



**The Maryland Broadband Cooperative
Fiber Optic Network**

**CONSTRUCTION
STANDARDS AND SPECIFICATIONS
AND
MATERIAL SPECIFICATIONS**

ENGINEERING AND CONSTRUCTION STANDARDS AND SPECIFICATIONS

1. GENERAL ENGINEERING GUIDELINES

- 1.1 The Contractor will be responsible for developing all drawings and general notes necessary to facilitate the acquisition of permits, including scaled plan and profile data, if required (“Contract Drawings”). The scale, size, and format of drawings, based on the requirements of the permitting agency, will be noted on both the permit and Contract Drawings.
- 1.2 The Contractor will be responsible for developing a set of project typical drawings and project specifications for review by Owner (“Project Specifications”). The Owner shall have ten (10) business days to review and comment on the Project Specifications. The Contractor will then incorporate any Owner comments into the Project Specifications and shall utilize these for development of all Contract Drawings.
- 1.3 Any drawings and details required for permitting approval will be included in the engineering design effort (e.g., bridge details, isometric views, construction details, make-ready drawings, etc.).
- 1.4 Engineering design should provide for the development of the most economically feasible and efficiently constructed route and should include the following criteria: safety and security of the cable facility, maintenance and restoration considerations, workman safety, and public welfare and safety.
- 1.5 Maintenance access and facility security concerns shall be noted for all construction methods including underground and aerial applications.
- 1.6 The transmission quality and characteristics of the fiber optic cable are degraded if the cable is subjected to excessive pulling tensions or excessively short bending radii. All engineering designs should be made in a manner to avoid such circumstances.
- 1.7 The number of fusion splices in any section will be controlled to reduce transmission loss.

2. CONTRACT DRAWINGS

- 2.1 Contractor shall prepare Contract Drawings that meet the Project Specifications and meet the requirements of the permitting authority.
- 2.2 Drawings shall be oriented to read from left to right. Offsets shall be shown from the curb as reference. Stationing and offsets shall be shown at running line deviations, points of intersection, permanent landmarks,

and target buildings. There shall be a minimum of two offsets and station marks on each page.

- 2.3 All handholes and manholes shall be planned as to not be in intersections and/or high traffic areas.
- 2.4 The Contract Drawings shall show all planned slack loop locations and ground rod locations. Drawings shall have a scale that meets the requirements of the permitting agency(ies). Drawings shall be supplied to the Owner in AutoCad 2000 format on CD and generated on 11x17 paper, unless directed differently by the permitting authority.
- 2.5 Aerial drawings shall include planned slack loop locations, planned splice case locations, down guys, pole to pole guys, anchors, arms, risers, and lateral cables. Aerial drawings shall also include offsets and stationing as described above.

3. PERMITS

- 3.1 Contractor will obtain and track the status of all permits and rights-of-way ("ROW") needed to construct the Network. The Contractor will work closely with Owner to determine the necessary ROW and permits and develop a permit tracking form.
- 3.2 The Project Manager for the Contractor will be required to meet with each agency, along with representatives from Owner, and collect the necessary information from the agencies for design and permit submittal. These meetings will commence no later than two (2) weeks after the "Notice to Proceed" is given to the Contractor.

4. PERMIT TRACKING FORM

- 4.1 The permit tracking form ("Permit Tracking Form") is a listing and status of all required permits and agreements associated with the Network. The Permit Tracking Form is an essential document utilized in planning and scheduling activity.
- 4.2 The Permit Tracking Form is prepared by the Contractor based upon initial contacts with agencies, landowners, and jurisdictions. The Permit Tracking Form is continuously updated by the Contractor as permitting progresses and shall be made available for review by the Owner.

5. REDLINE DRAWINGS

- 5.1 Contractor shall provide "As-Built" drawings in AutoCad 2000 format as well as 11x17 paper copies to the Owner. Contractor shall update actual construction progress on redline drawings during construction. Such drawings shall be available to the Owner for review throughout performance of the Work.

6.1 CONSTRUCTION SPECIFICATIONS

6.1.1 All materials and equipment shall be applied, installed, connected, erected, utilized, cleaned and conditioned in accordance with the instructions of the applicable manufacturer, fabricator or processor, except as otherwise provided in the Contract Documents. All conduits and cable shall be plugged or capped during the construction process and upon completion to prevent any intrusion of silt, water, or foreign substances into the Network. Contractor shall abide by the following acceptable practices to complete the installation:

6.2 DIRECT BURIED FIBER OPTIC CABLE

6.2.1 The Contractor's Project Manager or his/her designee shall carefully inspect cable during and prior to installation to be certain that it is free from defects or damage.

6.2.2 Bends of small radii and twists that might damage cable shall be avoided. During the installation, cable shall not be bent in a radius less than 20 times the outside diameter of the cable or as specified by the cable manufacturer.

6.2.3 Care is to be exercised during the plowing operation, to insure that the cable is fed either manually or by capstan into the ground through the plow loose and without tension.

6.2.4 All open cable ends, either placed or remaining on a cable reel, shall have a cable cap placed on them.

7. PLOWING

7.1 Plowing innerduct includes the hauling of inner duct from storage area to work location and any handling required to properly install (via direct burying) the innerduct in the ground to a minimum depth of 48", or in accordance with jurisdictional authorities. This includes coordination with utility owners in locating their facilities prior to the installation of the innerduct.

7.2 The equipment and construction methods used by the Contractor shall be such as to cause minimum displacement of the soil. The slot made in the soil by the cable plows shall be closed immediately by driving a vehicle track or wheel over the slot or by other suitable means.

7.3 Damage to banks, ditches, and roads caused by the equipment shall be immediately repaired and restored to original condition to the satisfaction of the jurisdictional authorities.

- 7.4 The Contractor shall promptly repair any damage to fences, lawns, shrubbery, drives, and any other property damaged during construction to original condition.

After installation, the fiber optic cable shall be tested for sheath faults to ground by the Contractor.

- 7.5 The start pits, finish pits, and pits at points of intersections will be excavated in advance of plowing. Utility crossings will be exposed prior to start of plowing operations. The Contractor will exercise care in the use of trenching equipment and shovels in joining slots and/or trenches to other slots/trenches to be certain that the cable is not damaged.

8. GRASS/SOD TRENCH INSTALLATION

- 8.1 Contractor shall excavate as required (i.e. machine trench, backhoe, hand dig, etc.) to install ducts as indicated in the Contract Drawings and typicals to allow a minimum of forty-two inches (42") of cover to top of conduit below finished grade, or as specified on the Contract Drawings and/or permits. The installation shall be complete with removal and disposal of excavated materials or materials not suitable for backfill and the installation of the conduit.
- 8.2 Restoration shall include the placement of select fill or clean backfill properly compacted. Clean backfill is defined as existing native soil containing material that is free of debris. Restoration may also include shoring, bracing, road bore connections, and all other operations necessary to complete the installation.
- 8.3 Trenches shall be kept as straight as practical. The bottom of the trench shall be smooth and free from any sharp edges. The trench shall be kept clear of debris and loose rock. All changes in trench grade shall be less than one foot (1') per ten feet (10').
- 8.4 In applications where HDPE ducts are installed, Contractor shall install the ducts to prevent excessive waving of the ducts within the trench. Contractor shall tension the ducts to prevent waving in the trench prior to backfilling. Conduits shall be installed in such a manner as to keep conduit configuration consistent. Conduits shall be bound along the trench line every ten feet (10') to maintain this configuration and minimize spiraling.
- 8.5 Warning tape shall be installed twelve inches (12") below existing grade.
- 8.6 Contractor shall be responsible to ensure tie ins and duct couplings are made to ensure elevations remain as straight as possible and that the duct and conduit joints provide an airtight seal. Contractor shall furnish duct couplers to achieve this requirement.

- 8.7 All trench sections must be closed at the end of each working day. Contractor shall restore the surface conditions to original or better conditions or as required by the jurisdictional authorities.
- 8.8 If Owner elects to use a dielectric cable, Contractor shall furnish and install 14 gauge insulated locate wire within all trench line excavations leading into access points. Locate wire shall be installed as described and as shown on the typical details. Where a metallic sheath is present in the cable no locate wire is necessary.
- 8.9 Contractor shall notify Owner of areas where minimum cover requirements cannot be met. Contractor shall ensure that locations with minimum cover are protected by such means as to cover conduit with ¼" steel plates, concrete slurry, or both. This material and installation cost shall be borne by Contractor.

9. PAVEMENT TRENCH INSTALLATION

- 9.1 Contractor shall excavate as necessary to install ducts as specified on the construction typicals or as specified on the Contract Drawings and typicals. The installation shall be completed by saw cutting the roadway surfaces, removing and disposing of excavated pavement and excess excavated material and installing the conduit.
- 9.2 Restoration shall include the placement of select fill or clean backfill compacted in eight-inch (8") lifts. Clean backfill is defined as existing native soil containing material that is free of debris and contains no cobbles. Restoration may also include shoring, bracing, road bore connections, and all other operations necessary to complete the installation.
- 9.3 Temporary pavement restoration shall be required when vehicular traffic shall be present prior to final pavement restoration. Final pavement restoration shall be governed by the jurisdictional authorities. Final asphalt restoration shall typically include roto-milling to remove existing asphalt six inches (6") on each side of the trench. Final concrete restoration shall typically include replacing the concrete to match the existing roadway cross-section.
- 9.4 Trenches shall be kept as straight as practical. The bottom of the trench shall be smooth and free from any sharp edges. The trench shall be kept clear of debris and loose rock. All changes in trench grade shall be less than one foot (1') per ten feet (10'). Conduits shall be placed in the excavation as straight as practical.
- 9.5 In applications where HDPE ducts are installed, Contractor shall install the ducts to prevent excessive waving of the ducts within the trench. Contractor shall tension the ducts to prevent waving in the trench prior to backfilling. Conduits shall be installed in such a manner as to keep conduit configuration consistent. Conduits shall be bound along the

trench line every ten feet (10') to maintain this configuration and minimize spiraling.

- 9.6 Warning tape shall be installed twelve inches (12") below existing grade.
- 9.7 Contractor shall be responsible to ensure tie ins and duct couplings are made to ensure elevations remain straight as possible and that the duct and conduit joints provide an airtight seal. Contractor shall furnish duct couplers to achieve this requirement.
- 9.8 Driveways, lanes, or roadways when required to be open cut, shall be opened just prior to the conduit placing. In no case shall the driveway, lane, or roadway be left impassable at the end of each workday. The general public safety is paramount and appropriate steps shall be taken to ensure safety at all times. Where a drive or roadway must be left open for traffic, Contractor must provide the material and method required to allow for movement of traffic.
- 9.9 Trenches shall be promptly backfilled with select material and placed so that final grade is restored to original grade to ensure no hazard to vehicular, animal or pedestrian traffic. No trenches shall be left open overnight. Upon approval all open trenches shall be properly guarded or barricaded to prevent damage or injury.
- 9.10 In areas inaccessible to tamping type rollers where compaction is required, a mechanical tamper of a size suitable for the work involved shall be used. Pneumatic tampers shall be operated at pressures no less than those recommended by the manufacturer.
- 9.11 If Owner elects to use a dielectric cable, Contractor shall furnish and install 14 gauge insulated locate wire within all trench line excavations leading into access points. Locate wire shall be installed as described and as shown on the typical details. Where a metallic sheath is present in the cable no locate wire is necessary.
- 9.12 Contractor shall notify Owner of areas where minimum cover requirements cannot be met. Contractor shall ensure that locations with minimum cover are protected by such means as to cover conduit with 1/4" steel plates, concrete slurry, or both. This material and installation cost shall be borne by Contractor.

10. BORE INSTALLATION

- 10.1 Boring shall be completed with the excavation of bore launching and receiving pits, any required shoring, any required rock removal, and the installation of the conduit at a depth no less than forty-two inches (42") of cover. Bore installation shall include pushing, boring, or simultaneously boring and pushing casing pipes and duct under roads, exit ramps, railroad tracks, driveways, sidewalks, trees, environmentally sensitive areas and other features indicated on the Contract Drawings or as

directed by jurisdictional authorities. Acceptable methods of boring include jack boring, dry auger boring, and directional boring.

- 10.2 Duct shall be installed in locations as shown on the Contract Drawings. Contractor shall plan all bores as to not exceed fifteen degrees (15°) of bends in the duct. Bore pits shall be placed to conform to regulations mandated by the jurisdictional authorities as necessary.
- 10.3 Before boring, Contractor shall check all obstructions and clearances. All existing utilities and facilities shall be located and remain open until the bore has been completed.
- 10.4 No bore pits or potholes shall be left open overnight. Upon approval, all open bore pits or potholes shall be properly guarded or barricaded to prevent damage or injury.
- 10.5 Contractors' bore operator and navigator shall maintain communication at all times. When visual obstruction or distance precludes un-aided verbal communication, the operator and navigator shall utilize radio communication devices. An additional third person that has a clear view of the entire operation shall be used, wherever practical without creating an additional safety hazard.
- 10.6 The boring operator shall have full control of the direction of the boring tool at all times. Shallow, misdirected, unsuccessful bores and voids shall be abandoned and completely at Contractor's expense. Under no circumstances shall the Contractor be allowed to cut or disturb pavement or asphalt, or excavate within the relative limits of any roadway surface to retrieve any lost boring apparatus.
- 10.7 All ends of bore casing shall be sealed using non-shrink grout. All conduits shall be capped, sealed watertight and shall be well marked to accommodate locating. All bore pits shall be dewatered.
- 10.8 Restoration shall include the placement of select fill or clean backfill compacted in eight-inch (8") lifts. Clean backfill is defined as existing native soil containing material that is free of debris and contains no cobbles. Restoration may also include shoring, bracing, road bore connections, and all other operations necessary to complete the installation. Surfaces shall be restored to original or better condition or as mandated by the jurisdictional authorities.
- 10.9 Contractor is to use proper dewatering and containment methods for removal and disposal of bore water and any and all additives for wall stabilization.
- 10.10 Setup of directional boring equipment must be made in a manner to minimize damage to the surrounding area. Emphasis shall be placed on setup locations to ensure that the equipment, debris, and/or bore water

overflow do not encroach onto private property or public drainage systems. Contractor shall be responsible for disposing of all waste.

- 10.11 All directional boring equipment shall have electrical protective devices to protect the operators from electrical shock. Owner requires that these devices not be circumvented in any way and that all protective safety equipment is worn or used by all required individuals. Anyone not wearing or using protective equipment shall not approach or touch the directional drilling equipment.
- 10.12 No items attached to the backside of the reamer shall be allowed without the use of a free-moving swivel to eliminate the rotation of trailing stem. When adding additional stem or attachments where the addition/attachment is not within sight of the bore machine operator, all power providing any movement to stems shall be disengaged and the stems at the boring rig shall be locked down. Power shall only be reinstated after the item being attached to the stem is securely connected and all personnel are clear of moving components.
- 10.13 Contractor shall be responsible ensure tie ins and duct couplings are made to ensure elevations remain straight as possible and that the duct and conduit couplers provide an airtight seal.
- 10.14 If Owner elects to use a dielectric cable, Contractor shall furnish and install 14 gauge insulated locate wire within all trench line excavations leading into access points. Locate wire shall be installed as described and as shown on the typical details. Where a metallic sheath is present in the cable no locate wire is necessary.

11. BRIDGE & TUNNEL ATTACHMENT INSTALLATION

- 11.1 Contractor shall furnish and install hangers and hardware for the attachment of the duct or conduit to bridges and tunnel walls. Hangers and hardware shall be as shown on the Contract Drawings. All hardware shall be hot dipped galvanized after manufacture.
- 11.2 Conduit used for bridge and tunnel attachments shall be bullet resistant FRE or GRS pipe. Conduit shall be supported at intervals shown on the Contract Drawings while not exceeding ten feet (10') separation between hangers. At no time shall Contractor install the conduit or hardware to be the lowest point on the bridge.
- 11.3 Contractor shall furnish and install expansion joints at all structure joints. At no time shall spacing of expansion joints exceed one hundred linear feet (100') of duct.
- 11.4 All nuts shall be tightened with a torque wrench to the appropriate pressure. Contractor shall double nut all hanger bolts. All nuts shall be placed with "Locktite" or an approved equal locking compound.

- 11.5 Installation and materials shall be in accordance with the jurisdictional authorities. Contractor shall perform the Work in such a manner to avoid disrupting vehicular or pedestrian traffic unless approved by the jurisdictional authorities.
- 11.6 Contractor shall install pullboxes as shown on the Contract Drawings. Pullboxes shall be independently supported so as to not rely on the conduit for support.
- 11.7 When necessary, Contractor shall perform cores of the bridge abutment walls or tunnel walls. Cores shall be performed as specified in Section 16, Coring. Contractor shall be sure to sweep the conduit gradually for all transitions to buried conduits. Steel conduit shall be maintained until the desired depth is achieved for the transition.
- 11.8 Conduit bends shall be no less than 36" radius. Prefabricated bends shall not be altered without Owner approval.

12. RODDING, ROPING, AND INNERDUCT INSTALLATION IN EXISTING DUCT

- 12.1 Contractor shall determine the integrity of existing sections of conduit prior to installation of any pull line.
- 12.2 Contractor shall use a variable length rodder to physically "rod" the existing innerduct. This activity will determine whether or not the conduit run is continuous or whether collapsed or damaged conduits exist. Should damaged conduit be found, Contractor shall notify the Owner.
- 12.3 Once a determination has been made that the conduit run is successful, Contractor shall "rope" the existing conduit run with a pull line or mule tape.
- 12.4 Proofed and/or verified conduits shall have innerducts placed within them as directed by Owner. Contractor shall use swivels any time innerduct is being installed to prevent twisting of the duct.
- 12.5 Contractor shall apply lubricant as required during the innerduct installation process.
- 12.6 Contractor shall provide enough manpower to sufficiently manage and supervise all installations.
- 12.7 Contractor shall ensure breakaway tension of the winch is within the specifications of the innerduct manufacturer.
- 12.8 Each innerduct shall have a pull line or other pull rope installed.
- 12.9 Contractor shall furnish and install a blank duct plug to each innerduct, making sure to tie-off all pull lines.

- 12.10 Contractor shall use caution through the entire rodding, roping and innerduct installation process to avoid damaging any existing conduits, innerducts, cables, or other previously existing plant.
- 12.11 Contractor shall prepare, and furnish to Owner, butterfly drawings of manhole system showing Owner duct and overall layout of ducts in the manhole.

13. MANHOLE INSTALLATION

- 13.1 The Contractor shall install manholes at locations as shown on the Contract Drawings and as approved by Owner. The Contractor shall install manholes to the specifications as depicted on the typical drawings and any applicable jurisdictional authorities' specifications.
- 13.2 Contractor shall place the manholes on a minimum eight-inch (8") thick bed. Bed material shall consist of clean three quarter inch (3/4") crushed stone placed on filter fabric. For open bottom manholes, Contractor shall place a rodent-proof mesh on top of the gravel bedding. The ducts shall enter and leave manholes exactly opposite each other. Frames and covers shall be installed to match existing grade unless otherwise noted and shall be shimmed with either steel or concrete spacers.
- 13.3 Contractor shall not use material less than five thousand pounds per square inch (5,000 psi) in density to shim frames and covers or as necessary to maintain the load rating on the manholes.
- 13.4 The manholes shall not be installed on steep banks or slopes where the cover cannot be leveled within a tolerance of one-inch (1") of drop to twelve inches (12") of grade.
- 13.5 All manhole penetrations shall be sealed with a non-shrink grout. All conduit and duct ends shall be sealed with Contractor supplied duct plugs/caps. Large diameter ducts shall be trimmed neatly inside the manhole. For PVC conduit installation, conduits shall be flush to the interior manhole wall. During installation of HDPE conduits, conduits shall extend 12" into the manhole.
- 13.6 Contractor shall install racks, hooks, and apurtences on manholes as per the manufacturer's recommendations.

14. HANDHOLE INSTALLATION

- 14.1 Contractor shall install handholes at locations as shown on the drawings and as approved by Owner. The Contractor shall install handholes to the specifications as depicted on the typical drawings and any applicable jurisdictional authorities' specifications.

- 14.2 Contractor shall place the handholes as per the typical drawings. Contractor shall place a rodent-proof mesh on top of the gravel bedding. The ducts shall enter and leave handholes exactly opposite each other.
- 14.3 Handholes shall be placed so that the top sits flush with the existing grade unless otherwise noted.
- 14.4 The handholes shall not be installed on steep banks or slopes where the cover cannot be leveled within a tolerance of one-inch (1") of drop to twelve inches (12") of grade.
- 14.5 All conduit and duct ends shall be sealed with Contractor supplied duct plugs/caps. Large diameter ducts shall be trimmed neatly inside the manhole. For PVC conduit installation, conduits shall be flush to the interior manhole wall. During installation of HDPE conduits, conduits shall extend 12" into the manhole.

15. ROUTE MARKERS

- 15.1 Contractor shall install cable route warning signs along the route to allow for route protection and maintenance. Contractor shall exercise special caution to locate the cable route markers and cable location signs to avoid interference with the warning tape, conduit, and any other existing facilities.

16. CORING

- 16.1 Contractor shall perform all cores into abutments, tunnel walls, manholes, handholes, and vaults by utilizing a core drill with a core type bit. Contractor shall drill a pilot hole prior to performing the core to verify the core's location. Contractor shall core a hole that is not more than one half inch (1/2") greater than the outside diameter of the conduit that is being placed through the core. Contractor shall seal the core utilizing a non-shrink grout. In addition, Contractor shall adhere to the specifications imposed by the owner of the facility being cored into.
- 16.2 Contractor shall perform all cores into buildings by utilizing a core drill with a core type bit. Contractor shall drill a pilot hole prior to performing the core to verify the core's location. Contractor shall core a hole that is not more than two inches (2") greater than the outside diameter of the conduit that is being placed through the core. Contractor shall furnish and install a link seal on both ends of the core and tighten in a criss-cross fashion. In addition, Contractor shall adhere to the specifications imposed by the owner of the facility being cored into.
- 16.3 Contractor shall stub out conduit according to NEC code.
- 16.4 All clean up is the responsibility of the Contractor.

17. UNDERGROUND FIBER OPTIC CABLE INSTALLATION

- 17.1 Contractor shall install fiber optic cable in the conduit system as specified in the Contract Drawings, and in accordance with the manufacturer's recommendations.
- 17.2 Each reel of fiber optic cable will be tested at the factory. The Contractor may at its discretion, reel test the fiber cable prior to installation. Contractor assumes responsibility of the fiber cable until Acceptance by Owner.
- 17.3 Contractor shall maintain comprehensible two-way radio communication among crew members at all times during fiber optic cable installation.
- 17.4 Owner is providing Contractor the option to blow, jet, or pull the fiber optic cable for installation. Should Contractor choose to install the cable by pulling, Contractor shall be responsible for furnishing and installing pull rope.
- 17.5 Contractor shall, to the best of its ability, install the fiber optic cable in the most consistent manner throughout the duct system. This shall include, but is not limited to, installation within the same color or location of duct.
- 17.6 Contractor is responsible for the protection of fiber optic cable until acceptance by Owner of the installed, spliced and tested cable from Contractor. This includes, but is not limited to, storage of the cable prior to installation, overnight protection because the entire cable was not installed prior to stopping work for the day, and during transportation to the jobsite.
- 17.7 Contractor shall leave slack coils as shown on the Contract Drawings. Cable slack coils shall have a radius no smaller than ten (10) times the outside diameter of the cable unless more stringent guidelines are recommended by the manufacturer. Contractor shall leave seventy-five feet (75') of cable slack coiled in handholes and manholes that will be utilized for splicing as shown on the Contract Drawings. In all other handholes and manholes, Contractor shall leave slack as noted on Contract Drawings and as needed for on-going operations and maintenance of the Network. All cable slack shall be neatly coiled and secured with black electrical tape.
- 17.8 Contractor shall rack all slack coils to the existing handhole or manhole racking. Cable shall be identified in each manhole/handhole utilizing cable tags. Contractor shall label all cable tags with a permanent marker. Labels shall include the count of fiber and any requested Owner information.
- 17.9 Contractor shall avoid bends of small radii and twists that may damage the fiber optic cable. During installation, Contractor shall not bend cable in a radius less than twenty (20) times the outside diameter of the cable.

Contractor shall utilize pulleys, sheaves, radius wheels, or other devices to meet this requirement.

- 17.10 Contractor shall not pull the cable with more than six hundred (600) pounds of dynamic tension and shall use a breakaway swivel. Contractor shall use safeguards such as adjustable slip clutch capstan winches or pulling dynamometers. Contractor shall be responsible for proving that all safeguards have been calibrated and demonstrate their functionality.
- 17.11 Contractor shall install the cable into the conduit system without splices in the fiber optic cable except where noted on the Contract Drawings.
- 17.12 Contractor shall dispose of all reels in an appropriate manner. Contractor shall also supply sufficient maintenance cable for restoration of the Network. Contractor shall properly dispose of any cable determined to be “unusable”.
- 17.13 Contractor shall redline drawings to produce and submit to Owner as-built drawings of the installed fiber optic cable.
- 17.14 Red line drawings shall be completed by Contractor. Red line drawings shall include:
 - 17.14.1 At **EVERY** manhole and handhole, verification of the occupied duct (e.g. Orange duct entering, Blue duct leaving).
 - 17.14.2 At **EVERY** manhole and handhole, Contractor must write down sequential footage markings at the manhole or handhole entry point for each cable. There should be two separate footages at each location with the footage recorded being correctly labeled as to its direction and location (i.e. 5005’ – North cable at Manhole POE; 3001’ – South cable at Manhole POE).
 - 17.14.3 At **EACH** splice manhole and handhole, Contractor must write down sequential footage markings at the manhole or handhole entry point and at the butt of the splice enclosure for each cable. There should be four separate footages at each butt splice location with each footage recorded being correctly labeled as to its direction and location (i.e. 5005’ – North cable at Manhole POE; 5055’ – North cable at entrance of splice enclosure; 3001’ – South cable at Manhole POE; 2051 – South cable at entrance of splice enclosure).

18. AERIAL FIBER OPTIC CABLE INSTALLATION

- 18.1 Contractor shall install fiber optic cable as specified on the Contract Drawings. Contractor shall install fiber optic cable in accordance with the manufacturer’s recommendations. Installation shall be performed in accordance with all jurisdictional authorities.

- 18.2 Each reel of fiber optic cable will be tested at the factory. The Contractor may, at its discretion, reel test the fiber cable prior to installation. Contractor assumes responsibility of the fiber cable until Acceptance by Owner.
- 18.3 All strand and fiber cable, down guys, pole-to-pole guys, anchors, arms, risers, lateral cables, etc. shall be installed as shown on the Contract Drawings. Not shown, but included, are bonds to other communication strands (not power communication) at first, last, and every tenth pole, fiber tags at every pole, tree trims, and pole stepping as required.
- 18.4 There shall be strand continuity throughout the system. Strand to strand bonds shall be accomplished using a separate bond clamp and #10 copper bond, (i.e. double framed poles).
- 18.5 Anchors and guy wires shall always be installed and tensioned prior to sagging.
- 18.6 Guy strand size shall be the same as the supporting strand when the guy has a lead over height ratio of 1/2 or better. 10M strand shall be utilized for sidewalk anchors and at locations where the lead over height ratio is less than 1/2.
- 18.7 Guys shall be attached to standard pole line hardware and anchor rods using a perform dead end, two-bolt clamp for 6.6M strand, three-bolt clamp for 10M strand or strand vice, or as otherwise approved by Owner.
- 18.8 Where authorized by the local utility companies an auxiliary eye attachment may be used to attach a guy to an existing anchor rod.
- 18.9 Anchor rods shall not protrude more than twelve (12) inches above ground level. Where authorized by the governing pole owner(s), strain insulators shall be installed on all down and pole-to-pole guys.
- 18.10 Guy guards (shields) shall be utilized on all down guys.
- 18.11 At junction poles and dead end poles, all strands will be bonded or grounded.
- 18.12 Metal, wood or fiberglass standoff may be used to clear obstructions if approved by the local utilities.
- 18.13 Fiber optic cable shall be smoothly installed using single lashing to strand except at railroad crossings, river/stream crossings, roadways and commercial driveways, these crossings shall be double lashed. Loose lashing or excessive twisting or weaving of cable around messenger shall be cause for rejection.

- 18.14 Cable shall not be pulled with more than 600 lbs. of dynamic tension. Safeguards, such as break-away swivels, adjustable slip-clutch capstan winches, or pulling dynamometers shall be used.
- 18.15 Cable rollers shall be placed as necessary to protect the cable and property and to assure proper clearance over driveways and streets.
- 18.16 Cable shall be lashed to a supporting strand using a 0.045" stainless steel lashing wire maintaining an average of 2,400 feet of lashing wire per 1,000 feet of strand.
- 18.17 Bends of small radii and twists that may damage the fiber optic cable shall be avoided. During cable placement, cable shall not be bent in a radius less than twenty (20) times the outside diameter of the cable or as specified by the manufacturer. Pulleys, sheaves or radius wheels shall be used to meet this requirement.
- 18.18 Cable shall not be pulled at greater than 180 degrees of cable bend per pull.
- 18.19 Lashing wire shall be terminated with a lashing wire clamp on each side of every pole. The lashing wire shall be wrapped two times around the strand before terminating in the lashing wire clamp. The lashing wire shall be placed between the two washers and shall be wrapped no more than 1/2 turn. The lashing wire must not cross itself under the washers. When the lashing wire is securely fixed, the end of the lashing wire shall not be exposed. When double lashing, do not place both lashing wires under the same washer.
- 18.20 At each pole the cable and strand shall be separated by cable support and spacers. A minimum of two (2) straps and spacers shall be used.
- 18.21 For each reel of fiber optic cable placed, the location of slack loops shall be determined by the Specifications and in accordance with jurisdictional authority or pole owners. Each reel will be utilized completely for each section. The length of slack loops shall be 100 linear feet or as specified by the pole owners. Slack loops shall be located as far from the pole as possible (with a minimum of 4 linear feet) and installed as shown in the Contract Drawings. Slack coils shall not be placed on the pole. Contractor shall not coil the cable on the pole, nor exceed the recommended bend radii in the slack loop.
- 18.22 Fiber warning tags will be placed at each pole. Contractor shall label all cable tags with a permanent marker. Labels shall include the count of fiber and any requested Owner information.
- 18.23 Contractor shall redline drawings to produce and submit to Owner as-built drawings of the installed fiber optic cable, which shall include:

- 18.23.1 At **EVERY** pole, the reel number(s) and sequential numbers at the pole.
- 18.23.2 At **EACH** slack loop, the sequential number entering and leaving the slack loop.
- 18.23.3 At **EACH** splice location, the sequential numbers entering and exiting the splice enclosure.

19. SHELTER INSTALLATION

- 19.1 Contractor shall furnish and install shelters as set forth in Exhibit C. The concrete pads for the shelters shall be sized equal to the shelters and be monolithic pours.
- 19.2 Crusher run driveways shall be installed and shall not exceed 12' wide and 24' long.
- 19.3 A one hundred Amp electric service will be installed to all shelter locations. Contractor is not responsible for costs charged by electric companies for this installation. Contractor will install the panel, conduit from the shelter to the meter channel, meter channel and pressure treated housing to mount the meter channel.
- 19.4 Contractor will assist in the negotiation of a lease on behalf of Owner and in the name of Owner. Contractor is not responsible to secure property to place the shelter. Owner will assist Contractor in this process.
- 19.5 Contractor will install a serving handhole and two conduits within the same trench into the shelter.
- 19.6 Contractor will install ground rods to ground the shelter to maximum resistance of 25 ohms.

20. GROUNDING AND BONDING

- 20.1 Contractor shall perform bonding and grounding of all armored cables as depicted in the typical drawings. All bonding and grounding shall be performed in accordance with the splice case manufacturer's specifications.
- 20.2 All bonds shall be clean and free of debris and sealed within the splice closure.
- 20.3 Ground rods shall be placed at all splice locations. The ground rod furnished by Contractor shall be five-eighths inch (5/8" diameter and eight feet (8') long copper clad and installed to leave eight inches (8") exposed inside the manhole or handhole. Contractor shall install a #6 AWG

jacketed solid copper wire from the ground rod to the splice closure attached via mechanical clamps.

21. FIBER OPTIC SPLICING

- 21.1 Splicing of fiber optic cable shall only occur at locations approved by Owner or as indicated on splice assignment sheets.
- 21.2 Contractor shall splice all fibers in accordance with and as designated in the splice assignment sheets approved by Owner. Contractor shall splice the fiber optic cable in accordance with the manufacturer's recommendations.
- 21.3 Contractor shall confirm, prior to splicing, that the information indicated by the splice assignment sheets are correct and consistent with what the Contractor actually encounters in the field. If any information is absent or incorrect on the splice drawings, it is the Contractor's responsibility to notify Owner and obtain the correct information.
- 21.4 Contractor shall inspect all splicing equipment prior to splicing activities to insure the equipment is in good, clean working condition. Contractor shall calibrate the splicing equipment as recommended by the manufacturer. Owner reserves the right to inspect the splicing equipment and to request the Contractor to calibrate and/or clean the equipment upon inspection.
- 21.5 All fibers are to be fusion spliced and organized, placed and secured in the splice enclosure equipment approved by Owner. Where applicable, a heat oven shall be used to heat shrink all sleeves. A heat gun that is hand applied shall not be permitted. Care must be exercised to prevent damage to exposed fibers by overheating. The acrylic coating should not be removed beyond the areas that will be covered by the heat shrink sleeves.
- 21.6 If a fiber/ribbon must be cut as part of the Work, Contractor shall check the fiber(s) with a fiber traffic identifier to confirm that the fibers do not have live traffic. Contractor shall not cut any fiber(s) without authorization by Owner. If splicing on or around active fibers is required, Contractor shall exercise special care and precautions. Additionally, Contractor shall have all necessary materials to make temporary and permanent repairs to any active fibers that may be damaged during the course of the Work.
- 21.7 All splicing shall be monitored by use of the splicing equipment's integrated local injection and detection or profile alignment system or separately by uni-directional testing with an OTDR. Although there are no requirements for individual splice loss, the overall span loss must meet the end-to-end loss requirements described in "Fiber Test Acceptance". Any re-splicing done at this time, before the splice case is closed and mounted, does not constitute an "attempt" as will be discussed further in this document. An "attempt" can only be determined when a bi-directional

loss value is measured for the splice in question via an OTDR as specified.

- 21.8 Splice data shall be recorded during the fusion splicing and shall include time of day, weather conditions including temperature and humidity, equipment used, and all other pertinent splicing information.
- 21.9 Within each splice enclosure, Contractor shall use a label maker to clearly print and identify each tray with the corresponding fibers and/or ribbons contained therein.

22. FIBER ACCEPTANCE TESTING

- 22.1 Contractor shall verify that all fibers have one-to-one continuity on the new cable both at the fiber level and the pigtail level. In addition, Contractor shall visually inspect fiber color and buffer tube color at each end of a span. Contractor shall immediately take action to correct any transposed or “frogged” fiber in the system. Contractor shall perform this testing and make any necessary repairs prior to fiber Acceptance testing.
- 22.2 Contractor shall follow the specifications set forth in “Fiber Optic Splicing”, “OTDR Testing”, and “Power (Insertion) Loss Testing”, for Owner’s Acceptance of the fiber system. This section shall identify the final deliverables Contractor will supply to Owner in order to receive acceptance of the fiber system.
- 22.3 Contractor shall submit the results from the OTDR and End-to-End Power Meter Testing to Owner for review. Contractor shall submit one (1) copy of the test results in an electronic format approved by Owner. Owner shall review this data and provide the Contractor with a list of deficiencies. Contractor shall then work in an expeditious manner to repair all of the deficiencies.
- 22.4 The bi-directional fiber loss calculations recorded on the *End-to-End Power Meter Test Results* form will be the guideline by which Owner will accept or reject the Work.
- 22.5 In the event that the Contractor cannot meet Owner’s allowable end-to-end power meter loss objectives due to excessive splice loss within two (2) additional splice reburn attempts, Contractor shall proceed with splicing according to the following parameters:
 - 22.5.1 Contractor shall notify Owner of the situation and provide documentation of all three (3) splice attempts.
 - 22.5.2 Contractor shall cut out approximately two inches (2”) of fiber on each side of the splice and provide it to Owner.
 - 22.5.3 Contractor shall attempt a final splice with power optimization to obtain a splice loss of no more than 0.10 dB greater than required.

22.5.4 If Contractor cannot obtain this loss, Contractor shall make one final splice to obtain a splice loss near the original condition. Contractor shall then mark the fiber "Out-of-spec" (OOS).

22.5.5 Contractor shall be responsible for providing test data on Owner approved forms.

23. OTDR TESTING

- 23.1 After all splice points for the fiber optic spans are completed, Contractor shall record measurements of the splice losses with an Optical Time Domain Reflectometer (OTDR). These measurements must be made after the splice cases are closed and permanently racked in manhole/handhole or lashed to strand in order to check for macro-bending problems, unless directed by Owner where temporary testing splices are required. Contractor shall follow Owner specifications to test the fiber optic cable as well as the specifications of the cable manufacturer and the equipment manufacturer.
- 23.2 Owner has standardized on GN NetWorks Optical Test System Emulation Software for analyzing, reporting and printing OTDR traces. The GN Networks software is able to read GN Nettest T5 format OTDR traces or Bellcore – GR-196 CORE OTDR Data Standard (Issue 1, 9/95) format traces. Owner requires the use of OTDRs that are able to produce one of these trace formats for the acceptance testing. OTDRs that are acceptable for testing on include; but not limited to; models CMA 4000/8800 and TD-3000. Operations of these OTDRs shall be in accordance with the manufacturers specifications.
- 23.3 Contractor shall note the fiber type and calibrate all testing and splicing equipment as applicable. This shall include, but not be limited to, dispersion, clad, pulse width, range, scan rate, and refractive index. Contractor shall set the machine to match the manufacturer's recommendation for the fiber being tested. Contractor shall use the same calibration for all similar type fibers in both directions within the same fiber optic span under test. Fibers shall be tested with an OTDR at 1310 nm and 1550 nm for Standard Single Mode Fiber.
- 23.4 Contractor shall test all fibers bi-directionally, after splicing has occurred. If testing from a terminated end, Contractor shall utilize a minimum of a one-kilometer (1 km) launch cord / pulse suppressor. Contractor shall allow enough time during the production of a trace to allow the signal to normalize before recording.
- 23.5 Contractor shall analyze the results of the OTDR testing to correct deficiencies in the field splices. Owner's guidelines for individual and overall fiber optic span splice loss shall be as follows:

Splice Method	Glass Type	Uni-Directional Guideline (+/-)	Power Meter Span Splice Loss Factor (@ 1310nm)	Power Meter Span Splice Loss Factor (@ 1550nm)
Single Fusion	Single Mode	0.20 dB	0.10 dB	0.10 dB
Mass Fusion	Single Mode	0.30 dB	0.15 dB	0.15 dB

23.6 When saving end-to-end signature test OTDR traces for each attempt of each fiber on the optic span, Contractor shall use the Owner approved format. Each diskette/CD shall be labeled with the cable type and make, the date the traces were shot, and the name of the person and company operating the OTDR. Contractor shall use the following labeling system to save traces during OTDR testing:

AAABBBWD.nnn where:

- AAA: Location code for the “from” site, provided by Owner
- BBB: Location code for the “to” site, provided by Owner
- W: The wavelength of the test (8 for 850 nm, 3 for 1310 nm, 5 for 1550 nm)
- D: Direction of the testing on the fiber optic span or Loop ID if direction included in Site Code
- nnn: The fiber number being tested

24. POWER (INSERTION) LOSS TESTING

- 24.1 When working on terminated fibers or as directed by Owner, Contractor shall test the fiber optic cable using two (2) self-contained optical power meters. Insertion loss testing shall be performed at 1310 nm and 1550 nm for Standard Single Mode Fiber.
- 24.2 Contractor shall provide the results from the insertion loss test on Owner’s *End-to-End Power Meter Results* form. All information must be filled out on the form including location of “from” and “to” test sites and reference loss at both locations, as well as the Contractor and operator information.
- 24.3 Contractor shall calculate the net span loss of the fiber under test in the field by subtracting the source reference reading of the equipment from the far end test power meter reading. Contractor shall be responsible to verify that the absolute value of the span loss of any given fiber is within Owner’s maximum calculated allowable loss budget. These loss budgets are provided by Owner and are calculated using actual recorded loss data of the fiber optic cable plus estimated losses due to splices, IFC pigtails, and connectors. If a fiber exceeds the budgeted loss, Contractor shall

analyze the OTDR traces to troubleshoot the fiber optic span and immediately correct the deficiencies.

- 24.4 Contractor shall perform the insertion loss test bi-directionally with the average of the loss in the two directions used for Owner's fiber system acceptance. However, no uni-directional span loss shall exceed 10% of the Maximum Calculated Allowable Budget as specified on the *End-to-End Power Meter Test Results* form.

MATERIALS SPECIFICATIONS

1. Fiber Optic Cable

Ez-Prep Loose Tube Cable – XX Fibers strand single armor

2. Shelters

- Size nominal 8' wide exterior x nominal 12' long exterior x nominal 9'1" high interior, one room concrete shelter
- Standard construction in accordance with product specifications. The structural loads of the proposed concrete shelter are as follows:
 - 200 pounds per square foot distributed floor loading while on foundation
 - 125 pounds per square foot distributed floor loading while lifting
 - 100 pounds per square foot distributed roof load
 - 120 mph wind load
 - Seismic zone 4
- Exposed aggregate exterior
- The proposed shelter walls are capable of stopping 30.06 rifle fire per UL752 requirements. Unless otherwise specified, the shelter door is not bullet resistant.
- The proposed shelter walls will provide a two hour fire rating
- The walls and ceiling will be insulated with hardboard insulation, total wall is R-11
- The interior walls and ceiling will be sheathed with ½" white nupoly board
- Light colored industrial grade vinyl tile floor covering
- One (1) 42" wide x 84" high insulated steel exterior door, with stainless steel ball-bearing tamper-proof hinges, passage style lever handle, deadbolt lockset and fiberglass weather hood
- One (1) hydraulic door closer

3. Power Distribution

- One (1) 200 Amp, 10,000 AIC, 120/240 VAC, single phase, 60 Hz, 30 space main breaker, snap-in utility power distribution panel, in a NEMA 1 surface mount enclosure
- Circuit breakers for all installed equipment and customer loads as specified

- One (1) 200 Amp, 240 Volt, fused, double pole, single throw safety switch
- Four (4) 20 Amp specification grade duplex receptacles
- One (1) 20 Amp specification grade exterior duplex receptacle on a ground fault interrupter circuit

4. Lighting

- Three (3) 80 Watt surface mounted fluorescent light fixtures with rfi noise suppression filters
- One (1) exterior door light with vandal resistant lens

5. HVAC

- Two (2) nominal 24,000 Btu/hr wall mount air conditioning units, with low ambient and compressor anti cycle controls, integral 5 kW resistance heat strips and washable dust filters
- Redundant lead/lag controls allowing approximately equal operating time on each air conditioning unit

6. Alarm Device Contacts

- The following alarm device contacts will be wired and brought to a location specified by the customer. The alarm wires will be coiled and tagged for identification per industry standards.
- There are no provisions for audible, visual or remote alarm monitoring offered, except where it is integral to the device offered or stated otherwise in this proposal
 - One (1) line voltage smoke detector
 - One (1) intrusion alarm switch with form "C" contacts rated .1 Amps at 28 Vdc
 - One (1) high temperature alarm, which will consist of single pole double throw dry contacts. Adjustment range is 30 - 110° F
 - One (1) low temperature alarm, which will consist of single pole double throw dry contacts Adjustment range is 30 - 110° F

7. Grounding

- Provisions for the connection of a grounding electrode conductor at the shelter service equipment

- One "halo" ground system consisting of a 2 AWG stranded green insulated copper halo, approximately 6 inches below the ceiling, with vertical 2 AWG bare/tinned copper drops through the floor at each corner. A length of wire is coiled at each drop to allow attachment to an exterior ring ground system by others
- One (1) 1/4" x 4 " x 24 " isolated copper ground plate

8. Generator Set

A standby generator power system with features as described below:

- Quantity: 1
- Type: Standby rated
- Fuel Type: Propane
- Manufacturer: Generac
- Model: SD20
- Output kW: 20
- Power factor: 1
- Phase: Single
- Voltage: 120/240
- Frequency: 60 Hz
- Governor: Electronic
- Enclosure: weatherproof
- Fuel tank type: subbase double wall
- Fuel piping: included
- Engine coolant heater: Volt:110
- Oil & Antifreeze: Included
- Battery and battery rack: included
- Battery voltage: 12Vdc
- Battery cables: Included
- Muffler Type: Critical
- Flexible exhaust section: Included

9. Control & Monitoring

- Meter package: hour, frequency, Voltage, ammeter
- Alarm contacts:
- Dry contacts:
- Remote annunciator: none

10. HDPE/Duct and Innerduct

High Density Polyethylene (HDPE) smooth or ribbed wall SDR 11 coilable 1.25" OD conduit.

11. Handholes

30"x48"x30" Polymer Concrete Box and Cover Assembly with a 20k load-rating lid.

12. Handhole Lock Assembly for use on NAWCAD Patuxent River (PAX) lids.

LockOut™ Device. Handhole locking device controls access to utility vaults and fiber boxes.