Operating procedures and capabilities
- Testing, diagnostics and troubleshooting
- Software applications
- Use of the system documentation to operate, diagnose, maintain, and expand the system.
- "Hands-on" use of the system, laptop computer and software, system test equipment, and any other system equipment supplied.

Provide course lengths as follows:

Course	Type of Training	Length (Days)
2070 Traffic Signal Controllers and Controller Software	Lecture and Hands-on Exercises	2
CCTV Field Equipment	Lecture and Hands-on Exercises	1
CCTV Central Video Equipment	Lecture and Hands-on Exercises	0.5
CCTV Central Software	Lecture and Hands-on Exercises	0.5
Spread Spectrum Radios	Lecture and Hands-on Exercises	1

Provide additional specific training as described below.

(B) Fiber-Optic Transceivers

Provide training for the fiber-optic transceivers as described below:

Course	Type of Training	Length (Days)
Transceivers		.5
Safety	Lecture	
Introduction to transceivers	Lecture	
Review of Maintenance Manual	Lecture	
Review of Operations Manual	Lecture	
Question and answer session	Lecture	

(C) CCTV Field Equipment

Provide training for the CCTV field equipment and the local CCTV camera software as described below:

Course	Type of Training	Length (Days)
Operations	Lecture	1
Theory of operation	Lecture, Demonstration	
Local camera programming	Lecture, Demonstration and Hands-on	
Camera addresses		
Presets		
Privacy zones		
Privacy zones		
Tours		
Other features		
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(D) 2070 Traffic Signal Controllers and Controller Software

Provide two sessions in the basic theory and operation of the 2070 controller equipment, cabinets, conflict monitors and other related equipment. Include in this training lecture and hands-on exercise in the use of the local controller software. Assume the attendees have a good working knowledge through their use of NEMA controllers.

The lecture, demonstration; hands-on class shall include the following sessions specific to the 2070 related family of hardware and software (controllers, cabinets, signal monitors and detectors:

Course	Type of Training	Length (Days)
Programming	Lecture, Demonstration and Hands-on	2
Phasing		
Timing		
Preemption		
Coordination		
Data transfer		
Operations	Lecture	
Theory of operation	Lecture, Demonstration and Hands-on	
Testing	Lecture, Demonstration and Hands-on	
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands-on	
Troubleshooting	Lecture, Demonstration and Hands-on	

(E) Spread Spectrum Radios

Provide training for the spread spectrum radio equipment as described below:

Course	Type of Training	Length (Days)
Operations	Lecture, Demonstration	1
Theory of operation	Lecture	
Safety	Lecture	
Antenna alignment	Lecture	
Site Surveys	Lecture, Demonstration and Hands-on	
Procedures		
Interpreting and understanding the results		
Programming and software	Lecture, Demonstration and Hands-on	
Configuration		
Repeater applications		
Maintenance	Lecture	
Routine maintenance	Lecture, Demonstration and Hands	
Testing	Lecture, Demonstration and Hands	
Troubleshooting	Lecture, Demonstration and Hands	

32.3. MEASUREMENT AND PAYMENT

Training will be measured and paid at the contract lump sum price. The price and payment will be full compensation for all work required by this section of these Project Special Provisions.

If the Contractor provides the same brand and model of the respective equipment provided in Phase 1, the Engineer may delete the training requirement for that product.

Payment will be made under:

Pay Item	Pay Unit
Training	Lump Sum

33. TESTING AND ACCEPTANCE

33.1. GENERAL

Conduct and complete successfully the following progressive series of tests before acceptance: factory acceptance testing, field demonstration test prior to installation, installed standalone tests, system test of the network hardware, management software and an operational test. Develop a comprehensive series of test plans for each device to determine the equipment was correctly installed and meets the requirements of materials, workmanship, performance and functionality required in the plans and project special provisions. The test plans shall describe the functions to be tested, purpose of test, setup requirements, procedures to be followed, any inputs and expected outputs for each test, criteria for pass/fail and any required tools or test equipment. Any software testers shall be pre-approved by the Department.

Develop as part of the Test Plan a Traceability Matrix of all the individual subsystem functional requirements to be used to cross-reference each planned test to a specific contract requirement to be verified. This Test Evaluation/Traceability Matrix shall be used by the Engineer to crosscheck the functional requirements and the results.

A key element of test plans, where appropriate, is the introduction of forced errors into the functional test. The test plan shall check the actual result of the forced error against the anticipated result. Test will be performed by the Contractor and witnessed by the Department. No deviation from the written test procedure shall be permitted without approval from the Engineer. Any changes to the approved test procedure to accommodate unforeseen events during the time of testing shall be documented in a copy of the master test procedure. Immediately following the conclusion of each test, the Department and the Contractor shall meet to agree on the results observed and recorded during the testing. This will form the basis for the conclusions reported in the test plan. All test results, notes, and observations shall be maintained in both electronic and hard copy. Maintain complete records of all test results during all stages of testing.

33.2. FACTORY ACCEPTANCE TESTING (FAT)

Conduct a factory acceptance test to verify to the Department that all design, materials, and performance requirements for this project are satisfactorily met. Perform the factory acceptance tests at the equipment manufacturer's facility or at an independent testing laboratory.

If the Contractor provides the same brand and model of the respective equipment provided in Phase 1 or Phase 2, the Engineer may delete the testing requirement for that product.

33.3. PRE-INSTALLATION FIELD DEMONSTRATION TESTING (FDT)

Conduct pre-installation tests on all devices at a Contractor-provided facility within New Hanover County. Perform the tests on all components supplied including, but not limited to, traffic signal controllers and conflict monitors, to verify that no damage was done to any unit during the shipment and delivery process. Notify the Engineer a minimum of 15 calendar days before the start of any tests. Conduct all tests according to

the approved test procedures detailed in this section. Each device shall pass the individual tests detailed below prior to installation.

Establish a local test facility to setup, program and test the traffic signal controllers and malfunction management units before installation. Install configuration, programming and phasing, local and coordinated timing before field installation. Confirm proper operation including color sequence, flashing, preemption and timing on a test board. Demonstrate and confirm the proper programming of the matching malfunction management unit for the same location. Test the malfunction management units by applying simultaneous input of conflicting colors. Perform an 8-hour burn-in of each controller and conflict monitor.

(A) Product Examination Test

Examine each device carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

(B) Continuity Test Specifications

Check the wiring to determine conformance with the applicable standards, specifications, and requirements.

(C) Operational Test Specifications

Operate each device long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

(D) Pre-installation Test Failure Consequence

If any unit fails to pass a FDT, the unit shall be corrected or another unit substituted in its place, and the test successfully repeated.

If a unit has been modified as a result of an FDT failure, prepare a report and deliver that report to the Engineer prior to the unit's shipment. The report shall describe the nature of the failure and the corrective action taken.

If a failure pattern develops (more than two failures), the Engineer will make a determination of the disposition of the failed equipment without additional cost to the Department or an extension of the contract period.

33.4. INSTALLED SITE TESTS

Conduct an approved, standalone equipment installation test at the field site. Test all standalone functions of the field equipment using equipment installed as detailed in the plans, or as directed by the Engineer.

Complete approved test plan forms and turn them over to the Engineer for review as a basis for rejection or acceptance. Provide a minimum notice of 30 calendar days prior to all tests to permit the Engineer or his representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a standalone test failure, prepare a report describing the nature of the failure and the corrective action taken and deliver it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the contract period.

Utilize vendor supplied device software to perform diagnostic tests of each device. The vendor supplied diagnostic software shall be provided to the Department before final acceptance. Test the following features of each competent as described below.

(A) Fiber-Optic Cable

Conduct optical time domain reflectometer (OTDR) tests on the cable on the reel and after the cable is installed and terminated. Provide written notification a minimum of ten days before beginning fiber-optic cable testing.

After splicing is completed, perform bi-directional OTDR tests on each fiber, including unused fibers, to ensure the following:

- Fusion splice loss does not exceed 0.05 dB;
- Terminations and connections have a loss of 0.5 dB or less; and
- Reflection loss is 40 dB or greater for each connector.

Install a 1000-foot pre-tested launch cable between the OTDR and fiber-optic cable to be tested.

If exceeded, remake splices until the loss falls below 0.05 dB. The Department will record each attempt for purposes of acceptance.

Furnish durable labeled plots and electronic copies on a CD or DVD of test results for each fiber including engineering calculations demonstrating that OTDR test results meet or exceed the attenuation requirements and that optical properties of the cable have not been impaired. Label all test results (plots and discs) with the manufacturer and model number of the OTDR testing equipment.

Provide a tabular summary or spreadsheet detailing and comparing the loss budget and actual loss calculations per link. Provide test results for fiber-optic cable that demonstrates the loss budget where the fiber originates and the point where the fiber meets an electronic device.

If any fiber exceeds the maximum allowable attenuation or if the fiber-optic properties of the cable have been impaired, take approved corrective action including replacement of complete segments of fiber-optic cable if required. Corrective action will be at no additional cost to the Department.

(B) Traffic Signal Controllers and Conflict Monitors

The following items, not otherwise required to be tested elsewhere, shall be tested: cable continuity, grounding, power-up self-test, proper controller sequencing, detector and pedestrian pushbutton calls.

(C) Communications System Support Equipment

Perform self-diagnostic tests on all electronic test equipment provided to the Department to ensure the equipment is proper operating order. Utilize the supplied test equipment in the training for the fiber-optic cable.

(D) CCTV Field Equipment

Develop an operational test plan that demonstrates all requirements of the equipment and software. Submit for approval before conducting tests.

Notify the Department at least 14 calendar days prior to the proposed date for the tests. The Department shall have the right to witness such tests, or to designate an individual or entity to witness such tests:

Perform the following local field operational tests at the camera assembly field site in accordance with the test plans. A laptop computer shall provide camera control and positioning. After completing the installation of the camera assembly, including the camera hardware, power supply, and connecting cables:

- Furnish all equipment, appliances, and labor necessary to test the installed cable and to perform the following tests before any connections are made;
- Verify that physical construction has been completed;
- Inspect the quality and tightness of ground and surge protector connections;
- Check the power supply voltages and outputs;
- Connect devices to the power sources;
- Verify installation of specified cables and connections between the camera, PTZ, camera control receiver, and control cabinet;
- Perform the CCTV assembly manufacturer's initial power-on test in accordance with the manufacturer's recommendation;
- Set the camera control address;
- Verify the presence and quality of the video image with a portable NTSC-approved monitor;
- Exercise the pan, tilt, zoom, focus, iris opening, and manual iris control selections, and the operation, preset positioning, and power on/off functions;
- Demonstrate the pan and tilt speeds and extent of movement to meet all applicable standards, specifications, and requirements;
- Verify proper voltage of all power supplies; and
- Interconnect the communication interface device with the communication network's assigned fiber-optic trunk cable and verify that there is a transmission LED illuminated.

Repair or replace defective or failed equipment and retest.

(E) Spread Spectrum Radios

Test the spread spectrum radios as follows:

- Check all ground, power, data, Ethernet and analog video connections;
- Run power up self test on each piece of equipment;
- Run all available vendor-supplied self-diagnostics;

- Check received signal strength, noise levels, bandwidth, and accuracy of test data transmission between each pair of nodes;
- Adjust hopping patterns as necessary to maximize the quality of the signal strength; and
- If adjusting the hopping pattern does not significantly improve the quality of the signal strength, then adjust antenna as necessary to maximize the quality of the signal strength.

33.5. SYSTEM TESTING

(A) General

Conduct tests as described below of the traffic signal and CCTV subsystems. Conduct approved device subsystem tests on the field equipment with the TMC equipment including, at a minimum, all remote communications hardware monitoring and control functions. These tests shall be a demonstration of overall system stability. During this test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum of 8 hours. The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of 8 hours.

Conduct device and subsystem tests of any repaired or replaced equipment.

Display the event log from the traffic signal and CCTV software for a minimum of 7 days. Complete approved data forms and turn them over to the Engineer for review, and as a basis for rejection or acceptance.

The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of 8 hours. If a component has been modified as a result of a test failure, prepare a report and deliver it to the Engineer prior to retesting.

Upon satisfactory completion of the testing for the TMC equipment as installed, the City of Wilmington shall integrate the traffic signal controllers from the copper serial-based communications to the serial communications network and restore full TMC command and control.

(B) CCTV Subsystem

After completing the integration of the Phase 2 CCTV cameras, conduct a minimum of a seven-day test of the CCTV subsystem hardware and software. This will include that portion of the communications network serving the CCTV subsystem. The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of 8 hours. If during that time it is determined by the Department there are hardware or software failures that are the responsibility of the Contractor, the Contractor shall make repairs or replacements to the satisfaction of the Department.

Test the following features of each competent as described below.

1) CCTV Field Equipment:

The following items, not otherwise required to be tested elsewhere, shall be tested for each CCTV site from the TMC:

- NTCIP objects;
- Power-up self-tests;
- Iris control;
- Preset functions;
- Presence and quality of the video image with a portable NTSC-approved monitor;
- Preset positioning, and power on/off functions;
- Camera and controller access and security from all laptops and workstations;
- Disconnect camera and take local control and reconnect camera at local cabinet to the communications and verify TMC control is regained;
- Confirm ability to change camera ID;
- Verify unique camera identifier and icons on GUI; and
- Viewing of camera image on each monitor.

2) CCTV Central Equipment:

Verify that all CCTV images can be displayed correctly on each monitor using the CCTV central software.

3) CCTV Central Software:

Thoroughly test all functions of the software from the TMC and the City's Signal Shop to ensure correct operation. Test the components of the CCTV central equipment from both the signal shop and the TMC as follows:

- Use the GUI interface to select and view each camera;
- Use each joystick/keyboard and test the ability to control the pan-tilt-zoom and iris settings of each camera; and
- Use each joystick/keyboard and test the ability to select and place any camera on any monitor.

(C) Traffic Signal Subsystem

After the City of Wilmington has completed the integration of the Phase 3 traffic signals, conduct a minimum of a seven-day test of the traffic signal subsystem hardware and that portion of the communications network serving the traffic signal subsystem. The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of 8 hours. If during that time it is determined by the Department there are failures that are the responsibility of the Contractor, the Contractor shall make repairs or replacements to the satisfaction of the Department.

Verify communications port addressing from the traffic signal controllers.

33.6. OBSERVATION PERIOD

(A) General

The observation period shall be completed by the project completion date. The observation period shall not begin until the both the CCTV and traffic signal subsystem tests have been successfully completed. The observation period shall not begin without the approval of the Engineer.

The observation period shall begin at least 30 days before final acceptance. A successful 30-day observation period shall consist of continuous operation with no more than a total of two calendar days of non-operation due to mechanical, electrical, or other malfunctions of either the CCTV or the traffic signal subsystems.

During the observation period, respond to failures of the Contractor's equipment within 2 hours and make repairs within 8 hours. For items that pose a traffic safety hazard such as a controller failure, complete repairs within 4 hours. If any failures affect major components for more than 48 hours, the Department shall suspend the observation period beginning when the failure occurred. Resume the observation period with the approval of the Engineer after successful repair or replacement. If three or more major component failures of a like nature occur, the Department shall terminate the observation period. Begin a new 30-day observation period with the approval of the Engineer after the faulty equipment has been repaired or replaced.

(B) CCTV Subsystem

The observation period shall begin upon the successful completion of the CCTV subsystem operational test. During this period, the Department shall observe equipment and software operation according to the requirements of the Plans and these Project Special Provisions.

Major subsystem components include the video matrix switch and its peripherals, CCTV cameras, CCTV monitors, fiber-optic video/data transceivers, fiber-optic cable, and CCTV cabinets.

(C) Traffic Signal Subsystem

The observation period shall begin upon the successful completion of the traffic signal subsystem operational test. During this period, the Department shall observe equipment and software operation according to the requirements of the Plans and these project Special Provisions.

Major subsystem components include the CCTV camera assemblies, fiber-optic data transceivers, controllers and conflict monitors, and cabinets.

33.7. FINAL ACCEPTANCE

Final system acceptance is defined as the time when all work and materials described in the plans have been furnished and completely installed by the Contractor; all parts of the work have been approved and accepted by the Engineer; and the CCTV and signal systems have been operated continuously and successfully for the 30 calendar day observation period.

The project will be ready for final acceptance upon the satisfactory completion of all factory acceptance, field demonstration, installed standalone, system and operational tests. In addition, final acceptance shall not occur until the completion of all punch-list discrepancies have been rectified, all documentation has been delivered and all required training has been completed.